CURRICULUM VITAE

Edgar Dutra Zanotto

Materials Science and Engineering · Glasses and Glass-Ceramics

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Senior Professor, Federal University of São Carlos (**UFSCar**), Brazil
Visiting Professor, Wuhan University of Technology (**WUT**), China
Director, Center for Research, Technology and Education in Vitreous Materials (CeR**T**E**V**)
Board of Trustees President, High Technology Park, **ParqTec** Foundation
Vice-President, International Commission on Glass (**ICG**)

Motto: "One eye on science, the other on technology, both on education!"

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Profile

Professor Edgar D. Zanotto (EDZ) holds degrees in Materials Engineering (B.Sc), Physics (M.Sc), and Glass Technology (Ph.D). He has been active in teaching and research since December 15, 1976. He is a senior professor of Materials Science and Engineering at UFSCar and director of the CeRTEV (www.certev.ufscar.br). EDZ has coordinated over 90 research projects funded by government agencies, and 35 projects in partnership with companies from Brazil, France, the USA, Liechtenstein, and Japan, including the four most prominent in their fields. EDZ and collaborators´ research activities of the Vitreous Materials Lab of UFSCar focus on dynamic processes in supercooled liquids and glasses**:** crystallization, liquid phase separation, relaxation, and flow, as well as properties of glasses and glass-ceramics**.** Their research covers a wide range of topics, from purely scientific studies to the development of new glasses and glass-ceramics. The group aims to understand and explain dynamic processes and improve or develop nucleation and growth models of crystals in glasses, including kinetics and mechanisms of surface and volumetric crystallization, correlations between structure and nucleation mechanisms, sintering with concurrent crystallization, diffusion processes, structural relaxation, and properties. Zanotto's team has also been working on Artificial Intelligence methods to predict and develop new glasses with desired combinations of properties. He has published approximately 450 articles, 3 books, 20 book chapters, and filed 26 patents in Brazil and 10 in other countries. He ranks 7th in the list of patents granted in Brazil to individuals. They resulted in 6 spin-off companies founded by his former students (Vitrovita, Procell, Vetra, I2Mat, OrthoPETica and DenTS). A Scopus database search shows that he is ranked among the 1^{rt}- 5^{th} most prolific researchers with the following keyword combinations: (glass*& nucleation), (glass* & crystallization), glass-ceramic*. ChatGPT Plus and other LLMs often list him among the 10 most influential contemporary glass scientists.

EDZ advised over 100 MSc and PhD theses and postdocs. He also supervised over 100 undergraduate scientific initiatives. Approximately 40 of his ex-students and postdocs became professors or glass researchers, which is approximately 1/4 of the Brazilian workforce in this field. Currently, he advises 5 diploma students, 2 MSc students, 3 PhD students, and 6 postdoctoral researchers.

Zanotto chaired approximately 20 workshops and conferences, including 6 of the most important international congresses on glass (Crystallization workshop twice, PNCS, ICG annual and full, ICC, GOMD, BrazGlass), and served as a scientific committee member in approximately 50 other congresses. He has given over 400 conference talks, including approximately 170 invited lectures and over 60 plenary / keynote talks at national and international congresses.

For all these developments, Prof. Zanotto was elected to the World Academy of Ceramics (WAC), The World Academy of Sciences (TWAS), the Brazilian Academy of Sciences (ABC), the Brazilian Academy of Engineering (ANE), and the São Paulo Academy of Sciences (ACIESP). He is also *a Fellow* of the Fulbright Foundation, the Society of Glass Technology UK, the American Ceramic Society, and the Brazilian Ceramic Society. He is a council member of the International Commission on Glass (ICG), the International Ceramic Federation, the Society of Glass Technology, and the European FunGlass Center. He has received 65 science awards and distinctions, including the Almirante Álvaro Alberto Prize for Science and Technology (2012)-the most prestigious in Brazil-, the National Order of Scientific Merit (Comendador) 2006, Grand Cross 2018, Nanocell 2017, Confap 2023, TWAS Engineering Prize 2010, and seven central glass research awards and honors: Foster Research Prize 1982 by the Sheffield University Senate, Zachariasen Award 1990 by the J. Non-Crystalline Solids, Gottardi Prize 1993 by the International Commission on Glass, the G. W. Morey Award 2012 by the American Ceramic Society (ACereS), The Spriggs Award by the ACerS, and the ICG President award 2025 by the International Commission on Glass. He has delivered some of most celebrated award lectures on glass: Willian E.S. Turner Memorial Lecture (SGT CCentenary, UK), Alfred Cooper Award Lecture (GOMD, USA); Samuel Scholes Memorial Lecture (Alfred University, USA), Frontiers of Glass Science Lecture (ACerS), Guru-Chela Lecture (GOMD-ACerS), the ICG´s President Lecture (ICG), and the USP Lecture.

Professor Zanotto has been an Editor of the *Journal of Non-Crystalline Solids* for 15 years, and of *Materials Research* for 13 years (founding editor, 1998), and an Advisory Board Member of the International Materials Reviews (UK)--associate editor--, Materials Research (Ibero-American), Materials (Switzerland), Discover Applied Sciences (UK), International Journal of Applied Glass Science (USA), Bulletin de la Sociedad Espanola de Ceramica y Vidrio (Spain), Papers in Physics (Argentine), Iranian J. Materials Science and Technology (Iran), J. Mat. Research and Technology (Brazil), Journal of Non-Crystalline Solids (Netherlands), and Cerâmica (Brazil).

He has contributed to academia, industry, and society in various executive and advisory positions: co-founder with G. Solórzano of the Brazilian Society for Materials Research (SBPMat) = Brazilian MRS, co-creator of UFSCar´s doctoral program in materials science and engineering 40 years ago (Capes level 7- top in Brazil), former vice-coordinator. He was also the first president of the Scientific Council of the Serrapilheira Institute, Advisor at IMPA, Rio de Janeiro, the top Mathematics Institute in the country, Adjunct Coordinator of the Scientific Board of FAPESP for 10 years (1995-2005), member of the engineering committee of CNPq, past-chairman of the Crystallization Committee of the ICG, and past chair of the GOMD - American Ceramic Society. Currently he is an Emeritus Counselor of the Brazilian Ceramic Association, President of the Board of Trustees of the High Technology Park (ParqTec) São Carlos, Brazilian representative at the council of IGC, ICF and Funglass, and Vice-President of the ICG.

Contents

Biosketch

Edgar Dutra Zanotto (EDZ) is a Senior Professor of Materials Science and Engineering at the Federal University of São Carlos (UFSCar) and Director of CeRTEV, the Center for Research, Technology and Education in Vitreous Materials. He holds degrees in Materials Engineering (B.Sc.), Applied Physics (M.Sc.), and Glass Technology (Ph.D.) and has been active in teaching and research since 15 December 1976.

His research combines fundamental glass science with technological development. The work of his team and collaborators addresses dynamic processes in supercooled liquids and glasses—including viscous flow, diffusion, structural relaxation, liquid-liquid phase separation, crystal nucleation and growth, overall crystallization, glass-forming ability, glass stability, and sintering—as well as the structure and properties of glasses and glass-ceramics. More recently, the team has used molecular-dynamics simulations to understand glassy dynamics, and machine-learning methods to predict properties and design glasses with desired combinations of performance.

EDZ has coordinated approximately 100 public research projects and about 35 projects in partnership with companies in Brazil, France, the United States, Liechtenstein, Japan, and Turkey. These activities have produced many scientific publications, patents, industrial know-how, improved commercial materials, and six spin-off companies founded by former students.

Research Output and Scientometric Indicators

Research output	Approximately 450 scientific articles (100 in the previous five years), 25 book chapters, 5 prefaces or forewords for other authors, 3 books, 26 Brazilian patents, and 10 patents in other countries.
Publication quality	Scopus-SciVal reports that 73% of papers published during the previous 10 years appeared in the top journals in the glass field by SNIP.
H-index	80 (Google Scholar), 72 (ResearchGate), 65 (Semantic Scholar), and 65 (Scopus).
Field-Weighted Citation Impact	Average FWCI during the previous 10 years ranged from 1.3 for last-author papers to 2.2 for first-author papers = approximately 30% to 120% above the corresponding world averages for publications of similar age and subject.
AD Scientific Index and Research Gate	Ranked 2nd in Materials Science and Engineering in Brazil and 4th in Latin America. Research Interest Score is higher than 99% of ResearchGate members.
Elsevier–Stanford ranking (2025)	30th among all scientists in all the hard and medical sciences in Brazil, and 384th worldwide in Applied Physics/Materials.
Leadership index	93%—the percentage of papers on which he is the senior author, as evaluated by the H-index-based measure.
Scopus keyword rankings	Between 1st and 5th among the most prolific researchers worldwide for combinations including glass* and nucleation, glass* and crystallization, and glass-ceramic*.

Patents ranking	He ranks 7th among individuals by number of patents granted in Brazil. First at UFSCar.
LLM-based assessments	ChatGPT 5 and other large language models frequently list him among the most influential contemporary glass scientists.

Selected Impact Indicators

- Approximately 40 former students and postdoctoral researchers became professors or glass researchers—roughly one-quarter of the Brazilian workforce in this field.
- More than 400 conference presentations, including approximately 170 invited lectures and over 60 plenary or keynote talks, plus about 1,000 co-authored presentations by students and collaborators.
- Chair or co-chair of approximately 20 workshops and conferences, including six major international glass congresses, and scientific committee service for approximately 50 others.
- 65 science and technology awards and distinctions.
- Four articles featured on journal covers: Pesquisa FAPESP (2002), Advanced Engineering Materials (2007), ACerS Bulletin (2010), and Materials Research Bulletin (2017).
- Elsevier statistics reported four papers among the 10 most downloaded articles in the Journal of Non-Crystalline Solids; glass and glass-ceramic definition papers became among the journal's most downloaded papers during a significant part of their lifetime.

Online Profiles and Full Publication Records

CeRTEV
LaMaV
CNPq Lattes CV
Google Scholar
ResearchGate contributions
ResearchGate research
Semantic Scholar
Exaly
AD Scientific Index 2022 profile
Pesquisa FAPESP profile

Education and Academic Appointments

- **1976:** B.Sc. in Materials Engineering, Federal University of São Carlos (UFSCar). Because materials engineers were scarce in Brazil at the time he was hired as an assistant professor at UFSCar.
- **1978:** M.Sc. in Applied Physics, Institute of Physics and Chemistry, University of São Paulo (USP), São Carlos; supervisor: Aldo Craievich. The degree was completed while he was already teaching at UFSCar.
- **1982:** Ph.D. in Glass Technology, University of Sheffield, England; supervisor: Prof. Peter F. James.
- **1987–1988:** Visiting Assistant Professor / Fulbright Fellow, Department of Materials Engineering, University of Arizona, Tucson, USA; hosts: Profs. Michael C. Weinberg and Donald R. Uhlmann.
- **1992–1993:** Specialization course and tesina on polymer crystallization, International School of Advanced Studies in Polymer Science, University of Ferrara, Italy.
- **1993:** Appointed Full Professor of Materials Engineering at UFSCar following a national public examination.
- **2005:** Sabbatical as a visiting scientist with Leon Glebov's group, College of Optics and Photonics (CREOL), University of Central Florida, Orlando, USA.
- **2022:** Visiting (Excellence Chair) Professor, Université Libre de Bruxelles, Belgium; host: Prof Stéphane Godet.
- **Current:** Senior Professor of Materials Science and Engineering at UFSCar, and Visiting (High-Level Talent) Professor at Wuhan University of Technology (WUT), China; host: Prof. Jihong Zhang.

Current Leadership and Executive Positions

- Senior (Emeritus) Professor of Materials Science and Engineering, Department of Materials Engineering (DEMa), UFSCar; member of the faculty since 1976 and currently teaching at the postgraduate level.
- Director of FAPESP's CEPID Center for Research, Technology and Education in Vitreous Materials (CeRTEV) since 2013. CeRTEV has a team of 15 professors (9 PIs) and approximately 70 research students and postdoctoral researchers, making it one of the five largest academic glass-research teams worldwide.
- Visiting Professor (High-Level Talent), Wuhan University of Technology (WUT), China; the **E**dgar **Z**anotto **G**lobal **L**aboratory of **A**dvanced **D**isordered Materials (**EZ-GLAD**) was created at WUT in 2026.
- Vice-President of the International Commission on Glass (ICG).
- President of the Board of Trustees of the São Carlos High Technology Park (ParqTec), where he has served since its foundation in 1984 and fostered the creation of approximately 200 spin-off companies.
- Creator and Board President of the EduSCar initiative.
- Current supervision: five diploma students, two M.Sc. students, three Ph.D. students, and six postdoctoral researchers.

Major Research Discoveries and Achievements

For nearly five decades, Prof. Zanotto's team has investigated the structure and dynamic processes of glasses and their parent supercooled liquids while balancing fundamental science with engineering and technological development. The strategy combines critical review of prior literature and patents, careful planning, modeling and simulation, theoretical calculations and targeted experiments. The detailed narrative below consolidates the research-discovery sections and hihlights some of their unique findings.

PART I: FUNDAMENTALS OF GLASS SCIENCE

1. Crystal Nucleation in Supercooled Liquids and Glasses

- **Surface vs. Volume Nucleation:** Heterogeneous surface nucleation predominates in the vast majority of oxide glasses, because free surfaces, cracks, solid impurities and other pre-existing defects lower the energy barrier to forming a stable nucleus relative to the bulk interior. We have shown that experimentally verifiable homogeneous volume nucleation is exceptional, occurring strictly under deep supercooling conditions where the reduced glass transition temperature T_{gr}=Tg/T_{liq}<0.6 (K/K). At such deep supercoolings, the thermodynamic driving force for crystallization becomes large enough to overcome the nucleation barrier even in the defect-free interior, so homogeneous nucleation only becomes visible in glasses whose composition allows them to be supercooled that deeply without crystallizing first at the surface.
- **A density-mismatch criterion, companion to T_{gr}:** Independent of the T_{gr}<0.6 threshold above, a second, complementary screening criterion has emerged from comparing the mass density of a glass to that of its isochemical crystal: glasses capable of measurable homogeneous nucleation typically show a density difference from their crystal of less than about 8%, whereas glasses that only ever nucleate heterogeneously can show density differences reaching as high as 30%. Hence, density is a simple macroscopic proxy for the same short- and intermediate-range structural similarity between glass and crystal that underlies the T_{gr} criterion — it can be measured far more easily than a full structural comparison, which makes it a practical first screen, though matching densities alone does not guarantee a detectable homogeneous nucleation rate; it is a necessary supporting condition rather than a sufficient one.
- **Surface Nucleation site density and kinetics:** Because surface nucleation dominates in practice, quantifying it is a distinct methodological problem from quantifying bulk nucleation. Our numerous counting protocols estimate the areal density of active surface sites by counting crystals that appear on sectioned or fractured samples after controlled heat treatment. These active sites are not spread uniformly over the surface; they are concentrated at scratches, and other pre-existing defects, so two samples of the same glass with different surface histories (as-

formed versus polished, for example) can show very different nucleation densities. Surface crystallization kinetics — both the density of active sites and the velocity of the growth front moving in from the surface — can differ substantially from bulk nucleation-and-growth behavior in the same glass. This matters practically because surface-initiated devitrification, not bulk nucleation, is the failure mode that limits processing windows for most commercial glass articles and glass-ceramic precursors, so bulk kinetic data alone cannot be used to predict it.

- **Validity of Classical Nucleation Theory (CNT):** Classical Nucleation Theory remains a fundamentally robust theoretical framework, but only when its four atomistic input parameters — interfacial energy (γ) between nucleus and melt, thermodynamic driving force (ΔG) for crystallization, effective transport diffusivity (D_{eff}) controlling how fast atoms can rearrange into the nucleus, and nucleation time lag (τ) before steady-state nucleation is reached — are measured or estimated realistically for the actual temperature and composition in question, rather than assumed to be temperature-independent constants borrowed from simplified textbook treatments. When these four quantities are supplied correctly, CNT predictions match measured nucleation rates well even deep into the supercooled regime. Most reported "failures" of CNT in the literature trace back to using oversimplified, constant values for one or more of these parameters rather than to a flaw in the theory itself. Our extensive MD simulations on different materials showed this outcome.
- **The historical scale of the original discrepancy:** It is worth stating plainly how large the original gap between CNT and experiment actually was (before MD simulations), because it explains why so much subsequent effort went into refining the theory rather than discarding it. Early tests that assumed the activation barrier for atomic attachment at the nucleus interface was equal to that for viscous flow, and that used a single fitted, temperature-independent interfacial energy, produced a discrepancy of 30 to 55 orders of magnitude between predicted and measured nucleation rates — likely the largest quantitative gap between theory and experiment ever reported in condensed matter physics and materials science. Replacing the viscosity-based assumption with directly measured nucleation induction times narrowed the gap somewhat but still left large discrepancies in both magnitude and temperature dependence, with a pronounced break in behavior below the temperature of maximum nucleation rate. Only allowing the interfacial energy to depend on nucleus size (via a Tolman-type correction, introducing a second fitted parameter alongside the size-independent surface energy) brought theory and experiment into close agreement — but it is important to note that in every such fit, neither the Tolman parameter nor the resulting size-dependent interfacial energy could be determined independently; both were obtained by forcing the theoretical and experimental maxima to coincide. This is a genuine caveat: even the versions of CNT that fit the data best remain calibrated against that same data with two free parameters, rather than predicting nucleation rates from independently measured inputs.
- **Molecular-dynamics validation across diverse systems:** Since 2018, molecular dynamics simulations — in which every CNT input parameter, including the diffusivity and size-dependent interfacial energy, is computed independently rather than fitted — have been used to test CNT directly for a deliberately diverse set of systems: the semiconductors BaS, ZnSe, and Ge, the metals Ni and Al, water (ice nucleation), and a metallic alloy. In every one of these chemically and structurally distinct systems, CNT's predicted nucleation rates and their temperature dependence agreed rather well with the values computed directly from the simulations (and with experimental data for some systems), providing independent, non-fitted support for the theory that complements the experimental parameter-refinement work above.
- **Low-temperature relaxation coupling:** Apparent low-temperature "breakdowns" of CNT near or below Tg do not reflect a real failure of nucleation theory; they stem from applying equilibrium-liquid assumptions to a non-equilibrium, structurally relaxing glass matrix. Below Tg the glass has not yet reached the structural (density, enthalpy) state that its temperature would dictate at equilibrium, and it continues to relax toward that state over time. Because nucleation rate depends on the instantaneous local structure, and that structure is itself still evolving, nucleation and structural relaxation proceed concurrently below Tg rather than nucleation occurring in an already-equilibrated matrix. As a direct practical consequence, measured nucleation rates in a sub-Tg glass are not a single fixed number for a given temperature — they change, often by orders of magnitude, simply as a function of how long the glass has already been held at that temperature before nucleation is assessed.
- **Transport scale invariance:** The effective transport diffusivity that governs the formation of a nanometer-scale critical nucleus (D_{nuc}) closely matches the diffusivity that separately controls the growth of an already-formed, sub-micrometer crystal (D_{gr}), i. e., $D_{nuc} \approx D_{gr}$. This is a nontrivial and practically valuable finding because nucleation and growth are normally measured by completely different experimental methods and are often assumed to be

governed by different atomic-scale mechanisms. Demonstrating that the same effective diffusivity describes both processes means that a single transport parameter, once measured from either nucleation or growth data, can be used to predict the other — considerably simplifying the experimental effort needed to build a full crystallization kinetics picture for a new glass composition.

- **Multistep nucleation pathways:** In multicomponent liquids, the initial atomic clusters that form on the way to nucleation frequently differ in composition or internal structure from the final, stable crystal phase that eventually grows. Energy-landscape modeling — which maps out the full range of possible intermediate structures and their associated free energies, rather than assuming a single direct path from liquid to crystal — demonstrates that nucleation in these systems often follows a multi-step precursor pathway: an initial, easier-to-form cluster appears first and only later transforms into the true stable phase, rather than the stable crystal nucleating directly from the liquid in one step. This has direct consequences for interpreting nucleation kinetics data, since a measured induction time or nucleation rate may actually reflect the formation of a transient precursor rather than the final observed crystal.
- **Kinetic vs. thermodynamic spinodal:** Beyond the classical distinction between nucleation-and-growth (below a barrier) and spinodal decomposition (barrierless, above a stability limit), recent work distinguishes a kinetic spinodal from the classical thermodynamic spinodal. The kinetic spinodal temperature (T_{KS}) marks the temperature at which the system falls out of ergodicity on experimentally accessible timescales — that is, the liquid can no longer explore its full configurational space fast enough to behave as a true equilibrium liquid, regardless of whether the thermodynamic driving force for decomposition has technically been crossed. At and below T_{KS}, crystal nucleation starts before relaxation back to the SCL state. This kinetic boundary sits above the (physically inaccessible) Kauzmann temperature and provides a better-defined, experimentally meaningful limit for how deeply a given liquid can actually be supercooled before nucleation takes over structural relaxation— directly connecting the nucleation kinetics with the aging and Kauzmann-paradox conclusions of Theme 7.

2. Crystal Growth Kinetics & Mechanisms

- **Viscosity-growth decoupling:** Direct comparison of crystal growth rates and viscosity across nine different undercooled glass-forming liquids, spanning a viscosity range from about 10^3 to 10^13 Pa·s, shows that viscosity describes the transport contribution to crystal growth well at low-to-moderate supercoolings and viscosities (below roughly 10^6 Pa·s) in every system tested — the Stokes-Einstein-Eyring (SEE) relation holds essentially from the liquidus down to about 1.15 Tg with no exceptions found. At higher viscosities, however, clear decoupling appears for at least three fragile liquids— diopside, lead metasilicate, and lithium disilicate — while no such decoupling was found for strong, fully polymerized (Q^4-type) network glasses such as silica. This decoupling in fragile liquids is attributed to dynamic heterogeneity: as a fragile liquid is deeply supercooled, its dynamics become increasingly spatially non-uniform, and some regions remain mobile enough to support crystal growth even as the bulk-averaged viscosity rises sharply. The practical consequence is that viscosity data cannot be used to predict the transport part of crystal growth (and nucleation)) in fragile glasses near Tg, though it remains a good predictor for strong glasses; the temperature window from about 1.15 Tg down to roughly 0.80 Tg is identified as the range where this question is least resolved and most in need of further study.
- **Which atomic species actually controls transport:** For supercooled liquid silica specifically, comparing effective diffusion coefficients calculated from crystal growth rates and from viscosity (via the SEE equation) against the independently, directly measured self-diffusion coefficients of silicon and oxygen shows that silicon, not oxygen, is the species that controls the diffusion dynamics relevant to both crystal growth and viscous flow above Tg. This is a specific, falsifiable mechanistic identification, not just a statement that "network-former diffusion controls transport": it identifies which of the two network-forming atoms in silica is rate-limiting, and it is part of why the SEE equation works so well for silica (a strong liquid) across its entire accessible viscosity range, from the melting point down to Tg, in contrast to the fragile liquids discussed above.
- **Direct growth velocity as a transport -probe:** Because growth rate is controlled by the same local, short-range atomic diffusivity relevant to crystallization rather than by bulk viscosity, directly measuring crystal growth rates as a function of temperature provides a far more accurate probe of the low-temperature mass transport actually relevant to nucleation and growth than does viscosity, which reflects a different, larger length-scale relaxation process. In practice this means growth-rate measurements, rather than viscosity data, should provide the preferred

experimental proxy for D_{nuc} whenever the goal is to understand or predict crystallization behavior specifically, reserving viscosity measurements for questions about bulk flow and forming behavior.

- **Stoichiometric and impurity sensitivity:** Impurities and even small deviations from the exact stoichiometric composition of a crystalline phase — deviations well within the range that might occur unintentionally from batching errors, volatilization during melting, or contamination — can change which phase precipitates first, alter its growth (and nucleation) kinetics substantially, and change the crystal morphology (for example, from compact equiaxed crystals to elongated dendritic ones). This means that kinetic parameters, growth-mechanism assignments, and glass-forming-ability conclusions derived from a carefully prepared, exactly stoichiometric laboratory composition should not automatically be assumed to hold for nominally the same glass produced under normal batching tolerances.

3. Crystallization Kinetics & Phase Transformations

- **JMAK Model applicability & limits:** The Johnson-Mehl-Avrami-Kolmogorov (JMAK) model, which describes the overall fraction of material transformed as a function of time using two fitted parameters (a rate constant and an exponent *n*), accurately fits the overall shape of many crystallization curves and is therefore widely used as a first-pass empirical description. However, physically interpreting the fitted exponent *n* as revealing the underlying nucleation and growth mechanism — a common practice in the literature — becomes invalid whenever nucleation is not randomly distributed in space or time, growth is anisotropic (faster in one crystallographic direction than another), or several crystalline phases form and impinge on one another simultaneously. In these common real-world situations the JMAK exponent can still be fitted mathematically, but it no longer corresponds to any of the textbook mechanistic interpretations (e.g., "*n*=3 means three-dimensional growth from a fixed number of nuclei"), so such interpretations should be treated with caution unless independently verified by microscopy.
- **Dynamic compositional evolution:** As metastable precursor phases precipitate during the early stages of crystallization, they selectively remove certain chemical components from the surrounding glass, which continuously shifts the composition of the remaining (residual) glass matrix over the course of the heat treatment. Because the thermodynamic driving force for further crystallization depends on the composition of the liquid or glass from which the next phase must nucleate, this compositional drift dynamically changes the driving force — and potentially even which phase is thermodynamically favored — as crystallization proceeds. Treating a multi-stage crystallization sequence as though it occurred in a fixed-composition matrix throughout therefore misses this feedback and can misidentify the sequence of phases expected to form.
- **"Mutant" crystals and the courtyard effect:** Even in a glass batched to an exactly stoichiometric composition, the crystals that actually precipitate in the earliest stages of crystallization are frequently not stoichiometric themselves: chemical analysis of primary crystals shows they can be enriched or depleted in specific components relative to the ideal crystal formula, forming transient "mutant" solid-solution crystals whose composition changes systematically as they grow (for example, becoming progressively closer to the ideal stoichiometry as crystal size increases, which allows the true critical-nucleus composition to be estimated by extrapolating composition back to zero size). Because each growing primary crystal draws its off-stoichiometric composition from the immediately surrounding glass, it leaves behind a compositionally depleted diffusion zone — a "courtyard" or "backyard" — in its vicinity. Secondary nucleation and growth are measurably suppressed within this depleted zone, meaning the spatial distribution of crystals in a partially crystallized glass is not simply a record of where nucleation was statistically likely, but is actively reshaped by the compositional footprint that earlier-formed crystals leave on their neighborhood. This is a distinct mechanism from the general compositional-drift effect above: it operates locally, around each individual crystal, rather than uniformly across the whole residual glass.
- **Ostwald's rule of stages, reconsidered:** The classical rule of stages holds that the first phase to crystallize from a supercooled liquid is often not the thermodynamically most stable phase available, but rather the metastable phase whose structure and free energy are closest to those of the parent liquid, because that phase typically has the lowest nucleation barrier even though it is not the final equilibrium product. This behavior is confirmed as a useful organizing heuristic in oxide glass-formers, but its scope is narrower than originally proposed: whether a metastable or a directly stable phase nucleates first depends on the relative nucleation barriers of each candidate phase for the specific system in question, not on a fixed universal hierarchy of stages that every glass must pass through. In one directly studied case, lithium disilicate (LS2) glass, a metastable lithium metasilicate (LS) phase was shown to coexist

with the stable LS2 phase for well over a hundred hours of heat treatment before disappearing — but careful kinetic analysis demonstrated that its presence did not actually alter the nucleation pathway or measured nucleation rate of the stable LS2 phase, so the rule should be treated as a helpful first expectation to test experimentally for a given composition, not as a law that predicts the crystallization sequence in advance, nor as an automatic explanation for anomalous nucleation-rate data.

- **PTR glass photothermal mechanism:** Photo-thermo-refractive (PTR) glass undergoes a specialized, two-step crystallization process distinct from ordinary bulk thermal devitrification. First, exposure to ultraviolet light photo-reduces silver ions dissolved in the glass to metallic silver atoms, which cluster together to form nanometer-scale metallic silver particles only in the regions that were illuminated. On subsequent thermal development (a controlled heat treatment below the bulk crystallization temperature), these silver particles act as heterogeneous nucleation sites specifically for sodium fluoride (NaF), so NaF nanocrystals grow only where the silver precursors were formed. Because the local refractive index depends on whether NaF nanocrystals have precipitated, this UV-plus-heat sequence writes a permanent, spatially localized refractive-index pattern into the glass, which is the physical basis for volume Bragg gratings used in laser and optical-filtering applications.

4. Glass Formation, Glass Stability & Critical Cooling Rates

- **Distinction between GFA and GS:** Glass-Forming Ability (GFA) describes how resistant a liquid is to crystallizing while being cooled down from the melt — essentially, how fast you must cool it to obtain a glass at all. Glass Stability (GS) describes something different: how resistant an already-formed glass is to crystallizing when it is subsequently reheated, for example during a forming or annealing step. These are governed by different kinetic regimes (cooling through the high-temperature growth-dominated range versus reheating through the near-Tg nucleation-dominated range) and are not interchangeable, even though a glass that forms easily on cooling often also happens to be reasonably stable on reheating; the two properties should always be measured and reported separately. A further refinement sharpens this distinction mechanistically: for most real compositions and laboratory or industrial practice, GFA is governed specifically by heterogeneous nucleation, which is the practically dominant but least controllable mechanism (since it depends on melt cleanliness, container surfaces, and processing history), whereas GS can depend on either homogeneous or heterogeneous nucleation depending on the composition and thermal history involved. Both properties, in turn, also depend on the crystal growth rate, so a composition cannot be fully characterized for either GFA or GS from nucleation behavior alone. But they are related...
- **Determinants of Critical Cooling Rate (R_c):** The critical cooling rate is the minimum cooling rate required to avoid detectable crystallization while quenching a melt into a glass. Rc is dictated by the total integrated overlap between the nucleation-rate curve and the growth-rate curve across the entire temperature range the melt passes through on its way from the liquidus down to Tg — not by any single scalar descriptor such as Tg itself, liquid fragility, or a single characteristic temperature difference read off a DSC trace. Two glasses with identical Tg and fragility can have very different R_c values if their nucleation and growth curves overlap to different extents, which is why single-parameter shortcuts for predicting Rc are inherently limited and why the full nucleation-and-growth curves, where available, remain the most reliable basis for predicting or explaining glass-forming ability.
- **Structural mismatch in Albite & B_2O_3:** The extraordinarily high glass-forming ability of the two most stable oxide glasses: albite ($NaAlSi_3O_8$) and of B_2O_3 — both of which are extremelly difficult to crystallize even at slow cooling rates or long treatment times— is driven principally by severe structural dissimilarity between the supercooled melt and its corresponding equilibrium crystal structure, rather than by unusually slow atomic mobility. Because the liquid's local atomic arrangement is so different from the crystal's, a large amount of structural reorganization is required to build even a small stable nucleus, which imposes a very high nucleation barrier regardless of how mobile the atoms are. This distinguishes these two systems from glasses whose good glass-forming ability comes mainly from high viscosity or sluggish diffusion instead.
- **Evaluation of stability parameters:** Numerous empirical parameters have been proposed over the decades to predict glass stability from a handful of characteristic temperatures read off a single DSC scan (onset of crystallization Tx, peak crystallization temperature Tc, glass transition Tg, and so on). A systematic comparative analysis across several tested oxide-glass datasets found that the Weinberg and Hruby parameters provided the highest predictive accuracy among the criteria examined, and that parameters built from the crystallization peak

temperature (Tc) consistently outperformed otherwise similar parameters built from the onset temperature (Tx), likely because Tx is more sensitive to instrumental sensitivity and baseline-drawing choices than the better-defined peak position. This ranking should be read as dataset-specific evidence in favor of the Weinberg and Hruby parameters rather than as proof of universal superiority, since no single stability parameter has been shown to generalize reliably across every glass-forming family, and any parameter should ideally be validated against real crystallization data before being trusted for a new composition.

- **Viscosity-liquidus predictors:** JeZCA and JeZiCA (**Je**anini-**Z**anotto-**C**assar-**A**ndreeta) are viscosity-liquidus predictors of the general form $\eta(T_{liq})/T_{liq}^2$, combining the melt's viscosity at the liquidus temperature with the liquidus temperature itself into a single screening metric. Because both quantities can, in principle, be estimated computationally or from limited experimental data before a bulk glass sample even exists, these predictors allow candidate compositions to be screened for likely glass-forming ability before committing to full-scale melting and quenching trials. They are specifically designed to remain useful in the realistic situation where heterogeneous (surface) nucleation dominates, which is where several older predictors, built on assumptions more appropriate to homogeneous nucleation, tend to perform poorly.
- **Non-Universality of predictors:** No single predictor of glass-forming ability or glass stability is universal across all compositions and processing conditions. The nucleation mechanism operating (surface versus bulk), the physical dimensions of the sample being quenched (which affect cooling rate and the available nucleation-site area), the crystal fraction considered acceptable for a material still to be called "glass," and the specific processing conditions used must all be explicitly specified whenever a critical cooling rate or a glass-forming-ability ranking is reported, since changing any one of these can change the answer even for the same underlying composition.

5. Glass Sintering & Sinter-Crystallization Dynamics

- **Competition between sintering and susrface devitrification:** When a glass powder is heated to consolidate it into a dense body, two processes compete directly for the same thermal budget: viscous-flow densification, in which surface tension drives glass particles to flow together and eliminate porosity, and surface-driven crystallization, in which crystals nucleate and grow at particle surfaces. If crystallization occurs before densification is complete, the newly formed crystalline phase locally increases the effective rigidity of the matrix — glass flows, but a crystal does not — which pins particle necks in place and arrests further pore elimination, leaving a porous, incompletely densified body. Successful sintering of a crystallizable glass powder therefore requires the processing schedule to complete densification before crystallization becomes extensive, rather than simply heating as fast as possible.
- **Cluster & polydisperse sintering models:** Classical sintering theory typically assumes an idealized packing of identical, monodisperse spheres, but real glass powders always contain a distribution of particle sizes and irregular shapes. In addition to accounting for simultaneous surface crystallization, the Prado-Zanotto "Clusters" glass sintering model instead explicitly accounts for the actual particle size distribution, the geometric packing arrangement, and particle shape effects, and as a result predicts densification behavior far more accurately than the traditional monodisperse-sphere approximation, particularly for the polydisperse, irregularly shaped powders typical of ground industrial cullet or milled laboratory glass.
- **Thermal profile optimization:** Because densification and crystallization compete as described above, the processing schedule can be tuned to favor densification: using higher heating rates reduces the time spent at intermediate temperatures where surface crystallization is most active, while using smaller particles increases the surface-tension-driven densification rate (which scales inversely with particle size) relative to the roughly size-independent surface nucleation rate. Combining an appropriately fast heating rate with a fine particle size opens a practical thermal processing window in which full densification can be completed before extensive matrix crystallization sets in — though the specific optimal combination is composition-dependent and must be determined for each glass system.
- **Realistic densification predictions:** Because they account for the true particle size distribution and packing geometry rather than an idealized monodisperse arrangement, our polydisperse and cluster-based sintering models predict shrinkage and densification curves that match experimentally measured behavior more closely than the classical monodisperse-sphere models, giving process engineers a more reliable tool for designing sintering schedules for real, non-ideal powders.

6. Liquid-Liquid Phase Separation (LLPS)

- **Non-Essential nature for nucleation:** Liquid-liquid phase separation — the splitting of a single homogeneous melt into two coexisting amorphous phases of different composition — is neither a mandatory prerequisite for crystal nucleation to occur, nor does it universally catalyze nucleation when it does occur. Many glasses crystallize readily without ever phase separating, and many phase-separated glasses show no enhancement of nucleation relative to what would be expected from their local compositions alone, so LLPS and crystal nucleation must be evaluated as two logically distinct phenomena that happen to co-occur in some, but not all, systems.
- **Compositional driving mechanism:** Where LLPS does promote crystal nucleation, the most defensible mechanism is compositional rather than interfacial: phase separation partitions certain chemical components preferentially into one of the two amorphous phases, and if that partitioning happens to shift the composition of one phase closer to the stoichiometry of an eventual crystal phase, the thermodynamic driving force for that crystal to nucleate within the enriched phase increases substantially — simply because less compositional rearrangement is now needed to build the crystal. This is a purely compositional effect and does not require the interface between the two amorphous phases to play any special catalytic role.
- **The comprehensive $BaO\text{-}SiO_2$ case study underlying this conclusion:** This compositional mechanism was established through a directly comparative experiment: barium disilicate crystal nucleation kinetics were tracked by optical microscopy in a $BaO\text{-}SiO_2$ glass composition lying inside the liquid-liquid miscibility gap (27–29 mol% BaO) against a composition just outside it (33.3 mol% BaO, free of LLPS), with the phase separation itself independently monitored via small-angle X-ray scattering and transmission electron microscopy. In the non-phase-separating composition, the nucleation rate was constant at any given temperature above Tg, as classical theory would predict. In the phase-separating composition, by contrast, the nucleation rate increased over time and approached a constant value that was essentially identical across starting compositions with widely different overall BaO content — and that constant value was reached at exactly the time the amorphous barium-rich phase itself reached its own equilibrium composition, as tracked by the integrated SAXS intensity. Critically, there was no correlation between nucleation rate and either the total interfacial surface area or the number of amorphous droplets present, only with the composition of the barium-rich phase — direct, quantitative evidence ruling out an interfacial-catalysis explanation in favor of the compositional one, and the specific case study behind the two more general conclusions on this theme.
- **Precursor functionality:** In specific, well-studied systems — including TiO_2-bearing glasses, certain borosilicate compositions, and PTR glass — phase separation can serve as an important structural precursor step that precedes and facilitates nanocrystal formation, effectively pre-organizing the local composition and structure before crystallization proper begins. This precursor role, however, is system-specific rather than general: it has been demonstrated clearly in these particular chemistries and should not be assumed to apply automatically to every phase-separating oxide glass.
- **Morphological impact:** The morphology that phase separation produces — isolated spherical droplets of a minority phase dispersed in a matrix, versus a bicontinuous, interconnected network of both phases — has a direct and measurable impact on the glass's mechanical and optical properties, since droplet and interconnected morphologies scatter light, transmit stress?, and permit selective leaching or dissolution in very different ways. Controlling which morphology forms (typically via composition and heat-treatment schedule) is therefore itself a materials-design lever, independent of the compositional and interfacial questions discussed above.

7. Structural Relaxation, Aging & Glass Thermodynamics

- **Unified definition of the glassy state:** Glass is defined as a non-equilibrium, non-crystalline state of matter that exhibits a glass transition on cooling or heating. Its atomic-scale structure closely resembles that of its parent supercooled liquid at the moment it was frozen-in, and — because it is a non-equilibrium state — it continuously relaxes toward the structure that the corresponding supercooled liquid would have at that same temperature if given enough time. Because a supercooled liquid itself is thermodynamically metastable with respect to the crystal, the glass's ultimate thermodynamic fate, given unlimited time, is crystallization rather than indefinite persistence as an amorphous state — though in practice this timescale is astronomically long at room temperature for most oxide glasses.

- **Property drift & sample history:** Because sub-Tg structural relaxation is a continuous, time-dependent process rather than something that stops once a glass cools below Tg, physical properties that depend on the glass's structural state — density, refractive index, enthalpy, and crystallization kinetics among them — drift measurably over time even at constant temperature. This makes a sample's complete thermal history (how it was cooled, how long and at what temperature it has been held since) an essential experimental variable that must be reported alongside any measured property, since two nominally identical glasses with different thermal histories can show meaningfully different property values.
- **Relaxation-viscosity decoupling:** Structural relaxation rates are not uniquely determined by the glass's equilibrium shear viscosity at that temperature, even though a simple Maxwell-model estimate (relaxation time equal to viscosity divided by an elastic modulus) is often used as a first approximation. In practice, Maxwell relaxation times calculated this way generally provide only a lower bound on the true structural relaxation time, meaning actual relaxation is typically slower than the simple viscosity-based estimate would suggest, reflecting the fact that different property relaxations (structural, enthalpic, volumetric) can proceed at somewhat different rates even in the same glass.
- **Kinetic asymmetrical aging:** When a glass held at one temperature is suddenly shifted to a new temperature (a temperature "jump") and then monitored as it relaxes toward the new equilibrium, the kinetics of that relaxation are not symmetric with respect to the direction of the jump. A down-jump (sudden cooling) produces relaxation that follows stretched-exponential kinetics, meaning the process appears to slow down over time relative to a simple exponential decay, typically attributed to a broadening distribution of relaxation times as the glass structurally evolves. A sufficiently large up-jump (sudden heating), by contrast, can produce compressed-exponential behavior, where relaxation appears to accelerate over time. This asymmetry reveals that the glass's relaxation dynamics themselves depend on the direction and history of the temperature change, not just on the starting and ending temperatures.
- **Sub-Tg nucleation dynamics:** Because nucleation and structural relaxation proceed concurrently below Tg (as established in Theme 1), nucleation in a sub-Tg glass may begin well before the glass has finished relaxing toward its new equilibrium structure at that temperature. As a direct consequence, any experiment designed to measure a "steady-state" nucleation rate at a given sub-Tg temperature must independently verify both that nucleation has reached a genuine steady state and that structural relaxation is not still significantly evolving during the measurement window — otherwise the reported nucleation rate may actually be an average over a period during which the underlying structure, and therefore the true nucleation rate, was still changing.
- **Rejection of the Kauzmann Paradox:** The Kauzmann paradox refers to the apparent problem that extrapolating a supercooled liquid's measured entropy below Tg predicts it would fall below the entropy of the corresponding crystal at some finite temperature T_K — an "entropy catastrophe" that would be thermodynamically absurd. Extensive re-evaluation from three distinct perspectives confirms there is no physical or experimental basis for this finite Kauzmann temperature: the apparent paradox arises from improperly extrapolating equilibrium-liquid entropy using a functional form that does not account for the fact that the liquid stops being able to relax fast enough to remain in equilibrium well before T_K would ever be reached. Even setting that objection aside and taking the naive extrapolation at face value, the kinetic-spinodal boundary discussed in Theme 1, together with incipient crystallization, would physically intervene and halt the supercooled liquid's descent long before the system could ever actually reach T_K — making the paradox physically moot in addition to being mathematically unjustified as an extrapolation.
- **Resolution of the medieval glass myth:** A popular myth holds that medieval cathedral window glass is visibly thicker at the bottom because glass is a liquid that has slowly flowed downward under gravity over the centuries. The original 1998 study that debunked this myth used a GeO2 glass as an experimental proxy for soda-lime-silica window glass, chosen because the two have similar glass transition temperatures, and calculated its characteristic structural relaxation time at room temperature to be longer than the age of the universe — a deliberately vivid comparator that made the numerical argument immediately intuitive and is a large part of why the study received substantial international media coverage well beyond the specialist glass-science literature. Measured room-temperature glass viscosity is so high (η>10^20 Pa·s) that any gravity-driven flow would be many, many orders of magnitude too slow to produce a visible effect even over a thousand years or more — the numbers rule out the flow explanation entirely. The actual, well-documented cause of the thickness variation is that historical crown-glass and cylinder-glass manufacturing methods inherently produced panes of uneven thickness, and craftsmen commonly

installed the thicker edge at the bottom for structural stability; the unevenness is therefore an artifact of how the glass was made, not of how it has behaved since installation. The same research line's modern definition of the glassy state (see the opening bullet of this theme) became, within months of publication, the most downloaded article in the history of the Journal of Non-Crystalline Solids, a striking indicator of how much unresolved conceptual interest the basic question "what is glass?" continues to attract even after a century of study.

8. Viscous Flow, Viscosity & Transport Kinetics

- **Breakdown of hydrodynamic models:** The Stokes-Einstein relation (linking a diffusing particle's size to its diffusivity and the medium's viscosity) and the closely related Eyring relation both assume that diffusion and viscous flow are controlled by the same underlying molecular rearrangement process, which holds reasonably well at high temperature. Under deep supercooling, roughly below 1.15 times Tg, this assumption breaks down: atomic diffusion and crystal growth rates become measurably faster than bulk shear viscosity alone would predict, because the local atomic hops needed for diffusion or for a single atom to attach to a growing crystal require much less cooperative, large-scale molecular motion than the flow events that dominate bulk viscosity. This decoupling is why viscosity cannot be used as a direct stand-in for diffusivity or growth rate once a melt is substantially supercooled (near and below 1.15 Tg).
- **Ionic vs. structural transport disconnect:** In glasses containing mobile alkali or alkaline-earth ions, fast ionic conductivity (for example, sodium ion mobility) reflects those ions hopping through an essentially fixed silicate or borate network via an "uncoupled" transport mechanism that does not require the surrounding network to rearrange. This fast ionic transport must not be confused with, or used as a proxy for, the much slower cooperative structural diffusion or viscous flow that is instead governed by the mobility of the network-forming species themselves (silicon and oxygen), since it is the network formers, not the mobile modifier ions, that must rearrange for the glass to structurally relax or flow. Conductivity measurements and viscosity measurements therefore probe two physically distinct transport processes that can have very different temperature dependences in the same glass.
- **Liquidus viscosity criterion:** Combining the melt's viscosity measured at its liquidus temperature with the liquidus temperature itself (T_{liq}), typically in a combined metric such as JeZiCA = $\eta(T_{liq})/T_{liq}^2$, provides an effective and experimentally (or computationaly) accessible criterion for predicting a composition's glass-forming capability. High liquidus viscosity slows the atomic rearrangement needed for crystals to grow even if nuclei have already formed, while a low liquidus temperature means the melt spends less absolute time in the high-mobility, growth-favorable temperature range on its way down to Tg; both factors independently favor successful glass formation, which is why combining them into a single metric outperforms using either quantity alone.
- **Workability classification framework:** Deriving the full viscosity-temperature profile of a melt, rather than just a handful of characteristic points, enables melts to be classified along a "workability" spectrum — described qualitatively as "ultra-long," "long," "intermediate," or "short" — based on how gradually or abruptly viscosity changes with temperature over the practically relevant forming range. A "long" glass changes viscosity gradually with temperature, giving glassworkers or automated forming equipment a wide temperature window in which to shape it, whereas a "short" glass stiffens abruptly over a narrow temperature range, demanding much tighter process control. This classification translates the underlying fragility and viscosity-curve data directly into a practical, industry-relevant descriptor used for process design in forming operations such as pressing, blowing, or drawing.

9. Glass Structure & Short/Medium-Range Order

- **Multi-Length scale structural analysis:** Comparative studies across related glass compositions demonstrate that structural similarity between glass and crystal must be evaluated across multiple length scales simultaneously — short-range order, medium-range order, and dynamic fluctuations — rather than at any single scale in isolation, because two compositions can appear nearly identical in short-range order while differing substantially in medium-range connectivity, or vice versa, and it is often the scale at which they differ that actually explains a difference in their nucleation behavior.
- **Spatial & temporal fluctuations:** Standard structural characterization techniques such as diffraction and spectroscopy report an average signal over a large sample volume, which can conceal rare, spatially localized regions of atypical structure that occupy only a small fraction of the total volume but are disproportionately important for nucleation, since a nucleation event only needs one such favorable region to succeed. Systematically

analyzing these spatial and temporal structural fluctuations — rather than relying solely on bulk-averaged data — has become a major organizing framework for understanding why nucleation rates in nominally homogeneous glasses can still show significant sample-to-sample or region-to-region variability.

- **Sub-Tg structural dynamics:** Well before any clearly crystalline diffraction or spectroscopic signature becomes detectable, sub-Tg structural relaxation already involves subtle, ongoing reorganization: modifier cations redistribute among available sites, and the population of Q^n species (network connectivity) shifts gradually toward whatever local arrangement is thermodynamically favored at that temperature. This means glass structure in the sub-Tg regime must be understood as a dynamically evolving system rather than a static one, with implications for interpreting any structural measurement made on a glass that has not been held at temperature for a very long time.

PART II: TECHNOLOGY AND APPLICATIONS

10. Glass-Ceramics, PTR Glass & BioSilicate

- **Glass-ceramics as an access route to "unobtainable" property combinations:** The defining conceptual argument for glass-ceramics as a materials class, revisited across five decades of this research program, is that controlled crystallization gives access to property combinations that neither a fully glassy nor a fully crystalline (conventionally sintered ceramic) material can achieve on its own — for example, simultaneously high mechanical strength, machinability, and bioactivity, or simultaneously near-zero thermal expansion and high optical transparency. A glass-ceramic's residual glass phase and crystalline phase can each be tuned somewhat independently through composition and heat-treatment schedule, so a property normally in tension with another (bioactivity versus strength, transparency versus toughness, low expansion versus formability) can be decoupled and separately optimized in the two phases rather than compromised in a single-phase material. This framing, rather than any single composition or application, is the unifying idea running through every subsequent conclusion in this theme.
- **Standardized definition:** Glass-ceramics we formally defined as inorganic, non-metallic materials produced by subjecting a precursor glass to controlled crystallization — occurring either internally (bulk nucleation and growth throughout the volume) or at the surface — such that the final material contains at least one crystalline phase embedded within a residual glass matrix, rather than being either fully glassy or fully crystalline. This multi-phase character is what gives glass-ceramics their distinctive combination of properties, since the crystalline and residual glass phases can be independently tuned through composition and heat-treatment schedule to combine, for example, the mechanical strength of a crystal with the moldability of a glass precursor.
- **Processing versatility:** Both monolithic routes, in which a solid glass block or sheet is heat-treated in place to nucleate and grow crystals throughout its volume, and powder sinter-crystallization routes, in which glass powder is simultaneously densified and crystallized (see Theme 5), offer viable production paths to a finished glass-ceramic. Which route is more appropriate for a given application depends on the glass's intrinsic glass-forming ability (can it be cast as a bulk monolith without premature crystallization?) and its surface nucleation propensity (does it crystallize preferentially from the surface, which would favor a powder route with high surface-area-to-volume ratio, or more uniformly, which would favor a monolithic route?).
- **A systematic taxonomy of nucleating agents:** Deliberately inducing internal crystallization at a controlled density, rather than relying on incidental (and less controllable) surface nucleation, generally requires adding a nucleating agent to the parent glass composition. A systematic examination of nucleating agents across many glass-ceramic systems shows they act through several distinct, non-interchangeable mechanisms: some (such as TiO_2 or ZrO_2) work by phase-separating first into a compositionally distinct amorphous droplet phase that then nucleates the target crystal, essentially combining the nucleating-agent role with the LLPS precursor mechanism described in Theme 6; others (such as noble-metal or fluoride additions) provide a heterogeneous nucleation site more directly, closer to the classical picture of a foreign catalytic particle; and still others work by simply lowering the thermodynamic or kinetic barrier to homogeneous nucleation of the desired phase without ever forming a distinct catalytic particle at all. Because these mechanisms are physically distinct, selecting a nucleating agent for a new glass-ceramic composition by analogy to an agent that works well in an unrelated system is unreliable; the mechanism, not just the historical precedent, should guide the choice.

- **PTR Nanocrystallization:** In PTR glass, as detailed mechanistically in Theme 3, ultraviolet exposure creates silver-containing precursor particles in the illuminated regions, and subsequent thermal development produces localized sodium fluoride (NaF) nanocrystals specifically where those precursors formed. Because the presence of these NaF nanocrystals locally changes the refractive index, this process writes a permanent, spatially controlled refractive-index modulation into the glass, which is the technological basis for volume Bragg gratings used to filter, combine, or stabilize laser wavelengths in photonic applications. This is not solely an academic result: this research directly assisted the company OptiGrate in reducing light scattering in its own PTR glass-ceramic product, which is now commercialized worldwide, giving Theme 3 and Theme 10's PTR conclusions a documented industrial outcome rather than only a laboratory demonstration.
- **Large-grain transparency breakthrough:** It is commonly assumed that glass-ceramics must contain nanocrystals well below the wavelength of visible light (typically under 100 nm) to remain optically transparent, since larger crystals would otherwise scatter light strongly. This assumption is not universally true: optical transparency can also be achieved with much larger, micrometer-scale crystals, provided the refractive index of the crystalline phase is closely matched to that of the residual glass matrix ($\Delta n \approx 0$), since light scattering at an internal interface depends on the refractive index mismatch across it, not on crystal size alone. This large-grain transparency route has been demonstrated in soda-lime-silica glass-ceramic systems, opening a materials-design space that does not require the tight nanocrystal-size control needed by the conventional nanocrystalline-transparency approach. Separately from the large-grain transparency route described above, this research program also holds what is reported as a world record for the most translucent glass-ceramic containing the largest crystallized volume fraction ever achieved, exceeding 97% crystallinity while retaining useful translucency — an extreme point on the crystallinity-versus-transparency spectrum, since transparency ordinarily becomes harder to sustain as crystalline volume fraction rises toward completion. This material was, as of the most recent reporting, under evaluation by na international company, indicating an active industrial evaluation pathway for a composition that pushes the large-grain transparency principle to its practical limit rather than remaining a laboratory curiosity.
- **BioSilicate[R] mechanical-bioactive synergy:** Our BioSilicate[R] demonstrates that fully crystallized glass-ceramics — as opposed to the partially amorphous or amorphous bioactive glasses more typically used in biomedical applications — can simultaneously achieve high mechanical strength and fracture toughness, because full crystallization removes the more brittle, lower-strength residual glass phase that would otherwise limit mechanical performance, while still maintaining strong bioactivity, provided the crystalline phase itself retains favorable dissolution and apatite-forming surface chemistry (see Theme 12). This combination directly challenges the older assumption in the biomaterials field that bioactivity and mechanical robustness necessarily trade off against one another.
- **Transparent ballistic glass-ceramics:** Designing a glass-ceramic for transparent ballistic armor requires co-optimizing two properties that are not automatically compatible: the optical transparency discussed above, which depends on refractive-index matching between crystal and matrix, and dynamic impact resistance, which depends on the crystalline phase's hardness, toughness, and its ability to arrest or deflect cracks under high-strain-rate loading. Because the compositional and microstructural choices that favor one property do not automatically favor the other, achieving both simultaneously is a genuine composition-plus-microstructure co-design problem, not a simple extension of either a transparent glass-ceramic or an opaque armor ceramic considered separately.
- **Benchmarking against commercial products:** Sintered low-expansion Li_2O-Al_2O_3-SiO_2 (LAS) glass-ceramics, produced using the sinter-crystallization routes described in Theme 5, have been directly compared on mechanical hardness and tribological (wear and friction) performance against a commercial cooktop plate made from the same nominal composition family (Buchner, Soares, Soares, Lepienski & Zanotto, Glass Technology — European Journal of Glass Science and Technology Part A, 2013), and found to be competitive with the commercial product. This benchmarking matters because it demonstrates that laboratory-derived sinter-crystallization science does not merely produce academically interesting microstructures — it translates into performance metrics that are directly relevant to an established, mass-market glass-ceramic product category (cooktop panels), closing the loop between fundamental processing science and real-world product performance.
- **The commercialization gap:** A bibliometric analysis of the glass-ceramics patent literature (Montazerian, Singh & Zanotto, American Ceramic Society Bulletin, 2015) found a striking and persistent gap between the volume of published research on new glass-ceramic compositions and the small number of compositions that have ever reached actual commercial production, most of which still trace back to a handful of base systems established decades ago (lithium aluminosilicate cooktops, mica-based machinable ceramics, and a few dental and bioactive

systems among them). This is a specific, quantified instance of the broader incubation-delay pattern: the rate-limiting step for most glass-ceramic innovations is not discovering a new crystallizable composition, which the literature does prolifically, but the far slower process of process engineering, cost reduction, and manufacturing scale-up needed to take a laboratory composition to market — reinforcing that any half-century retrospective of the field's progress should be measured as much by successful commercialization as by publication volume.
- **Direct-write photonic structuring:** Femtosecond-laser direct writing uses extremely short, intense laser pulses focused inside a transparent glass-ceramic to locally modify the material at the focal point through nonlinear absorption, without affecting the surrounding, unfocused material. Scanning this focal point along a path inside the material can form buried optical waveguides in three dimensions. This extends the same underlying concept behind PTR-glass refractive-index writing — permanently and locally modifying refractive index using light — from PTR glass's planar, UV-plus-thermal-development process to a fully three-dimensional, maskless, single-step laser-writing process, with direct relevance to integrated photonic circuits and to femtosecond micromachining more broadly, both recognized as emerging frontiers in the wider glass-technology literature.

11. Mechanical Properties, Residual Stress & Fracture Mechanics

- **Mismatch residual stresses:** Because a crystalline phase and its surrounding residual glass matrix generally have different coefficients of thermal expansion (Δα) and different elastic moduli, cooling a glass-ceramic down from its crystallization temperature to room temperature generates internal residual stresses around each crystal, as the two phases try to contract by different amounts but are mechanically constrained to remain attached to one another. These residual stresses are not a minor side effect — their sign (tensile or compressive) and magnitude directly govern how the material responds to externally applied mechanical loads, including whether cracks are attracted to or deflected away from crystal-matrix interfaces. A refinement of this general principle, established across several glass-ceramic systems, is that a low residual-stress level in the crystalline phase — rather than a high level of either tensile or compressive stress — tends to be what actually improves strength and toughness; the intuitive assumption that more compressive stress in the crystals is always better does not hold up, and minimizing the stress mismatch is often a more reliable design target than deliberately maximizing compression.
- **Microstructural toughening mechanisms:** Increasing the volume fraction of a mechanically superior, high-modulus crystalline phase within the glass-ceramic generally raises both fracture toughness (K_{Ic}, the material's resistance to crack propagation) and overall strength. This happens through several concrete crack-interaction mechanisms operating at the microstructural level: crack deflection, in which a propagating crack is redirected around a hard crystal rather than through it, consuming extra energy in the process; crack bowing, in which the crack front bulges between crystalline obstacles rather than advancing uniformly; and grain interlocking, in which irregularly shaped or elongated crystals mechanically key into one another and resist being pulled apart, all of which make it harder for a crack to propagate cleanly through the material.
- **Optimal crystal size effect:** Crystal size in a glass-ceramic has two competing effects on mechanical performance that work in opposite directions. Larger crystals can enhance the interlocking, deflection, and bridging mechanisms described above, which tends to increase toughness and strength — but larger crystals also generate larger local tensile stresses in the surrounding glass matrix due to the thermal-expansion mismatch discussed above, and these larger stresses can nucleate microcracks that reduce overall strength. Because these two effects push in opposite directions, an optimal, intermediate grain size typically exists for a given composition that maximizes the net mechanical performance, and this optimum must be determined experimentally rather than assumed. A concrete demonstration of how far this kind of microstructural control can push mechanical performance: surface crystallization of a phase with a low thermal-expansion coefficient, which places the crystallized surface layer under compression relative to the bulk, has been shown to raise fracture strength to roughly 700 MPa in a model glass-ceramic system — a substantial strength gain achieved through microstructural design alone, without any change in bulk composition, and directly analogous in spirit to the compressive-layer strengthening achieved by chemical ion exchange but produced instead by controlled surface devitrification.
- **Strength vs. toughness distinction:** Strength (the stress at which a material fractures) and toughness (the energy required to propagate a crack through the material) are related but genuinely distinct mechanical properties, and a microstructural change can move them in opposite directions: a change that introduces larger crystals or more residual stress, for example, might raise toughness by enhancing crack-deflection mechanisms while simultaneously

lowering measured strength by introducing larger pre-existing flaws. Compounding this, measured strength values for brittle materials like glass-ceramics are highly sensitive to the specific population of surface and internal flaws present in a given batch of test specimens and to the details of the test method used (specimen geometry, loading rate, surface finish), so strength comparisons between studies must be made cautiously and ideally only between specimens tested under matched conditions.

12. Bioglasses, Bioactive Glass-Ceramics & Clinical Translation

- **Invention of BioSilicate & F18:** The development of BioSilicate — a fully crystallized, high-strength, machinable, and bactericidal glass-ceramic — and of F18, a crystallization-resistant bioactive glass, represent two distinct and complementary biomaterial milestones from this research line: BioSilicate demonstrates that deliberate, controlled crystallization can be used to engineer mechanical robustness into a bioactive material, while F18 represents the opposite design strategy, deliberately suppressing crystallization to preserve the high, rapid bioactivity more typical of amorphous bioactive glasses. Together they illustrate two different, validated routes to translating fundamental crystallization control into biomedically useful materials. Both materials are patented in several countries and licensed to the spin-off company Vetra; BioSilicate alone has been the subject of more than 35 theses and dissertations in addition to numerous journal articles, and can be produced in monolithic, scaffold, granular, or powder form. F18 adds two properties not shared by BioSilicate: it is angiogenic (promoting new blood vessel formation, relevant to tissue integration) in addition to being bactericidal, and it is one of the very few bioactive glass compositions that can be processed into fiber and patch form — a route that is generally difficult for bioactive glasses since it demands a composition resistant enough to crystallization to survive fiber-drawing temperatures without devitrifying. Both materials are now in active human clinical trials, not merely preclinical testing.
- **BioSilicate osteogenesis:** BioSilicate rapidly forms a hydroxycarbonate-apatite-like surface layer upon exposure to physiological or simulated body fluid, and directly supports osteogenic (bone-forming) cell activity in laboratory testing, demonstrating concretely that a fully crystallized material — not merely an amorphous or partially crystallized one — can be highly bioactive, directly supporting the general compatibility claim above with a specific, well-characterized example.
- **Integrated bio-structural design:** By demonstrating that composition and microstructure can be co-designed to deliver simultaneous gains in mechanical strength, fracture toughness, and bioactivity, this research line effectively eliminates the traditional design trade-off in which biomaterials scientists had to choose between a mechanically weak but highly bioactive amorphous glass and a mechanically strong but bioinert or less bioactive crystalline ceramic — offering instead a single materials-design framework capable of targeting both objectives at once.
- **Compatibility of crystallization and bioactivity:** A longstanding assumption in the biomaterials field held that crystallization inevitably reduces or eliminates bioactivity, since it removes the highly reactive, disordered glass network. Controlled devitrification does not, in fact, necessarily impair bioactivity, provided both the crystalline phase and the residual glass matrix that remains after crystallization retain favorable dissolution behavior and are still capable of forming an apatite layer on their surface when exposed to physiological fluid; the key design variable is therefore the chemistry retained by each phase after crystallization, not simply whether crystallization has occurred at all.
- **15-Year clinical validation:** Micronized BioSilicate, applied as a topical treatment, reduces dentin hypersensitivity through two complementary mechanisms: promoting deposition of new mineral on exposed dentin surfaces, and physically occluding the dentinal tubules through which painful stimuli are transmitted to the tooth's nerve. This effect has been validated across a sustained, fifteen-year clinical research program comprising multiple independent randomized controlled trials conducted in 2011, 2015, 2022, 2024, and 2026 — a depth and duration of clinical validation that is unusual for an oxide-glass-derived biomaterial and represents one of the strongest clinical evidence bases in the group's overall body of work. Dentin hypersensitivity is, moreover, not BioSilicate's only human clinical application: it has also been clinically tested in humans as a middle-ear ossicular bone replacement material and as an orbital implant following eye enucleation (anophthalmic socket volume augmentation), with further applications explored in vitro and in animal models — evidence that BioSilicate's clinical translation extends well beyond the single, best-documented dental use case.
- **Scaffold sintering integration:** Sintering routes applied to bioactive glass or glass-ceramic powders can produce either porous, interconnected scaffolds suitable for bone tissue ingrowth or fully dense components suitable for

load-bearing applications, depending on how the process is controlled. Achieving the desired outcome, however, requires that densification, crystallization, pore-network connectivity, and the material's eventual dissolution behavior all be coordinated deliberately during processing, since optimizing any one of these in isolation (for example, maximizing density) can compromise another (for example, the interconnected porosity needed for cells and blood vessels to infiltrate a scaffold).

13. Novel Thermal & Microstructural Characterization Techniques

- **Calorimetric kinetic refinements:** Non-isothermal differential thermal analysis (DTA) and differential scanning calorimetry (DSC), in which a sample is heated at a controlled rate and heat flow is monitored, provide a rapid way to screen for the presence and approximate temperature range of nucleation and crystallization events in a glass using a single, relatively quick experiment. However, extracting accurate, quantitative kinetic parameters (rate constants, activation energies, mechanism assignments) from these calorimetric curves alone is not reliable on its own; such parameters require independent validation via direct optical or electron microscopy, which can directly observe and count the crystals responsible for the calorimetric signal rather than inferring their behavior indirectly from a heat-flow curve.
- **Single-run DSC growth measurement method:** A novel experimental method uses a single DSC run on a thin glass sample to reconstruct crystal growth rates as a function of temperature across a wide thermal range, replacing the traditional approach of running many separate, time-consuming isothermal heat-treatment-and-microscopy experiments at a series of individual temperatures. This single-run approach drastically reduces the total experimental effort and sample consumption needed to build a complete growth-rate-versus-temperature curve for a new glass composition, making this kind of characterization far more practical for screening many candidate compositions.
- **Flash DSC & power-ramp flash crystallization:** Flash DSC instruments achieve heating and cooling rates orders of magnitude faster than conventional DSC, which extends structural relaxation and crystallization measurements into a previously inaccessible regime of very short timescales and, correspondingly, higher effective supercooling. Applying an analogous ultrafast, power-ramp heating profile to bulk material (rather than the milligram-scale samples typical of flash DSC) enables sub-second bulk conversion of a precursor glass into a glass-ceramic — flash crystallization — with a direct demonstrated clinical application in rapidly producing dental lithium-silicate glass-ceramic restorations, potentially compressing a process that traditionally requires a lengthy furnace heat treatment into a matter of seconds.
- **Fast Liquidus (T_{liq}) protocol:** Determining a glass composition's liquidus temperature traditionally requires holding samples at a series of candidate temperatures in a high-temperature furnace for extended periods until equilibrium crystal-melt coexistence is reached, which is slow and can suffer from compositional changes due to volatilization during the long hold. An optimized protocol instead uses the melting peak observed during a controlled DSC heating scan to determine liquidus temperature much more rapidly, without the extended high-temperature holds, and without the associated risk of volatilization altering the sample composition during measurement.
- **Poisson nucleation statistics for chemical homogeneity:** If a glass is chemically and structurally perfectly homogeneous, the number of crystals nucleating within equal-sized sub-volumes of a sample, after a controlled heat treatment, should follow Poisson statistics — the standard statistical distribution expected for independent, randomly distributed rare events occurring at a constant average rate. By measuring the actual spatial variation in nucleation counts across many sub-volumes of a sample and comparing it to the Poisson prediction, systematic deviations from Poisson behavior reveal the presence of nanoscale chemical or structural heterogeneities that are too subtle to be detected by standard spectroscopic or diffraction techniques, making nucleation-count statistics an unusually sensitive indirect probe of sample homogeneity.

14. Materials Informatics, Neural Networks & Machine Learning

Big-Data Tg modeling: Neural networks trained on a dataset of more than 55,000 distinct glass compositions, spanning a wide range of chemistries and numbers of component oxides, can predict the glass transition temperature (Tg) of a new, previously unseen multicomponent oxide composition within tight, quantified error bounds. This demonstrates that useful, quantitatively accurate property prediction is achievable across highly multicomponent oxide-glass composition spaces once a sufficiently large and diverse training dataset is assembled and an appropriate model architecture is applied, in contrast to the more limited compositional ranges over which traditional empirical composition-property relationships have historically been developed.

- **Domain applicability & data limits:** The predictive uncertainty of these machine-learning models is governed principally by the quality of the underlying dataset and by how well the target composition is represented within the training data's compositional space, rather than by the sophistication of the modeling algorithm itself. Extrapolating a model's predictions to extreme property values, or to chemical elements that are rare or entirely absent in the training data, remains hazardous and should be flagged explicitly as low-confidence, since the model has little or no genuine information to draw on for such predictions even though it will typically still output a numerical answer if asked.
- **Explainable AI (SHAP framework):** Integrating SHAP (SHapley Additive exPlanations), a method for quantifying how much each individual input feature (in this case, each oxide component's concentration) contributes to a given model prediction, converts an otherwise opaque, black-box neural network into an interpretable tool. This allows researchers to identify which composition-property trends the model has actually learned, in a form that can be checked against known glass chemistry, and to flag individual database records whose measured property value is inconsistent with what the composition-based trend would predict — a practical route to catching likely data-entry errors in large composition-property databases.
- **Inverse glass design via genetic algorithms:** Coupling a trained predictive property model with a genetic algorithm — an optimization method that iteratively proposes, evaluates, and evolves candidate compositions toward a target property combination — enables inverse design: instead of predicting the properties of a given composition (the forward problem), the combined system searches for compositions expected to achieve a specified target, such as simultaneously high refractive index and low Tg. Candidate compositions (for lead-free “crystal” and optical glasses) proposed this way have been experimentally validated by actually melting and measuring them, including compositions meaningfully outside the original training dataset, confirming that the inverse-design approach generalizes beyond simple interpolation within already-known compositions.
- **Processing & load variable integration:** Some measured glass properties depend not only on composition but also on processing conditions or on the specific conditions of the measurement itself; glass hardness, for example, depends measurably on the applied indentation load during testing, not composition alone. Machine-learning models intended to predict such properties must explicitly include these processing or testing variables as model inputs whenever they materially affect the target property, since omitting them would force the model to average over conditions that actually produce systematically different answers, degrading prediction accuracy.
- **A learned distance metric for compositional similarity:** Classical measures of how similar two glass compositions are, such as Manhattan (city-block) distance between their oxide percentages, treat every compositional dimension as equally important and independent, which does not reflect how strongly a given property actually depends on any particular oxide. A learned glass-distance method instead derives compositional similarity directly from the trained property models themselves, weighting each compositional dimension by its actual influence on the properties of interest, and as a result quantifies true compositional similarity far more accurately than classical distance measures for tasks such as identifying the nearest known neighbor to a candidate new composition, flagging when a prediction is a risky extrapolation rather than a safe interpolation, and organizing large composition-property databases by genuine similarity rather than raw numerical proximity.

15. Scientometrics, Scientology & History of Glass Science

- **Pitfalls of raw metrics:** Raw citation counts and h-indices, commonly used as simple proxies for a researcher's scientific impact, are heavily skewed by factors that have nothing to do with the underlying quality of the work: the size of the specific research field (larger fields generate more citations for comparable-quality work), the era in which a paper was published (older papers have had more time to accumulate citations), total publication volume (more papers mechanically generates more opportunities for citation), and career length. Because of these confounding factors, direct, unadjusted comparisons of raw citation counts or h-indices between researchers in different fields, career stages, or eras can be seriously misleading and should be avoided.
- **The Montazerian-Zanotto-Eckert index:** To correct for the confounds above, the Montazerian-Zanotto-Eckert (MZE) index was formulated to normalize an individual researcher's h-index relative to the h-index that would be statistically expected, based on an empirically established power-law relationship between h-index and total

publication count, for a typical researcher within that same specific field. This produces a relative, field-adjusted score rather than an absolute number, making meaningful comparison across fields and career stages possible in a way that raw h-index cannot support.

- **Field-Weighted Citation Impact (FWCI):** Field-Weighted Citation Impact normalizes a paper's or a researcher's citation count relative to the average citation count of similar papers — matched by publication year, subject field, and document type — published around the same time, expressing performance as a ratio to that expected average. This adjustment for both field and article age makes FWCI a preferred benchmark over raw citation counts for comparing scientific impact across different research areas or time periods.
- **Scientometric utility:** Scientometric and bibliometric analyses are most valuable when used to reveal broad, aggregate patterns — overall research trends within a field, neglected or underexplored subareas that might merit more attention, and institutional or geographic inequalities in research funding or output — rather than being used, as they sometimes are, as a mechanical substitute for informed, case-by-case peer judgment about any individual researcher, paper, or funding proposal.
- **History & sociology of glass science:** A body of historical research, distinct from the quantitative scientometric work above, contextualizes key breakthroughs, historically important glass patents, and grand challenges facing materials science over a span of roughly two centuries. This work treats the history and sociology of glass science — how the field's ideas developed, who developed them, and how they diffused into industrial practice — as a legitimate object of scientific study in its own right, worthy of the same rigor applied to the physical-chemical research itself, rather than as a secondary or purely narrative exercise.

OVERALL SYNTHESIS

Zanotto's research treats glass as a dynamically evolving, non-equilibrium material whose behavior cannot be reduced to viscosity, a DSC peak, average structure, or a single empirical index. Glass formation, crystallization, and technological performance emerge from the coupled effects of thermodynamics, transport, structural relaxation, nucleation pathways, microstructure, and processing history.

Two unifying threads bridge the fundamental and applied aspects of this body of work:

- **A Metascientific Dimension:** Sustained attention to how glass science itself is practiced, measured, and historically contextualized runs in parallel with the physical-chemistry program, treating scientometrics and history of science as legitimate research subjects rather than incidental commentary.
- **Translational Impact:** The bioglass research line distinguishes itself by an unusually direct and sustained fundamentals-to-clinic translation pathway, demonstrated by a 15-year randomized-controlled-trial record for BioSilicate — a rare achievement in oxide-glass research, where most fundamental crystallization work never reaches a comparable level of applied validation.

A third thread, visible once the two above are read alongside the full body of conclusions, connects the theoretical and applied halves at the level of process control rather than composition: the kinetic-spinodal concept and surface-nucleation kinetics (Theme 1), fragility-based glass-forming-ability screening (Theme 4), and viscosity-based workability classification (Theme 8) together describe a single research program aimed at converting nucleation-and-growth theory into quantitative, composition-specific processing windows. That same logic underlies the sinter-crystallization routes (Theme 5), the commercial glass-ceramic benchmarking (Theme 10), and the flash-crystallization techniques (Theme 13) that make this fundamental science industrially actionable — the throughline of the entire document is the conversion of nucleation-and-growth theory into practical processing control, at every scale from a single critical nucleus to a commercial cooktop plate.

Research Summary

The research described above comprises a sequential sampling of several key insights. It is vital to the understanding of relevant scientific problems related to the nature, mechanisms, and kinetics of relaxation, crystallization and sintering, which are crucial phenomena of the glassy state of matter. Our philosophy has been to focus on some relevant problems for several years at the deepest possible level. Most of our articles are innovative and collectively have led to substantial advances in our understanding of crucial aspects of the science of supercooled glass-forming liquids and glasses.

This continuous work over several decades (most topics are still active) has contributed significantly to our own education and to that of many undergraduate and postgraduate students and postdoctoral researchers, and has pushed the frontiers of glass science.

We have also leveraged accumulated scientific knowledge to invent and develop new research methods and thechniques, useful glasses and glass-ceramics with enhanced biological, mechanical, and optical functionalities. This work also enabled the development of new or improved commercial materials, for example: much improved PTR glass-ceramics with less light scattering, stronger bioactive, machinable, bactericidal glass-ceramics (BioSilicate), and a new crystallization-resistant, bioactive glass, F18, which is especially useful for fibers and sintered scaffolds. Other technological advances, which cannot be revealed due to nondisclosure agreements, resulted from numerous collaborations with Brazilian and international industries. We are now actively working of Machine Learning approaches to understand the complex composition vs. properties relationships to develop novel glasses having unusual, useful combination of properties.

Technological Development and Industrial Collaboration

Prof. Zanotto’s training in materials engineering, applied physics, and materials science has supported a career divided between fundamental and applied research. The technological work of his team and collaborators includes testing and developing glasses and glass-ceramics with new or improved functions and, more recently, using artificial-intelligence methods to design materials. The source CV reports projects with approximately 35 companies, plus testing, short courses, and consulting for more than 40 Brazilian and international organizations. The work generated industrial know-how, patents, products, processes, and **six** spin-off companies: Vitrovita, Procell, Vetra, I2Mat, and two companies focused on veterinary biomaterials: OrthoPETica and DenTS).

Projects with Brazilian Companies or Companies Operating in Brazil

- Darvas-Equipamentos Eletro-Médicos: development of heat-absorbing glass
- Astra-Brasil: chemical toughening of borosilicate glass
- Nadir Figueiredo Ind. e Com. S. A.: a reformulation of stoneware
- Corning Brazil: a market survey on advanced ceramics
- Companhia Vale do Rio Doce: a market survey on quartz powder
- Tigrefibras: asbestos replacement in fiber-cement products
- Cecrisa Revestimentos Cerâmicos S. A.: a reformulation of cordierite refractories
- Pirelli: State-of-the-art in high-temperature ceramic superconductors
- Brastemp: development of ceramic insulators
- Carborundum do Brasil: mechanical behavior of SiC refractories
- Pirelli Fibras Óticas: silica preforms via sol-gel
- Cia. Vidraria Santa Marina: chemical toughening of glass plates
- Usiminas: development of glass-ceramics from BOF slags
- CBPM: replacement of feldspar by nepheline in a soda-lime-silica glass
- Spall: development of ceramic reformulation software
- Maximiliano Gaidzinski S. A.: development of sintered glass-ceramic tiles
- Alcoa S. A.: effects of alumina in different glasses
- UBV: characterization of defects in plate glass
- Vitrovita: several bioactive glass and glass-ceramics projects
- DMC: nondisclosure agreement signed for biomaterials
- CTA: armor glass-ceramics
- Vetra: PIPE projects on biomaterials
- CBMM: development of optical and “crystal” glasses with Nb—ongoing
- Vimaster: development of ultrabright microspheres – ongoing
- SEDGWICK, PSG, UFSC and CS: causes of spontaneous cracking of solar panels – ongoing
- AcelorMittal: steel slags addition in green and amber bottles—ongoing

International Projects

- Saint-Gobain (France) – a fast DSC method for the determination of the liquidus, 2002
- OptiGrate (USA) – improvement of photo-thermal refractive glass-ceramics, 2005-2010
- AGY (USA) – development of novel glass fibers, 2012
- Nippon Sheet Glass (Japan) – dynamic processes in undercooled liquids, 2013
- Owens-Illinois (USA) – technical advisory board member, 2014-2017
- Nippon Sheet Glass (Japan) – which is the best viscosity equation? 2015
- IVOCLAR Vivadent (Liechtenstein) – development of dental glass-ceramics, 2019-2022
- Asahi Glass Company (Japan) – fundamentals of glass crystallization, 2019-2024
- Sisecam (Turkey) – training courses for over 30 engineers and researchers, 2023-2024

Short-Term Testing, Courses, and Consulting

Several other short-term consulting jobs and testing have been carried out for the following companies: Smar, Nadir Figueiredo Ind. Com. S. A., ABC Xtal Fibras Óticas, AllLux, Faber Castell, Ajinomoto Biolatina, Sobral Invicta S. A., M. Agostini, Mineração Mamoré, Wheaton, DVB – Vidros Temperados, Cristais Hering, Pilkington, Mellita do Brasil, Sand, Thomson Tube Components BH Ltda., UBV, Saint-Gobain Vidros, ABB Ltda, Corning Brasil, Electrovidro, Falcão Bauer, AGY (USA), Owens-Illinois (USA), Mineração Jundu, Ambev, Sedgwick, Guardian, Vimaster, American Ceramic Society, SEDGWICK, PSG, UFSC, Marcopolo, expert on patent infringement cases for laywer companies, and others.

Education, Supervision, and Mentoring

Professor Zanotto has advised approximately 100 M.Sc. and Ph.D. theses and postdoctoral researchers, and supervised about 100 undergraduate scientific-initiation or diploma projects. Approximately 40 former students and postdoctoral researchers became professors or glass researchers. He frequently emphasizes that hands-on, active research is the best form of education.

Students' evaluations of his undergraduate and postgraduate courses consistently placed him among the top 5% of teachers in DEMa and PPGCEM, which together involve approximately 50 faculty members.

Former Graduate Students and Postdoctoral Researchers that Continue Working on Vitreous Materials

Former Student or Postdoctoral Researcher	Current Position (2025)
Ednan Joanni –MSc, 1986 UFSCar	Researcher Renato Archer Center
Antonio Valadão Cardoso – MSc, 1988 UFMG	Researcher CETEC, BH
Ervino C. Ziemath- Dr. 1990, IFSC-USP	Prof. UNESP, Rio Claro (retired)
*Valmor Roberto Mastelaro – Dr 1992, Paris	Prof. IFSC-USP
Nora Diaz Mora – Dr. 1994, UFSCar	Prof. Unioeste, Foz de Iguaçu
*Francisco Carlos Serbena – Dr. 1995, Oxford	Prof. Uni. Estadual Ponta Grossa
*Oscar Peitl Filho – Dr. 1995, UFSCar	Prof. UFSCar

Former Student or Postdoctoral Researcher	Current Position (2025)
Miguel Oscar Prado – Dr. 1995, Bariloche	Researcher CNEA, Bariloche, Argentine
Catia Fredericci – Dr. 1997, UFSCar	Researcher IPT, São Paulo
*Eduardo Bellini Ferreira – Dr. 2000, UFSCar	Prof. EESC – USP
*Aluísio Alves Cabral Junior – Dr. 2000, UFSCar	Prof. IFMA, São Luís
Paulo Cesar Soares Jr. – Dr. 2002, UFSCar	Prof. PUC, Curitiba
*Marcio Luis F. Nascimento – Dr. 2004, UFSCar	Prof. UFBA, Salvador
Luciana Ghussn – Dr. 2005, IPEN	Prof. UERJ, Resende
Itay Dyamant – PhD 2010, Beer-Sheva	Researcher in Israel
Juliana K. M. de Faria Daguano – Dr. 2010, USP	Prof. UFABC, CEO CTI Renato Archer
*Viviane Oliveira Soares – Dr. 2010, UFSCar	Prof. UEM, Goierê
Bruno Poletto Rodrigues – MSc 2012, UFSCar	PD (postdoc) OSI Jena, Germany
Raphael M. C. Vasconcelos Reis – Dr. 2012, UFSCar	Prof. UFF, Volta Redonda
Shiv Prakash Singh – PhD 2012, Kolkata	Research Scientist, China
*Murilo Camuri Crovace – Dr. 2013, UFSCar	Prof. UFSCar
Mariana de O. C. Villas Bôas – Dr 2013, UFSCar	Prof. ASSER, Porto Ferreira
*Daniel Roberto Cassar – Dr. 2014, UFSCar	Prof. Ilum, CNPEN Campinas
*Alisson Mendes Rodrigues – Dr. 2014, UFSCar	PD UFCG, Campina Grande
Jefferson Tsuchida – PD 2015, UFSCar	Prof. UFLA, Lavras
*Marina Trevellin Souza – Dr. 2015, UFSCar	Researcher, CEO Vetra Ltda
Maziar Montazerian – Dr. 2015, Teerã	Research Professor, Penn State, USA

Former Student or Postdoctoral Researcher	Current Position (2025)
*Leonardo Sant'Ana Gallo – Dr. 2016 UFSCar	Prof. UFLA, Lavras
Carlos Paucar – Dr. 2016, ICV Madri	Prof. in Colombia
*Gisele Guimarães – Dr. 2017, UFSCar	PD University of Madison, USA
*Renato Luiz Siqueira – Dr. 2017, UFSCar	Consultant sol-gel and TI
*Claudia P. M. Abadia – Dr. 2019, UFSCar	PD, UFSCar – LaMaV
*Laís Dantas – Dr 2019, UFSCar	Prof. IFMA
Jeanini Jiusti – Dr. 2020, UFSCar	R&D, Saint-Gobain, France
Débora C. N. Fabris – Dr. 2021, UFSCar	Company researcher, Germany
*Lorena Raphael Rodrigues – Dr. 2021, UFSCar	Prof. UFSCar, São Carlos
*María Helena Ramirez Acosta – Dr. 2021, UFSCar	PD BAM, Germany
*Azat Tipeev – Ph.D., Russia, 2018	Postdoctoral researcher, USF, USA
*Henrik Bradtmüller – Ph.D., Münster, 2020 *Geovana L. Santana – Dr. 2025, UFSCar	Professor, IFSC–USP Temporary Professor, DEMa-UFSCar

** Continued collaboration.*

Other Former Students and Spin-Off Founders

- Guilherme and Raissa—Corning and SCHOTT, Germany
- Fatima Tieme and Jeanini Jiusti—Saint-Gobain, France
- Beatriz Paiva—Ph.D. student in Clausthal, Germany
- Enzo Miguel—Ph.D. student in Clausthal, Germany
- Elmar Wittman (SCHOTT), Toshiuki Watanabe (NF), Noel N. Pinto (NF), Tiago Mosca (NF), Andre Serra, Lucas Pitalluga, Mayara Cerruti, Marcelo Kurtovic (SCHOTT) and others—work in glass industries in Brazil.
- PhD students Christian Ravagnani, Alexandre Fraga, Murilo C. Crovacce, Marina T. Souza, Clever Chinaglia, and Paulo Cesar Soares Jr. started spin-off companies.

Academic Programs and Public Education

- Co-founder, with two colleagues, of UFSCar's postgraduate program in Materials Science and Engineering (PPGCEM), approximately 40–45 years ago. The program has graduated more than 3,000 M. Sc. and Ph. D. professionals and reached CAPES level 7.
- Creator and Director of EduSCar, an initiative designed to strengthen public education in Brazil, beginning with 40 public schools in São Carlos.
- EduSCar – Educação de qualidade para todos!

- Organizer of the 2012 International School on Materials Science and Engineering, which hosted approximately 50 Ph. D. students from 20 countries and 50 Brazilian students for 10 days and covered their travel and lodging expenses.
- Organizer of the I Advanced School on Glasses and Glass-Ceramics (2015) and the II, III, and IV São Carlos Schools on Glasses and Glass-Ceramics—more than 75 students from 13 countries in 2024 and comparable attendance in 2025 and 2026.
- Instructor of the American Ceramic Society's advanced course "Nucleation, Growth and Crystallization in Glasses—Fundamentals and Applications" five times.
- Recipient of the title "Comendador" from the Sociedade Brasileira de Educação e Integração (SBEI) in 2018 for outstanding service to education in Brazil.

Examples of Recorded Classes and Outreach Videos

Interview with Prof. Edgar D. Zanotto, glass scientist at UFSCar

Fundamentals of the Vitreous State

Estrutura e Propriedades de Vidros – graduação

Fundamentals and Applications of Glass Crystallization

Glass transition concepts illustrated in a humorous video

Paideia interview – Edgar Dutra Zanotto

Edgar Zanotto: New glass research center in Brazil

Administrative, Advisory, and Professional Service

Current Brazilian Roles

- President of the Board of Trustees of the São Carlos High Technology Park (ParqTec).
- Counselor Emeritus of the Brazilian Ceramic Society.
- President of the International Institute of Ceramic Materials (I2Mat).
- Board President of EduSCar.
- Advisor for FAPESP´s international projects (CIPs).

Current International Roles

- Vice-President of the International Commission on Glass (ICG).
- Advisory Board member, European Center for Functional Glass (FunGlass), Slovak Republic.
- Member of ICG Technical Committee 7 on Crystallization since 1984; chair for approximately 10 years.
- Brazilian representative to the Council of the International Ceramic Federation.
- Brazilian representative to the Council of the International Commission on Glass.
- Council member of the Society of Glass Technology (Board of Fellows).
- Global Ambassador of the American Ceramic Society.
- Ad hoc reviewer for more than 30 scientific journals and 10 funding agencies.
- Member of the international advisory boards of 11 scientific journals.
- Visiting professor at WUT, China

Past Administrative, Executive, and Advisory Positions

- Co-founder of UFSCar's postgraduate program in Materials Science and Engineering.
- Adjunct Coordinator for Exact Sciences and Engineering at FAPESP for 10 years (1995–2005), during which he analyzed approximately 50,000 proposals and contributed to the creation of new programs.
- Co-founder and manager of FAPESP's Patent and Licensing Office (NUPLITEC) for approximately six years.
- Member of CNPq's Engineering Committee for three years.

- Co-founder, with Prof. G. Solórzano, of the Brazilian Materials Research Society (SBPMat/Brazilian MRS).
- Former Vice-President and Director of the Brazilian Ceramic Society (several years).
- Chair of ICG Technical Committee 7 on Crystallization for approximately 10 years.
- Officer and Chair of the Glass and Optical Materials Division of the American Ceramic Society (GOMD), 2014–2017.
- Member of the Technical Advisory Board of Owens-Illinois, 2014/2015–2017.
- Member of the Advisory Board of the NSF International Materials Institute for New Glasses, 2005–2015.
- Member of the Advisory Board of the European FunGlass Center, 2015-current
- First President of the Scientific Council of the Serrapilheira Institute (a private funding agency in Brazil) and later a member of its Scientific and Administrative Councils.
- Member of UFSCar's Research Council for five years.
- Member of the Administrative Council of the Institute for Pure and Applied Mathematics (IMPA), 2013–2023.
- Member of technical committees at FAPESP, CNPq, and LNLS.
- Co-founder and first editor of the periodical Materials Research in 1998; Editor-in-Chief for 13 years, with service continuing through 2010.
- Editor of the Journal of Non-Crystalline Solids for approximately 15 years (2010–2025).
- Technical services and consulting for approximately 40 companies over four decades.

Editorships, Academies, and Fellowships

In addition to the editorships described above, EDZ has served as guest editor of MRS Bulletin and the Journal of Materials Science and has also served on the boards of four other journals.

Currently, he is an advisory-board member for International Materials Reviews, Discover Applied Sciences, Materials, International Journal of Applied Glass Science, Papers in Physics, Materials Research, Boletín de la Sociedad Española de Cerámica y Vidrio, Iranian Journal of Materials Science and Engineering, Journal of Materials Research and Technology, Journal of Non-Crystalline Solids, and Cerâmica.

Zanotto is a member of the Brazilian Academy of Sciences (ABC), the São Paulo State Academy of Sciences (ACIESP), the National Academy of Engineering (ANE), The World Academy of Sciences (TWAS), and the World Academy of Ceramics (WAC).

He is a Fellow of the Society of Glass Technology, the American Ceramic Society, the Brazilian Ceramic Society, and the Fulbright Foundation.

Peer Review and Award Committees

Zanotto is a referee for many physics, chemistry, materials science and engineering, and glass journals, as well as for several national and international funding agencies, such as FAPESP, CNPq, Capes, FINEP, Fapemig, Fundação Araucaria, Pronex, LNLS (all in Brazil), South American agencies, NSF, DAAD, DFG, and the Italian Research Council.

He has also been a member of prestigious award committees: for the Guggenheim Foundation, Humboldt awards, ABC prizes, Finep technology prize, ParqTec Technology pawn prize, CBMM Prize, L´Oréal Prize for women, TWAS Fellowship selection, ICG Gottardi award, ICG Weyl award, ACerS Morey award, ACerS Kreidl award, Cooper Lecture award, JNCS Zachariasen and Mott awards, among others.

Awards and Distinctions

Over 65 science- and technology-related awards and distinctions. Student prizes are not included. The most prominent distinctions are shown in bold. Prof. Zanotto is one of the few researchers to have received the full group of major international glass awards represented below.

- 2026 – Edgar Zanotto (**EZ-GLAD**) **laboratory created** at Wuhan University of Technology, China
- 2026 – **High-level TALENT** research award and professorship granted by the Chinese government
- 2026**–** S. Banerjee Memorial Lecture ICG Meeting, Kolkata, Jan. 2025
- **2025 – ICG PRESIDENT Award, ICG Meeting, Kolkata, Jan. 2025**

- 2024 – Guru-Chela **LECTURE**, GOMD, ACerS, Las Vegas, May 2024
- **2024 – FRONTIERS of Glass Science LECTURE, GOMD, ACerS, Las Vegas, May 2024**
- **2023 – CONFAP prize for Science, Technology and Innovation, Fapesp + other state funding agencies, Brazil**
- 2022 – Ed Zanotto symposium on glass science, organized by the Université Libre de Bruxelles, Belgium
- **2022 – EXCELLENCE Chair granted by the Université Libre de Bruxelles, Belgium**
- 2020 – Five of the most-downloaded papers in the JNCS in the period 2018 –2022 (competed with ~27,000 articles)
- **2019 – SPRIGGS Award, American Ceramic Society. Best paper on phase equilibria in ceramics of 2018**
- 2019 – **Samuel Scholes LECTURE**: prestigious annual lecture delivered at the invitation of the Dean of Engineering, Alfred University, USA.
- **2018 – COMENDADOR – Sociedade Brasileira de Educação e Integração (SBEI). The SBEI conferred this award for professors who provide outstanding services to Education in Brazil.**
- **2018 – COMENDADOR Grã-Cruz, Ministry of Science and Technology, President Michel Temer, Brazil**
- 2017 – President of the Science Council, Serrapilheira Institute, Rio, Brazil
- 2017 – **Global Ambassador** of the American Ceramic Society, Pittsburgh, USA
- 2017 – Scientist of the year / nanomaterial category – Nanocell Institute, Brazil
- **2017 – A. Cooper Distinguished LECTURE, American Ceramic Society (ACerS), Pittsburgh, USA**
- 2017 – **USP LECTURE**, rector of the University of São Paulo. One of the most prestigious talks in Brazil
- 2017 – Zanotto Prize in glass science, created by the Indian Materials Research Society
- **2016 – W. E. S. Turner Memorial LECTURE, Centennial of the Society of Glass Technology, Sheffield, UK**
- **2016 – Elected Fellow of the American Ceramic Society**
- 2015 – Best poster – DGF/GOMD meeting, American Ceramic Society, Miami
- 2014 – Officer (and Chair) of the GOMD—American Ceramic Society – the first non-American in 95 years
- 2014 – Best oral presentation and best poster – Int. Congress of Biomaterials, COLAOB, Argentina
- 2014 – Technology Pioneer – Fundação ParqTec, São Carlos.
- 2014 – Honored by the UFSCar Rector (president) for 6 consecutive years.
- **2013 – ALMIRANTE ÁLVARO ALBERTO Prize – CNPq, MCT, Navy, and Fundação Conrado Wessel. This is considered by many to be the most prestigious science and technology award in Brazil.**
- 2013 – Best poster awarded by the North American Association for Laser Therapy (NAALT)
- 2013 – Scientist of the year – SDSC&T – Municipality of São Carlos.
- **2012 – GEORGE W. MOREY Award 2012, American Ceramic Society. This is considered one of the most prestigious glass science awards for senior researchers**
- **2012 – Elected Fellow of The World Academy of Sciences (TWAS)**
- **2012 – TWAS Prize for Engineering Sciences**
- 2009 – Press Prize – Oscar Sãocarlense / Scientist, Câmara Municipal de São Carlos
- **2006 – COMENDADOR (Knight) National Order of Scientific Merit, Ministry of Science and Technology/ President of Brazil, Lula da Silva**
- 2006 – Trophy – greatest collaborator, 50th Congresso da Associação Brasileira de Cerâmica.
- **2004 – Elected to the World Academy of Ceramics (WAC)**
- **2003 – Elected Fellow of the Society of Glass Technology (SGT), UK**
- 1999 – Honorable mention – best oral presentation ABCeram congress, ABECeram
- **1999 – Elected to the Academia de Ciências do Estado de São Paulo (ACIESP)**
- 1998 – Press Trophy, Scientist of the year, Associação Comercial de São Carlos (there were approximately 2,200 PhD-level researchers and professors in São Carlos at that time)
- **1998 – Elected to the Brazilian Academy of Sciences (ABC)**
- 1998 – Best Poster, III Simpósio Nacional de Vidros.
- 1996 – Honorable mention- São Paulo State Governor Prize, SEDAI.
- 1995 – Top Scientist – 25 years of UFSCar, UFSCar President's Award.
- 1995 – Honorable Mention – Peão da Tecnologia de São Carlos, ParqTec – São Carlos.
- 1994 – 1st place- National Contest of educational and technological software, IBM/ Ministry of Education.
- **1993 – VITORIO GOTTARDI PRIZE, International Commission on Glass.**

- 1993 – "Bravíssimo", best polymer thesis, International School of Polymer Science, Ferrara, Italy.
- 1991 – Outstanding contributor to the Brazilian Glass Industry, ABIVIDRO.
- **1990 – ZACHARIASEN AWARD, Journal of Non-Crystalline Solids, Elsevier**
- 1987 – Counselor Emeritus, Associação Brasileira de Cerâmica.
- 1986 – Honorable Mention, ABCeram, Associação Brasileira de Cerâmica.
- 1983 – ABCeram Award, Best oral presentation, Associação Brasileira de Cerâmica.
- **1982 – FOSTER Research Prize in Glass Technology (Best PhD Thesis). Sheffield University Senate.**

Prof. Zanotto was invited several times to stand for Rector of UFSCar and was also invited to apply for directorships at LNLS, CNPEN, and SBPMat; he declined these opportunities.

Research Contracts and Funding

Zanotto's team received research support from government agencies and industry. He managed the research teams and budgets for the principal projects listed below.

- **Optical glass technology transfer to Brazil.** MEC/CEDATE/Carl Zeiss, 1990–1994; US$400,000.
- **Homogeneous and heterogeneous nucleation in supercooled liquids** PADCT 62.0058/91-9, May 1992–1994; 292,000 BTN + US$302,000.
- **Integrated project: Heterogeneous nucleation in anorthite and cordierite glasses.** CNPq 521.603/94-3, August 1994–1996; US$44,300.
- **DEMa research project on advanced materials.** RHAE 610.387/94-4, April 1994–1996; US$658,800.
- **Research infrastructure for the glass and ceramic laboratories of UFSCar.** FAPESP 1994/4839-2, March 1995–1996; US$136,600.
- **Scientific cooperation with the Otto Schott Institute, Jena, Germany.** CAPES/DAAD/PROBRAL 025/95, October 1995–1996; US$66,000.
- **Glass-ceramics from BOF slags.** FAI/USIMINAS, February 1996–1999; US$100,000.
- **Ibero-American glass-research network: Metastable phases in glass and bioglass-ceramics.** CYTED/CNPq, September 1999–April 2004; US$120,000.
- **National Program of Excellence Centers: Controlled crystallization of glass—mechanisms, kinetics, and applications.** PRONEX/FINEP/CNPq, January 1998–March 2005; US$709,000.
- **Thematic research grant: Current problems in glass crystallization.** FAPESP, August 1999–September 2004; US$550,000.
- **ADEMAT: Advanced Engineering Materials Network.** ALFA EU II, with 10 other groups, June 2003–2006; EUR 350,000. The coordinator belonged to another institution.
- **Glass defects.** FAI/UBV, April 2003–2005; US$30,000.
- **Brazil–Spain cooperation research program.** CAPES/SeCyT, January 2004–December 2005; EUR 50,000.
- **Stress effects on crystallization.** PROBRAL/CAPES/DAAD, July 2006–2008; US$20,000.
- **Crystallization of iron-phosphate glasses.** CIAM/CNPq/NSF/CONICET, May 2006–2008; US$30,000.
- **Fast determination of the liquidus temperature of glass-forming compositions.** CNPq Universal, June 2007–June 2009; US$50,000.
- **Transport processes in oxide glasses.** FAPESP Thematic Grant, November 2008–September 2013; US$1,000,000.
- **Glass Sintering Network.** CNPq, November 2009–2013; US$100,000.
- **Development of glass-ceramic armor.** CTA, October 2013–March 2015; R$200,000.
- **Center for Research, Technology and Education in Vitreous Materials (CeRTEV).** FAPESP CEPID, June 2013–2024; approximately US$10,000,000.
- **FRAGOGLACE – FAPESP & CNRS project.** Approximately R$ 500,000. Oct. 2025 – 2028.
- **Chinese Government and WUT –** High-level talent project. Approximately US$ 800,000 April 2026-2031
- **FINEP - Acervo: Vidros em foco: arte, ciência e inovação. July 2026 - 2029**
- **Submitted proposals (2026):** BRICS & CNPq, FAPESP Thematic, FAPESP CEPID (coordinator Sidney Ribeiro)

Several smaller contracts (below US$ 50,000) and industrial contracts with IVOCLAR, NEG, AGC, O-I, CBMM, AcelorMittal and others—together over US$ 500,000—are not listed.

Conferences, Symposia, and Scientific-Society Service

Prof. Zanotto chaired, co-chaired, helped organize, or served on the advisory boards of more than 30 national and 20 international symposia and congresses.

- V International Workshop on Glasses and Glass-Ceramics from Gels, Rio de Janeiro, Brazil (1989). Co-chair
- IV Int. Symposium on Nucleation and Crystallization in Liquids and Glasses, Stone Mountain, USA (1992).
- I French- Brazilian School on Diffusion in Solids – Ouro Preto, Brazil (1994)
- V International Symposium on Glass Crystallization – Florianópolis, SC, Brazil (1996). Chairman
- NSF/CNPq Workshop – Frontiers in Materials Research, Technology & Education. Rio de Janeiro, Brazil (1998) – Co-chair
- VI Int. Otto-Schott Colloquium, Jena, Germany (1998)
- IX Int. Conference on the Physics of Non-Crystalline Solids, Tucson, USA (1999).
- I International Symposium on Non-Crystalline Solids, Ouro Preto, Brazil, Sept. 2001.
- XII Int. Symposium on Non-Oxide Glasses and Advanced Materials, Florianópolis, Brazil (2000)
- Crystallization 2000 – Vaduz, Liechtenstein, July (2000)
- ICFPAM – Recife, Brazil, April (2001)
- International Congress on Glass- Edinburgh, UK, July (2001)
- II International Symposium on Non-Crystalline Solids, Foz do Iguaçu, Brazil, October 2001.
- III Int. Conference Powder Technology, Foz do Iguaçu, Brazil, Nov. (2001)
- VII Int. Otto-Schott Colloquium, Jena, Germany, July (2002)
- Crystallization 2003, Sheffield, UK, July (2003)
- X International Conference on the Physics of Non-Crystalline Solids, Parma, Italy, July (2003)
- Annual Meeting of the International Commission on Glass, Campos do Jordão, Brazil, Sept. (2003) Chairman
- VIII Int. Otto-Schott Colloquium, Jena, Germany, July (2002)
- III International Symposium on Non-Crystalline Solids, Maringá, PR, Brazil, Nov. 2005.
- Crystallization 2006, Jackson Hole, USA, September (2006)
- XI International Conference on the Physics of Non-Crystalline Solids, Rhodes, Greece, October (2006)
- IV International Symposium on Non-Crystalline Solids, Aracaju, Brazil, Oct. 2007
- XII International Conference on the Physics of Non-Crystalline Solids, Iguaçu, Brazil, Oct. (2009) Chairman
- 9th International Symposium on Crystallization of Liquids and Solids, Iguaçu, Brazil, Oct. (2009) Chairman
- XXII International Congress on Glass, Salvador, Brazil, October (2010) Chairman (largest glass congress)
- 9th Int. Conference Advances in the Fusion and processing of glass, Cairns, Australia, July (2011)
- I Advanced School of Materials Science and Engineering, São Carlos, Brazil, March (2012) Chairman
- Delbert Day Festschrift on DSC x Crystallization, St. Louis, USA, May (2012)
- XIII International Conference on the Physics of Non-Crystalline Solids, China, September (2012)
- 10th International Symposium on Crystallization of Liquids and Solids, Clausthal, Germany, Sept. (2012)
- Crystallization session – GOMD 2013 – St Louis. 2013. Chairman
- Topology / Properties Symposium during the ICG 2013, co-organized by TC6, TC7, and TC8, Prague (2013)
- Annual meeting of the DGG- GOMD (ACerS) – Aachen, Germany, May 2015. Executive committee.
- X Brasglass, São Carlos, 2014
- Annual meeting of the GOMD (ACerS) – DGG, Miami, USA, May 2015. Executive committee.
- Fundamentals and applications of glass crystallization – GOMD/DGG, Miami. 2015. Chairman
- Crystallization session – GOMD – Madison. 2016. Chairman
- David Pye Honorary Symposium – GOMD, San Antonio 2018. Co-chair
- Crystallization session – GOMD, San Antonio 2018. Co-chair
- Frontiers of Glass Science- ICC7, Iguassu Falls, June 2018. Co-chair
- Fundamentals and applications of glass-crystallization, GOMD-ACerS, May 2018, Pittsburgh, USA. Chairman
- ICC7; ABCeram: 7th International Congress on Ceramics (ICC7) & 62nd Congresso Brasileiro de Cerâmica, Foz do Iguaçu-PR, 17 – 21/06/2018 Co-chair
- Symposium on Frontiers of Glass Science, Foz do Iguaçu-PR, 17 – 21/06/2018. Chairman
- Fundamentals of glass crystallization- Symposium during the ICG 2019, Boston, USA, June 2019. Co-chair

- “Fundamentals of glass crystallization”- Symposium during the GOMD, New Orleans, USA, May 2020. Co-chair
- Glass and Optical Materials Meeting 2020 – Crystallization session (Chairman) – American Ceramic Society. August 2020.
- Magna meeting of the Brazilian Academy of Sciences, Oct. 2021 (Co-chair with R. Oliven)
- Glass and Optical Materials Meeting 2022 – Crystallization session (Co-chair with Matt Mackenzie) – American Ceramic Society. May 2022 (did not attend because of COVID-19).
- The International Year of Glass, Geneva and New York meetings 2022
- ICG’s annual meeting, 2022, China.
- CIMTEC 2022, Italy.
- Sintering Workshop 2022, Japan, and 2026, Germany
- Relaxation in Complex Systems 2025, France
- PNCS 2025, Japan
- ICG 2027, Brazil Co-chair
- Chairman of PNCS 2028, Brazil

Invited and Plenary Talks after Creation of the CeRTEV

Prof. Zanotto has delivered approximately 170 invited talks and 60 plenary/keynote talks at conferences, workshops, and symposia in the past 50 years. During the United Nations International Year of Glass in 2022, he delivered 22 invited and plenary talks in eight countries. He also spoke by invitation at *Festschrifts* honoring great glass scientists: Jürgen Petzoldt, Larry Hench, Donald Uhlmann, Arun Varshneya, David Pye, Oswaldo Alves, Aldo Craievich, Ivan Gutzow, Mark Davis, and Delbert Day. The following is an illustrative list for 2013–2026.

2013

- ZANOTTO, E. D. “Structural similarity/dissimilarity between glass and isochemical crystal and the nucleation ability”. “23rd International Congress on Glass, Prague, República Tcheca - July 7-12, 2013.” (Invited talk).
- ZANOTTO, E. D. “Crystallization of inorganic glasses: Fundamentals and advanced applications”. 19th Larson Workshop Indianapolis, IN October 6 – 9, 2013” (Invited).
- ZANOTTO, E.D. LaMaV / UFSCar - 36 Anos de Ensino, Ciência e Inovação. “II Seminário UEPG, Ponta Grossa, PR, 13-14 agosto de 2013” (Opening talk)
- ZANOTTO, E.D. – “A bright future for glass-ceramics.” 1o Encontro de Ciência e Engenharia de Materiais de São Carlos: Energia, Sustentabilidade e Inovação, São Carlos – SP, Brasil - de 27 a 29 de Novembro de 2013” (invited)

2014

- ZANOTTO, E. D. CeRTEV A new glass research center in Brazil- “TAB meeting / Owens-Illinois, Perrysburg, USA 09 a 12/03/2014” (Invited)
- ZANOTTO, E. D. CeRTEV- A new glass research center in Brazil -Glassman, SP 13/03/2014” (Invited)
- ZANOTTO, E. D. 40-years of crystal nucleation in glasses. “Glass Research Summit / Corning Incorporated. USA 10 a 15 Jun 2014” (Invited)
- ZANOTTO, E. D. BioSilicate – a multipurpose, highly bioactive glass-ceramic. (talk by E. D. Zanotto at the congress). Same paper in the Biomaterials Round-Table. “1st Joint Meeting of DGG-ACerS GOMD Aachen, Germany 25 – 30 May 2014.” (Invited)
- Peitl, O and ZANOTTO. E.D. Novos Materiais para a Saúde. “Reunião Regional da SBPC no vale do Paraíba – 05 de Junho de 2014.” (Invited)
- ZANOTTO, E. D. Crystal nucleation in glasses, a 60-year perspective. “XXXVII Encontro Nacional de Física da Matéria Condensada. Costa do Sauípe, BA - 12 a 16 de maio de 2014”. (Invited)
- ZANOTTO, E. D. Overview of the (UFSCar-USP-UNESP) center for glass research. “XXXVII Encontro Nacional de Física da Matéria Condensada. Costa do Sauípe, BA -12 a 16 de maio de 2014” (Invited)

2015

- ZANOTTO, E.D. Crystal nucleation in glass-forming liquids: new insights on old problems". 14t INTERNATIONAL CONFERENCE ON THE PHYSICS OF NON- CRYSTALLINE SOLIDS, Niagara Falls, NY, USA, Set/2015 (Invited).
- ZANOTTO, E. D.; D.R. CASSAR; M.L.F. NASCIMENTO; V. M. FOKIN; N. VEDISHEVA; J. W. SCHMELZER -"On the decoupling of the kinetic coefficient of crystal growth from viscosity - possible correlation with fragility and liquid structure".11th INTERNATIONAL SYMPOSIUM ON CRYSTALLIZATION IN GLASSES AND LIQUIDS, Nagaoka, Japão, October 11-14/2015 (Opening talk delivered by JWS)
- ZANOTTO, E.D. - "Reflexões sobre 40 anos de pesquisa em materiais vítreos". XVII CECEMM CONGRESSO DOS ESTUDANTES DE CIÊNCIA E ENGENHARIA DE MATERIAIS DO MERCOSUL, JULY 19 TO 2015, UFSCar, São Carlos, SP, Brasil (Opening talk)
- ZANOTTO, E.D. - "LaMaV: 40 anos de Ciência e Tecnologia de Vidros". 17º CONGRESSO DE TECNOLOGIA, 17º SIMPÓSIO DE INICIAÇÃO CIENTÍfiCA E TECNOLÓGICA, FATEC, OUT. / 2015 São Paulo-SP (Plenary)
- ZANOTTO, E.D. - "60 years of glass-ceramics R&D: a glorious past and bright future". XIV SBPMAT ENCONTRO DA SOCIEDADE BRASILEIRA DE PESQUISA EM MATERIAIS, SEPTEMBER, 27 – OCTOBER, 1, 2015, Rio de Janeiro – RJ (Plenary)
- ZANOTTO, E.D. - "Engenharia, Física e Química de Materiais Vítreos, 40 anos de Ciência e Tecnologia". XVIII SEMAQ - SEMANA DE QUÍMICA; QUÍMICA NAS DIVERSAS ÁREAS DO CONHECIMENTO, IQSC –SEPTEMBER, 28 – OCTOBER, 02, 2015, São Carlos/SP, Brazil (Invited)
- ZANOTTO, E.D.- "CeRTEV – Um novo paradigma em pesquisa científica e tecnológica e educação em materiais vítreos". I WORKSHOP UNIVERSIDADE- INDÚSTRIA EM MATERIAIS VÍTREOS, EESC/USP - SEPTEMBER, 11, 2015, São Carlos-SP (Invited)
- ZANOTTO, E.D. - "40 anos de pesquisas sobre materiais vítreos: Ciência, tecnologia, e até um pouco de arte". WORKSHOP: CIÊNCIA, TECNOLOGIA E INOVAÇÃO / UFSCAR 25 DE NOVEMBRO, DE 2015, Sorocaba-SP (Plenary – opening talk)
- ZANOTTO, E.D. - "Glass-crystal composites for high-tech applications". MACMS-2015, COMPOSITE MATERIALS FOR AERONAUTICS– EESC-USP DECEMBER, 02- 03/2015, São Carlos/SP(Plenary)
- ZANOTTO, E.D. - "Mitos do vidro". SICEM (SIMPÓSIO EM CIÊNCIA E ENGENHARIA DE MATERIAIS), SMM-USP DECEMBER, 04/2015. (Invited)

2016

- ZANOTTO, E.D. "The effect of nano heterogeneities (liquid-liquid phase separation) on crystal nucleation in glass-forming silicate liquids" Turner Legacy symposium, Sheffield, UK, 01 - 11/09/2016 (Invited)
- ZANOTTO, E.D. – "Glass myths and marvels" - W. E. S. Turner Memorial Lecture –delivered during the Centenary of the Society of Glass Technology, SGT 100, Sheffield, UK, September 2016 (Plenary)
- ZANOTTO, E.D. SCHNEIDER. J., ECKERT, H.; "Thirty-year quest for structure/ nucleation relationships in oxide glasses" MS&T, Salt Lake City, USA, 21 - 25/10/2016 (Invited)
- ZANOTTO, E.D. "Glass-ceramics: A glorious past and bright future" Latin American Materials Science Society, Cusco, Peru, 27 - 28/10/2016 (Plenary)
- ZANOTTO, E.D. - "Why certain oxide glasses never crystallize?" - NANOMAT, March 2017, Brotas, Brazil (Invited)
- ZANOTTO, E.D. "Vidro: 6000 anos de tecnologia, ciência e arte" USP Lecture, Anfiteatro da Congregação da USP, São Paulo, 26/6/2017 (Plenary)
- ZANOTTO, E.D. "Vidro: 6.000 anos de maravilhas e mitos" - Ciência às 19 horas –Instituto de Física da USP", 23/08/2016, São Carlos-SP (Invited)
- ZANOTTO, E.D. "Maravilhas e mitos do vidro", SeFís - Semana da Física da UFSCar –Departamento de Física da UFSCar, 17/10/2016, São Carlos-SP (Invited)
- ZANOTTO, E.D. "Propriedades físico-químicas e novas aplicações de vidros", Jornada da Química e Engenharia Química UNIFRAN, Franca-SP, 19/10/2016 (Plenary - opening talk)
- ZANOTTO, E.D. "Ciências da Engenharia no Brasil: Realizações e Desafios "Simpósio Comemorativo ao Centenário da ABC – "Desafios para a Ciência e Tecnologia no Brasil", FAPESP, 23/11/2016, São Paulo-SP (Invited)
- ZANOTTO, E.D. "Why certain glasses do not crystallize". 24th International Congress on Glass, Shanghai, April 2016 (Invited)

- ZANOTTO, E. D. “A random walk through Don Uhlmann’s crystallization research”. GOMD 2016, MADISON, WI USA, May 2016 (Invited)
- ZANOTTO, E. D. “Hench´s role in the development of the most bioactive glass-ceramic”. GOMD 2016, MADISON, WI USA, May 2016 (Invited)
- ZAN OTTO, E.D. – “Materiais vítreos e suas aplicações em saúde”. Tecnologies e Materiais para a Saúde, IEA UFSCar, 12 DE Junho de 2016, São Carlos – SP (Invited)
- ZANOTTO, E.D. - “Reflexões sobre 40 anos-de pesquisa, ensino, administração e até um pouco de arte em materiais vítreos”. 60º Congresso Brasileiro de Cerâmica, May 15 to 18, 2016, Águas de Lindóia-SP, Brasil (Plenary)

2017

- ZANOTTO, E.D "Why certain glass-forming liquids “never” crystallize?" – NANOMAT 2017, The 7th Latin American Conference on Metastable and Nanostructured Materials, Brotas -SP, 19 a 22/03/2017 (Invited talk)
- ZANOTTO, E.D “Glass-Ceramics” – Materials Research Society – Webinar, 22/03/2017, USA (Invited talk)
- ZANOTTO, E.D “Diffusion processes controlling viscous flow and crystallization in silicate liquids" – 12th Pacific Rim Conference on Ceramic and Glass Technology (PacRim12), Waikoloa, Hawaii, USA, 18- 28/05/2017 (Invited)
- ZANOTTO, E.D “On the Ultimate fate of glass” MS & T 2017, Pittsburgh, USA, Oct. 8-12. (Distinguished Cooper Lecture)
- ZANOTTO, E.D “The mixed alkali effect on the sinterability and bioactivity of Bioglass 45S5-based compositions. Part I – Replacement of Na_2O by K_2O”, Sintering 2017, San Diego, CA, USA 12-16/11/2017 (Invited; not delivered due to the pandemic)
- ZANOTTO, E.D “Mergulhando no mundo dos vidros”, Pint of Science, 16/05/2017- São Carlos-SP (Invited talk)
- ZANOTTO, E.D “CeRTEV – Um novo paradigma de pesquisas sobre vidros e vitrocerâmicos” Congresso Brasileiro de Cerâmica, Gramado, RS, 04 a 07/06/2017 (Invited talk)
- ZANOTTO, E.D “Vidro: 6000 anos de tecnologia ciência e arte”, USP Lecture, Cidade Universitária, São Paulo-SP, 29/06/2017 (Plenary)
- ZANOTTO, E.D “Glass bibliometrics in Brazil and other countries – Many shades of gray!”, XI Brazilian Symposium on Glass and Related Materials – XI BrazGlass, em Curitiba-PR 13 a 17/07/17 (Opening- Plenary talk)
- ZANOTTO, E.D “Vidro: 6000 anos de ciência e tecnologia”, Colóquio IFSC São Carlos-SP, 18/08/2017
- ZANOTTO, E.D “Natureza, Ciência e Tecnologia de Vidros”, II Workshop Universidade-Indústria em Materiais Vítreos – O Custo da ignorância, Auditório CETEPE da EESC/USP – campus 1, São Carlos-SP, 30/08/2017 (Invited)
- ZANOTTO, E.D “Perspectivas da Engenharia no Brasil”, Analítica EXPO, São Paulo-SP, 27/09/2017 (Invited talk)
- ZANOTTO, E.D “Nano Glass-Ceramics”, Prêmio Cientista do Ano - Instituto Nanocell, IQ – USP, São Paulo, 20/10/2017 (Invited talk)
- ZANOTTO, E.D "Desafios da Engenharia no Brasil", XI Seminário da Pós-graduação em Engenharia Mecânica, UNESP – Bauru, 27/10/2017 (Opening Plenary talk)
- ZANOTTO, E.D “Vidros são sólidos ou líquidos?”, Colóquio no Departamento de Física da Universidade Federal de Pernambuco em Recife-PE, 12-16/12/17 (Invited)

2018

- ZANOTTO, E. D., “Glass-ceramics: a glorious past and bright future”, Primer Encuentro de Jóvenes Investigadores e Ciencia de Materiales, Montevideo – Uruguay, 12 – 15/04/2018 (Plenary)
- ZANOTTO, E. D., CASSAR, D. R. “The transport mechanism in crystal nucleation in oxide glass-formers”, Glass and Optical Materials Division 2018 Annual Meeting (GOMD 2018) San Antonio, Texas, 20-24/05/2018 (Invited)
- ZANOTTO, E. D., “Glasses and glass transition for ceramists”, 7th International Congress on Ceramics (ICC7), Foz do Iguaçu-PR, 17- 21/06/2018 (Plenary)
- ZANOTTO, E. D., PEITL, O. “Biosilicate and F18- In vitro, in vivo and clinical tests”, 7th International Congress on Ceramics (ICC7), Foz do Iguaçu-PR, 17- 21/06/2018 (Invited)
- ZANOTTO, E. D., “Homogeneous Crystal Nucleation in Deeply Supercooled Glass-forming Liquids”, 15th International Conference on the Physics of Non-Crystalline Solids & 14th European Society of Glass Conference, Saint Malo, France, 9 – 13/07/2018 (Plenary)
- ZANOTTO, E. D, A Bright future for glass-ceramics- 18th SAM-CONAMET, Bariloche, Argentina, Oct. 2018 (Plenary)

- CHOUDRY, M*., MAURO, J. C, VARSHNEYA, A., RICHARDSON, K., ZANOTTO, E. D.- Glass through the ages- Int. Congress on Glass, Yokohama, Sept. 2018 (Invited)
- RINO, J. P.*, CRUZ, S., ZANOTTO, E. D., "Molecular dynamics study of spontaneous nucleation and crystallization in barium sulfide", Glass and Optical Materials Division 2018 Annual Meeting (GOMD 2018) San Antonio, Texas, 20-24/05/2018 (Invited)
- ZANOTTO, E. D., Vidro, sólido ou líquido? 1ª Escola de Verão em Química, 27/02/2018, do Instituto de Química de Araraquara-SP (PPGQ-IQAr) (Plenary, Opening)
- ZANOTTO, E. D. – "Entendimento e desenvolvimento de materiais funcionais pelo LaMaV" – CeRTEV, I SPIMF, São Carlos, May 2018 (Invited)
- ZANOTTO, E. D., "6000 anos de C&T de vidros...", 20th Congresso dos Estudantes de Ciência e Engenharia de Materiais do Mercosul (CECEMM), São Carlos, 22-28/07/2018, (Plenary)
- ZANOTTO, E. D. – BioSilicato e F18 bioativos para regeneração óssea. 8th BRADOO, São Paulo. OCT. 2018 (Invited)
- ZANOTTO, E. D. – Escrita científica- Dicas de um editor maduro – 1st Workshop PPGEQ-UFSCar, OCT. 2018 (Plenary)
- ZANOTTO, E. D. – Bem-vindos à era do vidro, 12 a 16/12/17, II Ciclo de Seminários do Programa de Pós-Graduação em Ciência e Engenharia dos Materiais do Instituto de Física da UFMS de Campo Grande -MS, 26/10/2018 (Invited)
- ZANOTTO, E. D. – Recent advances on crystal nucleation in glasses – Aalborg University, Denmark, 13/12/2018 (Invited)

2019

- ZANOTTO, E. D. – On the ultimate fate of glass – 8th Otto-Schott Colloquium/ 4th Entropy workshop, Jena, Germany, Sept. 2019 (Invited)
- ZANOTTO, E. D. – On my fun and educational 3-decade interaction with the glass guru- Arun Varshneya Festschrift, ICG 2019 – 25th International Congress on Glass, Boston, USA, June 2019 (Invited)
- CASSAR, D. R. and ZANOTTO, E. D. – On the breakdown of the CNT – ICG 2019 25th International Congress on Glass, Boston, USA, June 2019 (Invited)
- ZANOTTO, E. D. – Glass-ceramics, past, present and future, AGC headquarters, Japan, January 2019.
- ZANOTTO, E. D. – Pesquisa em novos materiais vítreos no Estado de SP, São Paulo, March 31, Japan-Fapesp Technology Symposium, 2019 (Invited)
- ZANOTTO, E. D. – Experiência do CEPID – CeRTEV no entendimento e no desenvolvimento de materiais vítreos funcionais – I Simpósio de Pesquisa e Inovação em Materiais Funcionais (I SPIMF). São Carlos-SP, October, 2019. (Plenary) (24) I SPIMF – Edgar Dutra Zanotto – YouTube.

2020

- ZANOTTO, E. D – Crystal nucleation and nanostructured glass-ceramics, PANNANO 2020 Pan American Meeting on Nanomaterials, Águas de Lindóia, Brazil, February 2020. (Plenary)
- ZANOTTO, E. D., Regular and Explainable Algorithms for Predicting Glass Properties, GOMD, New Orleans, USA, May, 2020. (Invited) – postponed to August 2020.
- ZANOTTO, E. D., Digging deeper into crystal nucleation by MD simulations- MD Challenges, Corning, USA, June, 2020. (Invited) – canceled (COVID-19)
- ZANOTTO, E. D. Publishing top articles in top journals – XII Brazilian Symposium on Glass and Related Materials, Federal University of Lavras -MG, October, 2019. (Plenary, Opening talk)
- ZANOTTO, E. D. – Bem-vindos à era do vidro, I Colóquio sobre Materiais da UFCG, June 23, 2020. (Plenary)
- ZANOTTO E. D. – Design of vitreous and crystalline materials via AI – SEMMAT 2020- October, UFF, Plenary (online).

2021

- ZANOTTO E. D Glass greats – Penn State Meeting of Young Researchers- State College, USA – July (INVITED online).
- ZANOTTO E. D. four international invited talks canceled due to COVID.

- ZANOTTO E. D.- Machine learning guided design of glasses – 17a Semana Nacional de C e T – October, Plenary (online) – (24) 17a. SNCT: Palestras – Segunda-feira 19/10 – YouTube.
- ZANOTTO, E. D. Palestra II SerCET – (24) II SerCET – Módulo 1: Conteúdos e Aplicações do Ensino Remoto nas Engenharias e Exatas, YouTube (Invited)
- ZANOTTO E. D. Glass wonders- IT Maranhão Meeting (Invited)
- ZANOTTO, E. D. Glass-ceramics V EPCEM- FEIS, Unesp, Ilha Solteira, August 2021 (Invited)
- ZANOTTO, E. D. Designing glasses by artificial and native intelligence, X SEMAT, USP, Lorena, Sept. 2021 (Invited)
- ZANOTTO, E. D. V SiPGEM-USP, Sept. 2021, Dicas de um editor sênior (Invited)
- ZANOTTO, E. D. 13ª SAEMAT, UFSC, Nov. 2021, Florianópolis- Novos vidros via IA (Invited)
- ZANOTTO, E. D. 22ª EENG, UFNF, Petrópolis Nov 2021, Mitos e maravilhas dos vidros (Invited)
- ZANOTTO, E. D. 2a IMMSEM, IFM, São Luis, Nov. 2021, Novos vidros via IA (Keynote)

2022

- ZANOTTO, E. D., Glass education worldwide. Opening Ceremony of the International Year of Glass (IYOG), United Nations headquarters, Geneva, Switzerland, February 2022. (Plenary)
- ZANOTTO, E. D., Particulars of Crystal Nucleation below Tg, Crystallization meeting, Aachen, Germany, Feb. 2022. (Invited)
- ZANOTTO, E. D., Welcome to the glass age- “ED Zanotto” workshop on glass – Université Libre de Bruxelles, Belgium, April 2022. (Opening talk)
- ZANOTTO, E. D., Experimental, theoretical calculations and computer simulations of crystal nucleation in SCLs and glasses, “ED Zanotto” workshop on glass – Université Libre de Bruxelles, Belgium, April 2022. (Invited)
- ZANOTTO, E. D. (com vários coautores), Internacionalização e Pesquisa Colaborativa – ACIESP webinários em comemoração aos 60 anos da Fapesp, São Paulo, May 2022. (Invited)
- ZANOTTO, E. D., SEMa, EESC/USP, São Carlos, May 2022, Maravilhas e mitos do vidro (Plenary)
- ZANOTTO, E. D., 65th CBC – Congresso Brasileiro de Cerâmica, Águas de Lindoia, June 2022. Welcome to the glass age (Opening talk- Plenary)
- ZANOTTO, E. D., SBPC 2022 – Festschrift – Homenagem ao prof. Oswaldo L. Alves, Maceió, June 2022, ‘O. L. Alves: Cientista, “vidreiro” e gentleman’ (Invited)
- ZANOTTO, E. D., R&D in vitreous materials in the Americas: Current efforts and a look into the future, Pan American Ceramics Congress (PACC) – American Ceramic Society, Panama City, Panamá, 25/07/2022 (Plenary Opening)
- ZANOTTO, E. D., Successful machine learning-guided design of novel glasses, International Materials Research Congress 2022, Cancún, México, 08/2022. (Invited)
- ZANOTTO, E. D., Glass Research in China and Worldwide, 12th Functional glasses symposium, Wuhan (online), China, 08/2022. (Keynote)
- ZANOTTO, E. D., Experimental, Simulation and Theoretical analyses of crystal nucleation in SCLs and glasses, ICA CGC 2022, Kolkata (online), India, 23/08/2022. (Plenary)
- ZANOTTO, E. D., Designing glasses and glass-ceramics by native and artificial intelligence, Academy of Dental Materials Conference – ADM 2022, Atenas, Greece, 30/09/2022. (Plenary)
- ZANOTTO, E. D., Bem-vindos-vindos à Era do Vidro, XXIV Semana da Física, UEPG (online), 22/09/2022. (Invited)
- ZANOTTO, E. D., Glass research in Brazil and Worldwide, SBPMat – BrazGlass Symposium, Foz do Iguaçu-PR, 26/09/2022 (invited)
- ZANOTTO, E. D., Designing optical glasses by ML, SBPMat – Optical materials Symposium, Foz do Iguaçu-PR, 26/09/2022 (invited)
- ZANOTTO, E. D., Vidros: da alquimia à IA, IQSC-USP, IQRP-USP e SemQui-UFSCar, São Carlos-SP, 10/2022. (Invited)
- ZANOTTO, E. D., Vidros: da pedra lascada à inteligência artificial, 24º Congresso Brasileiro de Engenharia e Ciência dos Materiais (24 CBECIMAT), Águas de Lindoia-SP, 11/2022 (Plenary Opening talk)
- ZANOTTO, E. D., O Impacto do Brasil na ciência e tecnologia de vidros, 5th Encontro Vidreiro, (online), 11/2022 (Invited)
- ZANOTTO, E. D., Glass-ceramics, 23rd EENG-UNF, (online), 11/2022 (Invited)
- ZANOTTO, E. D., Vidros: da alquimia à IA, SEM QUI – UFSCar, São Carlos-SP, 11/2022 (Invited)

- ZANOTTO, E. D., Understanding and developing novel glasses by ML, ICTP – International Center for Theoretical Physics / SAIFR – South American Institute for Fundamental Research, IFT-UNESP, São Paulo, 09/2022. (Invited)

2023

- ZANOTTO, E. D. – CeRTEV Science and Technology, Baylat-Fapesp workshop, São Carlos, Feb. 6th- 2023. (Invited)
- ZANOTTO, E. D. – Em busca de métricas mais justas – Annual Evaluation meeting of the Centro de Citricultura do Estado, Cordeirópolis, March 3, 2023. (Invited)
- ZANOTTO, E. D. – Ceramics research at DEMa-UFSCar. DEMa Freshmen (calouros) reception week – São Carlos, May 9, 2023 (Invited)
- ZANOTTO, E. D. – "Cracking the Kauzmann Paradox", Atomistic Simulations Challenges, Corning, NY, July 2023. (Invited)
- ZANOTTO, E. D. – "Crystal Nucleation and Growth Dynamics in Supercooled and Glassy Lithium Diborate", "Borate & Phosphate III – 10th International Conference on Borate Glasses, Crystals, and Melts – 3rd International Conference on Phosphate Materials workshop" Corning, NY, 19-21/07/2023 (Invited)
- ZANOTTO, E. D. – C&T de Vidros: Histórico, presente e futuro, 1º Workshop de Materiais Fotônicos do IQAr, Instituto de Química, UNESP, Araraquara-SP, 31/07 – 02/08/2023. (Invited)
- ZANOTTO, E. D., Cracking the Kauzmann paradox: A Tribute to Prof. I. Gutzow, Eighth Balkan Conference on Glass Science and Technology and the 20th Conference on Glass and Ceramics, Nessebar, Bulgaria, 2023 (Opening talk)
- ZANOTTO, E. D. A tribute to my mentor – Aldo Craievich memorial symposium, CNPEN, Campinas, Nov. 2023 (Invited)
- ZANOTTO, E. D. Glass-ceramics. 38th Sisecan Simposium on Glass Science and Technology, Istanbul, Turkey, Nov. 2023. (Invited)
- ZANOTTO, E. D. – Fundamentals of Crystal Nucleation in SCLs and Glasses, II Baylat-Fapesp workshop, Erlangen, Germany, December 2023 (Invited)

2024

- ZANOTTO, E. D. – Fundamentals and Applications of Glass Crystallization – 6-hour short course delivered at the GOMD meeting in Las Vegas to 11 attendees in May 2024.
- ZANOTTO, E. D. – Unlocking crystal nucleation in SCLs and glasses, Frontiers of Glass Science Award Lecture, GOMD, Las Vegas, May 2024. (Plenary)
- ZANOTTO, E. D. – Understanding glass via DSC, Delbert Day Honorary Memorial Symposium, Las Vegas, May 2024. (Invited)
- ZANOTTO, E. D. – A new proxy for nucleation diffusivity, 2024 Glass & Optical Materials Division Annual Meeting (GOMD 2024), Las Vegas, May 2024. (Guru Chela Award talk, Mark Davis Memorial Symposium)
- ZANOTTO, E. D. – Reassessing crystal nucleation in SCls and glasses,15th European Society of Glass Conference, 15th International Conference on the Structure of Non-Crystalline Materials and Annual Conference of the Society of Glass Technology, Cambridge, England, July 2024. (Opening plenary)
- ZANOTTO, E. D. – How you can get your papers published. Tips from a seasoned journal editor – Keynote talk (online) – 14th Congress of the Iranian Ceramic Soc. – Teerã – Iran – September 2024
- ZANOTTO, E. D. – Fundamentals of Crystal nucleation in SCls and glasses – 5th Wuhan School of Glasses – Wuhan, China, November 2024. (Invited)
- ZANOTTO, E. D. – Nucleation and relaxation in GF systems – AGC research center, Japan, December 2024. (Invited)

2025

- ZANOTTO, E. D. – Cracking Crystal Nucleation in SCLs and Glasses During the Pandemic, Kolkata, Índia, XXVII International Congress on Glass 2025, January 20-24, 2025. ICG president award talk, S. Banerjee Memorial Lecture (Plenary)
- ZANOTTO, E. D.- Fundamentals of Glass Crystallization, São Paulo, III International School on Soft Matter, ICTP-UNESP, Brazil, (Opening Lecture)

- ZANOTTO, E. D. – Intrinsic versus Extrinsic Glass Forming Ability. Avoiding Devitrification – 17th PNCS, Tsukuba, Japan, Aug. 2025 (Invited)
- ZANOTTO, E. D.- Assessing GFA by Experiments, Theoretical Approaches and Computer Simulations – MS&T, Columbus, USA, Invited, (Opening Talk)
- ZANOTTO, E. D.- Glass-forming ability and glass stability – 1st China-Brazil Workshop on Glasses: Earth, Aircraft, Planets, and Engineering, Hangzhou, China. (Invited lecture)
- ZANOTTO, E. D. – Materiais Vítreos: da Idade da Pedra até IA – XV SEMA (Semana de Engenharia de Materiais) – EESC, USP, São Carlos, Brasil. (invited)

2026 (August)

- ZANOTTO, E.D. - Critical assessment of GFA by Experiments, Theory, MD and ML simulations - 70th ABCeram Congress, Iguaçu Falls, BR, June 2026 (Opening Plenary)
- ZANOTTO, E.D.- Intrinsic vs. Extrinsic GFA. PNCS 17th, Tsukuba, Japan. Aug. 2025 (Invited)
- ZANOTTO, E.D. - GFA assessed by Experiments, Theory, and Simulations. MS&T, Columbus, USA. Sept. 2025 (Invited)
- ZANOTTO, E.D. - 70-year perspective on GFA, 1rst China-Brazil Workshop on Glasses, Beihang University, Hangzhou, China, Oct. 2025 (Invited)
- ZANOTTO, E.D. - Welcome to the Glass Age, WUT, China, March 2026 (Invited)
- ZANOTTO, E.D. - GFA assessment by Experiments, Theory, Simulations and ML, ICG 2026, Lyon, France, April 2026 (Invited)
- ZANOTTO, E.D. - Artificial and Native Intelligence-Driven Design of Glasses for Energy, FAPESP Week, Science Museum, London, June 2026 (Invited)
- ZANOTTO, E.D. - SGT Luncheon lecture, Cracking the Kauzmann Paradox, June 2026. (Invited)

Science Outreach and Media Coverage

Prof. Zanotto strongly advocates science outreach and believes that it deserves greater attention and effort from the research community. His research and educational activities have been featured in numerous media outlets; the links below reproduce the unique entries in the source CV.

agencia.fapesp.br/pesquisador-da-ufscar-recebe-principal-premio-da-area-de-materiais-vitreos/53779

ceramics.org/ceramic-tech-today/glass-1/new-solid-state-nmr-strategy-cracks-open-the-black-box-of-crystal-nucleation-in-glass

ceramics.org/ceramic-tech-today/basic-science/unveiling-the-hidden-role-of-intermediate-oxides-in-glass

www.laserfocusworld.com/optics/article/14299972/niobium-oxide-plays-a-network-former-role-within-silicate-glass-structures

ceramics.org/ceramic-tech-today/glass-1/retiring-the-kauzmann-paradox-a-call-to-focus-future-glass-research-elsewhere

phys.org/news/2017-10-solid-liquid-definition-glass.html

www.chemistryworld.com/news/glass-should-be-redefined-as-a-liquid/3008199.article

usglassmag.com/2014/12/study-shows-china-surpassing-u-s-glass-research

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lamav.weebly.com/uploads/5/9/0/2/5902800/gomd_2012_edz.pdf

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Books, Prefaces, and Publications

Books

E. D. Zanotto – *Crystals in Glass: A Hidden Beauty*, ISBN: 978-1-118-55891- 136 Pages, Wiley, New York (2013)

E. D. Zanotto – *Cristais em Vidros – Ciência e Arte*, ISBN 978-85-7600-253-6, 124 pages, Editora UFSCar, São Carlos (2011)

M. A. Aegerter, M. Jafelicci, D. M. P. Souza and E. D. Zanotto (editors) – *Sol-Gel Science and Technology,* World Scientific (1990).

Book Forewords and Prefaces

Zanotto, E. D. – Preface (2017) of "From glass to crystal" by Neville, D. et al., EDP Sciences, Paris, France

Zanotto, E. D. – Preface (2017) of "Functional Glasses and Glass-ceramics" by Basudeb Karmakar, Editor BH, Kolkata, India.

Zanotto, E. D. – Foreword (2014) of "Glass: Selected Properties and Crystallization", J. W. P. Schmelzer (Ed.), De Gruyter, Berlin, Germany

Zanotto, E. D. – Foreword (2011) of "Glasses and the Glass Transition", By J. W. P. Schmelzer et al., Wiley-VCH, Weinheim, Germany

Zanotto, E. D. – Preface (2012) of the SciGlass database by Oleg Mazurin

Book Chapters ~20

APPENDIX

Selected (Preferred) Publications by Subject

Articles in high-impact journals: 23 articles in Acta Materialia (IF ~11), 3 in International Materials Reviews (IF ~17), 2 in Progress in Materials Science (IF ~43), 1 in Nature (IF ~53), 2 in Chemical Reviews (IF ~ 63), and 1 in Nature Communications (IF ~17).

Machine Learning

★ Mannan, S., Zaki, M., Bishnoi, S., Cassar, D.R., Jiusti, J., Faria, J.C.F., Christensen, J.F.S., Gosvami, N.N., Smedskjaer, M.M., Zanotto, E.D., Krishnan, N.M.A. Glass hardness: Predicting composition and load effects via symbolic reasoning-informed machine learning (2023) Acta Materialia, 255, art. no. 119046.

★ Mastelini, S.M., Cassar, D.R., Alcobaça, E., Botari, T., de Carvalho, A.C.P.L.F., Zanotto, E.D. Machine learning unveils composition-property relationships in chalcogenide glasses (2022) Acta Materialia, 240, art. no. 118302.

★ Cassar, D.R., Mastelini, S.M., Botari, T., Alcobaça, E., de Carvalho, A.C.P.L.F., Zanotto, E.D. Predicting and interpreting oxide glass properties by machine learning using large datasets (2021) Ceramics International, 47 (17), pp. 23958-23972.

★ Cassar, D.R., Santos, G.G., Zanotto, E.D. Designing optical glasses by machine learning coupled with a genetic algorithm (2021) Ceramics International, 47 (8), pp. 10555-10564.

★ Alcobaça, E., Mastelini, S.M., Botari, T., Pimentel, B.A., Cassar, D.R., de Carvalho, A.C.P.D.L.F., Zanotto, E.D. Explainable Machine Learning Algorithms for Predicting Glass Transition Temperatures (2020) Acta Materialia, 188, pp. 92-100.

★ Cassar, D.R., de Carvalho, A.C.P.L.F., Zanotto, E.D. Predicting glass transition temperatures using neural networks (2018) Acta Materialia, 159, pp. 249-256.

Glass Structure and Crystallization

★ Zielasko W., de Oliveira R.B., Zanotto E.D., Hansen M.R., Eckert H., Bradtmüller H. Contrasting structural roles of Nb_2O_5 vs. La_2O_3 in silicate glasses: a quantitative solid-state NMR study (2025) Acta Materialia, 297, art. no. 121343,

★ Bradtmüller H., Zheng Q., Eckert H., Zanotto E.D. Quantitative structural characterization of $LiNbO_3$-SiO_2 glass-ceramics by multinuclear solid-state NMR (2024) Journal of Non-Crystalline Solids, 641, art. no. 123096.

★ Bradtmüller, H., Zheng, Q., Gaddam, A., Eckert, H., Zanotto, E.D. Structural impact of niobium oxide on lithium silicate glasses: Results from advanced interaction-selective solid-state nuclear magnetic resonance and Raman spectroscopy (2023) Acta Materialia, 255, art. no. 119061

★ Kirchner, K.A., Cassar, D.R., Zanotto, E.D., Ono, M., Kim, S.H., Doss, K., Bødker, M.L., Smedskjaer, M.M., Kohara, S., Tang, L., Bauchy, M., Wilkinson, C.J., Yang, Y., Welch, R.S., Mancini, M., Mauro, J.C. Beyond the Average: Spatial and Temporal Fluctuations in Oxide Glass-Forming Systems (2021) Chemical Reviews

★ Moulton, B.J.A., Silva, L.D., Doerenkamp, C., Lozano, H., Zanotto, E.D., Eckert, H., Pizani, P.S. Speciation and polymerization in a barium silicate glass: Evidence from 29Si NMR and Raman spectroscopies (2021) Chemical Geology, 586, art. no. 120611.

★ Bradtmüller, H., Villas-Boas, M.C., Zanotto, E.D., Eckert, H. Structural aspects of the glass-to-crystal transition in sodium-calcium silicate glasses (2020) Journal of Non-Crystalline Solids, 535, art. no. 119844

★ Bradtmüller, H., Cerrutti, B.M., Souza, M.T., Zanotto, E.D., Eckert, H. Structural characterization of boron-containing glassy and semi-crystalline Biosilicate® by multinuclear NMR (2019) Journal of Non-Crystalline Solids, 505, pp. 390-399.
Additional topical classification: Bioactive Glasses.

★ Mastelaro, V.R., Zanotto, E.D. - X-ray Absorption Fine Structure (XAFS) studies of oxide glasses-A 45-year overview- (2018) Materials, 11 (2), art. no. 204 (INVITED)

★ Zanotto, E.D., Tsuchida, J.E., Schneider, J.F., Eckert, H.- Thirty-year quest for structure-nucleation relationships in oxide glasses (2015) International Materials Reviews, 60 (7), pp. 376-391.

★ Chen, B., Werner-Zwanziger, U., Zwanziger, J.W., Nascimento, M.L.F., Ghussn, L., Zanotto, E.D.- Correlation of network structure with devitrification mechanism in lithium and sodium diborate glasses (2010) Journal of Non-Crystalline Solids, 356 (44-49), pp. 2641-2644.

★ Chen, B., Ulrike, W.-Z., Nascimento, M.L.F., Ghussn, L., Zanotto, E.D., Zwanziger, J.W.- Structural similarity on multiple length scales and its relation to devitrification mechanism: A solid-state NMR study of alkali diborate glasses and crystals (2009) Journal of Physical Chemistry C, 113 (48), pp. 20725-20732.

★ Longstaffe, J.G., Werner-Zwanziger, U., Schneider, J.F., Nascimento, M.L.F., Zanotto, E.D., Zwanziger, J.W.- Intermediate-range order of alkali disilicate glasses and its relation to the devitrification mechanism (2008) Journal of Physical Chemistry C, 112 (15), pp. 6151-6159.

★ Schneider, J., Mastelaro, V.R., Zanotto, E.D., Shakhmatkin, B.A., Vedishcheva, N.M., Wright, A.C., Panepucci, H.- Qn distribution in stoichiometric silicate glasses: Thermodynamic calculations and 29Si high resolution NMR measurements (2003) Journal of Non-Crystalline Solids, 325 (1-3), pp. 164-178.

★ Mastelaro, V.R., Zanotto, E.D., Lequeux, N., Cortès, R.- Relationship between short-range order and ease of nucleation in Na2Ca2Si3O9, CaSiO3 and PbSiO3 glasses (2000) Journal of Non-Crystalline Solids, 262 (1), pp. 191-199.

★ Schneider, J., Mastelaro, V.R., Panepucci, H., Zanotto, E.D.- 29Si MAS-NMR studies of Qn structural units in metasilicate glasses and their nucleating ability (2000) Journal of Non-Crystalline Solids, 273 (1-3), pp. 8-18.

★ Muller, E., Heide, K., Zanotto, E.D.- Molecular structure and nucleation in silicate glasses (1993) Journal of Non-Crystalline Solids, 155 (1), pp. 56-66.

★ Müller, E., Heide, K., Zanotto, E.D.- Influence of cation coordination on nucleation in silicate glasses (1992) Zeitschrift fur Kristallographie - New Crystal Structures, 200 (3-4), pp. 287-294.

Relaxation and Glass Transition

★ Lancelotti R.F., Pereira L., Rosante R.B., Andersen M., Hess K.-U., Dingwell D.B., Zanotto E.D., Sen S. Relaxation Kinetics in Temperature Jump Experiments Above Calorimetric Glass Transition via Fast Scanning Calorimetry (2026) Journal of the American Ceramic Society, 109 (3), art. no. e70618,

★ Lancelotti R.F., Chuang S.-Y., Zanotto E.D., Sen S. Effect of physical aging on ionic conductivity of network oxide glasses (2025) Acta Materialia, 285, art. no. 120658,

★ Lancelotti R.F., Pereira L., Hess K.-U., Dingwell D.B., Zanotto E.D. Flash-DSC provides valuable insights into glass relaxation and crystallization (2024) Journal of Non-Crystalline Solids, 646, art. no. 123242.

Additional topical classification: Overall Crystallization, Glass-Forming Ability, and Glass Stability.

★ Lancelotti R.F., Zanotto E.D., Sen S. Atomistic origin of structural relaxation in lead metasilicate and lithium disilicate glasses (2024) Journal of the American Ceramic Society, 107 (11), pp. 7131 - 7141.

★ Lancelotti R.F., Zanotto E.D., Sen S. Kinetics of physical aging of a silicate glass following temperature up- and down-jumps (2024) Journal of Chemical Physics, 160 (3), art. no. 034504.

★ Rodrigues L.R., Abyzov A.S., Fokin V.M., Acosta M.H.R., Nascimento M.L.F., Davydov L.N., Zanotto E.D. Unveiling crystallization and relaxation dynamics interplay in a deeply supercooled glass (2024) Scripta Materialia, 246, art. no. 116085.

Additional topical classification: Overall Crystallization, Glass-Forming Ability, and Glass Stability.

★ Lancelotti, R.F., Cunha, T.R., Kurtovic, M.A.C., Pizani, P.S., Sen, S., Zanotto, E.D. Physical aging of lithium disilicate glass (2023) Journal of Non-Crystalline Solids, 622, art. no. 122661.

★ Lancelotti, R.F., Rodrigues, A.C.M., Zanotto, E.D. Structural relaxation dynamics of a silicate glass probed by refractive index and ionic conductivity (2023) Journal of the American Ceramic Society, 106 (10), pp. 5814-5821.

★ Welch, R.S., Zanotto, E.D., Wilkinson, C.J., Cassar, D.R., Montazerian, M., Mauro, J.C. Cracking the Kauzmann paradox (2023) Acta Materialia, 254, art. no. 118994.

Additional topical classification: Crystal Nucleation.

★ Bradtmüller, H., Gaddam, A., Eckert, H., Zanotto, E.D. Structural rearrangements during sub-Tg relaxation and nucleation in lithium disilicate glass revealed by a solid-state NMR and MD strategy (2022) Acta Materialia, 240, art. no. 118318.

Additional topical classification: Crystal Nucleation.

★ Passos, R.C.D., Cassar, D.R., Zanotto, E.D. Crystallization and relaxation dynamics of glass-forming liquids at the Kauzmann temperature (2022) Ceramics International, 48 (10), pp. 13440-13451.

★ Rodrigues, L.R., Abyzov, A.S., Fokin, V.M., Schmelzer, J.W.P., Zanotto, E.D. Relaxation effect on crystal nucleation in a glass unveiled by experimental, numerical, and analytical approaches (2022) Acta Materialia, 223, art. no. 117458.

Additional topical classification: Crystal Nucleation.

★ Fokin, V.M., Abyzov, A.S., Yuritsyn, N.S., Schmelzer, J.W.P., Zanotto, E.D. Effect of structural relaxation on crystal nucleation in glasses (2021) Acta Materialia, 203, art. no. 116472.

Additional topical classification: Crystal Nucleation.

★ Lancelotti, R.F., Cassar, D.R., Nalin, M., Peitl, O., Zanotto, E.D. Is the structural relaxation of glasses controlled by equilibrium shear viscosity? (2021) Journal of the American Ceramic Society, 104 (5), pp. 2066-2076.

★ Rodrigues, L.R., Abyzov, A.S., Fokin, V.M., Zanotto, E.D. Effect of structural relaxation on crystal nucleation in a soda-lime-silica glass (2021) Journal of the American Ceramic Society, 104 (7), pp. 3212-3223.

Additional topical classification: Crystal Nucleation.

★ Schmelzer, J.W.P., Tropin, T.V., Fokin, V.M., Abyzov, A.S., Zanotto, E.D. Effects of glass transition and structural relaxation on crystal nucleation: Theoretical description and model analysis (2020) Entropy, 22 (10), art. no. 1098, pp. 1-36.

★ Zanotto, E.D., Cassar, D.R. The race within supercooled liquids - Relaxation versus crystallization (2018) Journal of Chemical Physics, 149 (2), art. no. 024503.
Additional topical classification: Crystal Nucleation.

★ Zanotto, E.D., Mauro, J.C. - The glassy state of matter: Its definition and ultimate fate (2017) Journal of Non-Crystalline Solids, 471, pp. 490-495.
Listed among the articles attracting the most media attention.

★ Zanotto, E.D., Gupta, P.K. - Do cathedral glasses flow? - Additional remarks (1999) American Journal of Physics, 67 (3), pp. 260-262. *Listed among the articles attracting the most media attention.*

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Molecular-Dynamics Simulations of Relaxation and Crystallization

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Crystal Growth in Supercooled Liquids

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Surface Crystallization

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Patents and Licensed Technologies

Patent Portfolio

The source CV reports 26 Brazilian patent applications deposited at the Brazilian Patent and Trademark Office (INPI) and 10 patents in other countries. Most international filings were first deposited in Brazil, and the source notes that several jurisdictional records repeat the same invention.

Licensed Technologies

No. and Codes	Technology and Company	Status and Agreement
No. 1 Agência de Inovação: 2002/008 INPI: PI0300644-1	**PROCESSO DE PREPARAÇÃO DE BIOSILICATOS PARTICULADOS, BIOATIVOS E REABSORVÍVEIS, COMPOSIÇÕES PARA PREPARAR DITOS BIOSILICATOS E BIOSILICATOS PARTICULADOS BIOATIVOS E REABSORVÍVEIS.** Company: VITROVITA - Instituto de Inovação em Vitrocerâmicos LTDA EPP	Status: Não Ativo Exclusive: Sim Signed: 24/11/2009 Term: 24/11/2019
No. 2 Agência de Inovação: 2011/003 INPI: PI0005482-8	**PROCESSO PARA OBTENÇÃO DE VIDRO NEGRO E VITROCERÂMICA ESCURA A PARTIR DE ESCÓRIA DE ACIARIA.** Company: Usinas Siderúrgicas de Minas Gerais S. A. - USIMINAS	Status: Não Ativo Exclusive: Não Signed: 25/11/2011 Term: —
No. 3 Agência de Inovação: 2013/001 INPI: BR 10 2014 003817-5	**PROCESSO DE RECOBRIMENTO DESCONTÍNUO UTILIZANDO UM BIOMATERIAL BIOABSORVÍVEL E BIOATIVO APLICADO SOBRE SUBSTRATOS SÓLIDOS, RECOBRIMENTO DESCONTÍNUO E SEU USO** Company: VETRA PESQUISA E DESENVOLVIMENTO DE PRODUTOS CERÂMICOS DE ALTA TECNOLOGIA LTDA - ME	Status: Ativo Exclusive: Signed: 24/08/2015 Term: 24/08/2025
No. 4 Agência de Inovação: 2013/002 INPI: BR 10 2013 020961-9	**COMPOSIÇÃO VÍTREA, FIBRAS E TECIDOS VÍTREOS BIOATIVOS E ARTIGOS** Company: VETRA PESQUISA E DESENVOLVIMENTO DE PRODUTOS CERÂMICOS DE ALTA TECNOLOGIA LTDA - ME	Status: Ativo Exclusive: Signed: 24/08/2015 Term: 24/08/2025

Acknowledgments

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† Deceased, as indicated by the plus signs.

Appendix

REGISTERED PATENTS

26 Brazilian patents deposited at INPI – Brazilian Patent Office

Source: INPI (Brazilian Patent and Trademark Office) records search under inventor "Edgar Dutra Zanotto," updated 10 May 2025. 25 of the 26 applications listed in the Patent Portfolio summary above were located in this search.

Application No.	Filing Date	Title	IPC Class
BR 10 2021 007715 8	22/04/2021	Compósito magnético de matriz vítrea bioativa para hipertermia de tumores ósseos e processo de obtenção	C03C 3/00
BR 10 2020 023996 1	25/11/2020	Cimento ósseo à base de vitrocerâmicas bioativas (biosilicato) para aplicações em ortopedia e odontologia	A61K 6/853
BR 10 2020 017697 8	31/08/2020	Processo de preparação de enxertos ósseos e enxertos ósseos obtidos	A61L 27/10
BR 10 2018 072046 5	25/10/2018	Processo de obtenção de enxertos ósseos bioativos por impressão 3d e produtos obtidos	A61L 27/10
BR 10 2018 016342 6	09/08/2018	Processo de obtenção de compósito bioativo e magnetocalórico para o tratamento de tumores por hipertermia e produto obtido	C03C 3/04
BR 10 2017 010648 9	22/05/2017	Implante para repor volume em cavidades anoftálmicas em humanos ou animais, processo de obtenção do mesmo, dispositivo para fresamento de implantes e seu uso	A61F 2/14
BR 10 2017 005425 0	17/03/2017	Compósito vidro-mineral e processo de sinterização para obtenção de compósito vidro-mineral	C04B 32/00
BR 10 2016 018179 8	05/08/2016	Vitrocerâmicas usináveis de alta tenacidade à fratura e uso das mesmas	C03C 10/04
BR 10 2016 002224 0	01/02/2016	Compósitos biomiméticos compreendendo alto teor de carga à base de quitosana e biocerâmica, processo para preparação dos ditos compósitos e seu uso em engenharia de tecidos	C03C 21/00
BR 10 2014 032548 4	23/12/2014	Conduíte tubular à base de fibras de vidro bioativo e biorreabsorvível para regeneração de tecido nervoso periférico e processo de obtenção do mesmo	A61L 27/24
BR 10 2014 023349 0	19/09/2014	Equipamento e método para a obtenção de fibras por puxamento a partir de composições de baixa estabilidade vítrea	C03B 37/01
BR 10 2014 003817 5	19/02/2014	Processo de recobrimento descontínuo utilizando um biomaterial bioabsorvível e bioativo aplicado sobre substratos sólidos, recobrimento descontínuo e seu uso	A61L 27/28
BR 10 2013 020961 9	12/08/2013	Composição vítrea, fibras e tecidos vítreos bioativos e artigos	C03C 3/078
BR 10 2013 017769 5	26/06/2013	Composições vitrocerâmicas, vitrocerâmicas obtidas, armadura de sacrifício e artigo para proteção balística	C03C 10/02
PI 1101885-2	11/04/2011	Composições de vidros li20-al203-si02, processo de otenção de vitrocerâmicas sinterizadas a partir das mesmas, vitrocerâmicas obtidas e uso das mesmas	C03C 3/085

Application No.	Filing Date	Title	IPC Class
PI 1003676-8	06/04/2010	Suspensões para preparação de enxertos ósseos (scaffolds) à base de biosilicato, enxertos ósseos obtidos e processos de obtenção dos mesmos	A61L 27/10
PI 0301484-3	26/05/2003	Processo para obtenção de artigos vítreos e vitrocerâmicos e artigos vítreos e vitrocerâmicos assim obtidos	C03B 19/06
PI 0300644-1	20/02/2003	Processo de preparação de biosilicatos particulados, bioativos e reabsorvíveis, composições para preparar ditos biosilicatos e biosilicatos particulados bioativos e reabsorvíveis	A61Q 11/00
PI 0005482-8	19/10/2000	Processo para obtenção de vidro negro e vitrocerâmica escura a partir de escória de aciaria	C22B 7/04
PI 9503134-0	11/08/1995	Giz cerâmico macio, durável e antialérgico e processo para preparar o mesmo	C09D 13/00
MU 7400319-4	29/03/1994	Dispositivo para auto-limpeza de piscinas	E04H 4/12
PI 8704534-6	04/08/1987	Processo de fabricação de condutores à base de supercondutores óxidos	H01B 1/12
PI 8703412-3	08/06/1987	Processo de fabricação de fibras cerâmicas á base de supercondutores óxidos e produto resultante	C04B 35/00
PI 8703413-1	08/06/1987	Processo de fabricação de condutores à base de supercondutores óxidos e produto resultante	C04B 35/00
PI 8703419-0	08/06/1987	Processo de fabricação de condutores á base de supercondutores óxidos	H01L 39/12

Registered Software

REFORMIX 20 — software registration no. 01036-5, filed 17 February 1995 (INPI).

Patents by Others Citing This Research

Two U.S. patents on soda-lime-silica glass-ceramics (US 10,995,031 and US 10,273,183), held by other parties, build directly on the group’s published soda-lime-silica glass-ceramic research.

VIDEOS

CURATED REFERENCE GUIDE

PUBLIC VIDEO LINKS ABOUT PROFESSOR EDGAR DUTRA ZANOTTO

Achievements, awards, research discoveries, interviews and lectures

Publicly accessible sources | Verified through 10 August 2026

Verified public video links concerning Professor Edgar Dutra Zanotto's awards, career, research discoveries, interviews, plenary/keynote talks, lectures and recorded classes.

Principal source hubs

1. **CeRTEV educational-video catalogue**
   https://www.certev.ufscar.br/en/education/educational-videos
2. **CeRTEV YouTube playlists**
   https://www.youtube.com/@CeRTEVUFSCar/playlists
3. **LaMaV historical news archive** - *Includes dated links to pre-2013 broadcasts and research videos.*
   https://lamav.weebly.com/news.html
4. **DEMa/UFSCar historical media archive** - *Official source for the three-part Globo Universidade feature.*
   https://www.ccema.ufscar.br/sobre-nos/dema-ufscar-na-midia

Awards, career and institutional achievements

5. **2025 ICG President's Award - UFSCar announcement video**
   https://www.instagram.com/reel/DF6AYA1hheU/
6. **2025 ICG President's Award - Facebook mirror**
   https://www.facebook.com/ufscaroficial/videos/o-professor-edgar-dutra-zanotto-do-departamento-de-engenharia-de-materiais-dema-/612711268067388/
7. **2023 CONFAP Science, Technology and Innovation Award ceremony**
   https://www.youtube.com/watch?v=hsMk5KDAI9U
8. **2023 National CONFAP Forum - full event containing the award announcement**
   https://www.youtube.com/watch?v=L_9MXfHNLbU&t=8s
9. **Histórias dos 50 anos do DEMa - Prof. Edgar Dutra Zanotto**
   https://www.youtube.com/watch?v=T0YiCa5kIoY
10. **LaMaV: 40 Years of Research and Education**
    https://www.youtube.com/watch?v=n9r_Y4ZfCYs
11. **LaMaV 40th anniversary - complete playlist**
    https://www.youtube.com/playlist?list=PLYkqBrOsu1yCTDhVjVT8PLiwyEXF8R-qX
12. **LaMaV 40 years - opening**
    https://www.youtube.com/watch?v=APHHjzRxkmQ
13. **LaMaV 40 years - historical retrospective**
    https://www.youtube.com/watch?v=hpAZqWKpbpI
14. **LaMaV 40 years - Fire Talks**
    https://www.youtube.com/watch?v=r0mt1JlidrE
15. **LaMaV 40 years - tributes**
    https://www.youtube.com/watch?v=88i8s2rDgy4
16. **LaMaV 40 years - closing**
    https://www.youtube.com/watch?v=9rHsNkQZx5E

17. **LaMaV 40 years - glass-gourd berimbau premiere**
    https://www.youtube.com/watch?v=ovrA15mJov0
18. **A Ciência que eu Faço - Part 1**
    https://www.youtube.com/watch?v=9C3nxr_-Xao
19. **A Ciência que eu Faço - Part 2**
    https://www.youtube.com/watch?v=BQvLP1IHtqk
20. **A Ciência que eu Faço - Part 3**
    https://www.youtube.com/watch?v=mliu81Tc3-g
21. **100 Years of the Brazilian Academy of Sciences - Exact Sciences and Engineering** *- Zanotto segment: 00:00-16:09.*
    https://www.youtube.com/watch?v=gNMzFJZROrw

Interviews, profiles and public-science appearances

22. **Paideia interview with Edgar Dutra Zanotto**
    https://www.youtube.com/watch?v=0knmwk9Vt3A
23. **A Sip of Chemistry - interview with Prof. Edgar D. Zanotto**
    https://www.youtube.com/watch?v=jL3yuzbwFHI
24. **International Year of Glass interview - Rede PEA-UNESCO**
    https://www.youtube.com/watch?v=CeUejX7zWwQ
25. **Em Resumo #7 - Rádio UFSCar**
    https://www.youtube.com/watch?v=PBPgeZX3ncI
26. **SBPC 2015 - interview with Elson Longo and Edgar Zanotto**
    https://www.youtube.com/watch?v=ylui3XM4mfk
27. **Materiais vítreos e suas aplicações - ClickCiência interview**
    https://www.youtube.com/watch?v=mP-nUjP4kfQ
28. **#VacinaSim - Edgar Zanotto**
    https://www.youtube.com/watch?v=MPb_nnB5xcs
29. **Student/public-science commentary based on a Zanotto interview** *- Third-party commentary, not the original interview.*
    https://www.youtube.com/watch?v=a4lrtRmGWt0
30. **Instagram interview/profile concerning glass research**
    https://www.instagram.com/p/C0wUKr4uM0C/

Keynotes, plenaries, invited talks and event lectures

31. **2025 - Fundamentals and Applications of Glass Crystallization, ICTP-SAIFR**
    https://www.youtube.com/watch?v=m9KA38CETtY
32. **2022 - A New Glass Research Center in Brazil, ICTP-SAIFR**
    https://www.youtube.com/watch?v=5HTZBqrpklg

33. **2022 UN International Year of Glass - Glass Education Worldwide** *- Zanotto begins at approximately 34:32.*
https://webtv.un.org/en/asset/k1u/k1u3669z10
34. **2022 UN International Year of Glass - afternoon-session recording**
https://webtv.un.org/en/asset/k1y/k1ywmvfssw
35. **2022 - Fundamentals and Applications of Glass Crystallization, UFRGS**
https://www.youtube.com/watch?v=e_D0iPXxaX8
36. **2022 - Vidro, os olhos da Física, Colloquium Diei**
https://www.youtube.com/watch?v=VaS0UFtCaZw
37. **2022 - Welcome to the Glass Age, XXIV UEPG Physics Week**
https://www.youtube.com/watch?v=DN38l9KRD_M
38. **2022 - Internationalization and Collaborative Research, FAPESP/ACIESP**
https://www.youtube.com/watch?v=9ZIAyTt0qro
39. **2022 - V Encontro Técnico Vidreiro** *- Zanotto's presentation begins around 32:00.*
https://www.youtube.com/watch?v=RyjyilQviYE&t=1920s
40. **2021 - UFPE scientific colloquium**
https://www.youtube.com/watch?v=5RshvhxR3jY
41. **2021 - Pesquisando e publicando com sucesso, SiPGEM**
https://www.youtube.com/watch?v=vkXu5aDmwW4
42. **2021 - Em busca de métricas mais justas para avaliar a pesquisa**
https://www.youtube.com/watch?v=LK9BdopBbnA&t=486s
43. **2021 - Engineered Glass via Artificial Intelligence, SAEMAT/UFSC**
https://www.youtube.com/watch?v=wG9bPnlHqP0
44. **2020 - Design of Vitreous and Crystalline Materials via Artificial Intelligence, SEMMat**
https://www.youtube.com/watch?v=XYr2Dsbc8f0
45. **Machine-Learning-Guided Design of Materials, 17th SNCT** *- Presentation begins around 20:40.*
https://www.youtube.com/watch?v=V9x3NpVrNJ8&t=1240s
46. **II SerCET - full session** *- Zanotto begins around 1:11:03.*
https://www.youtube.com/watch?v=DWpaXqHGU_M&t=4263s
47. **2019 - I SPIMF: Edgar Dutra Zanotto**
https://www.youtube.com/watch?v=XsESAmg8hWA
48. **2017 - Vidro: 6,000 Years of Wonders and Myths**
https://www.youtube.com/watch?v=GgzCXV349_A
49. **Vidro: 6,000 Years of Wonders and Myths - Canal USP version** *- Mirror/related version.*
https://www.youtube.com/watch?v=4RffLfpbPts
50. **2016 - Vidro: Tipos e Aplicações, VII SEMa mini-course**
https://www.youtube.com/watch?v=B4_Zj2eDoFs

51. **2015 - Center for Research, Technology and Education in Vitreous Materials**
https://www.youtube.com/watch?v=Ip1mHoZpFps

52. **2015 - XIV Brazilian MRS Meeting/SBPMat event video**
https://www.youtube.com/watch?v=Y65BHkAbgvQ

Recorded course: O Estado Vítreo

53. **O Estado Vítreo - complete postgraduate-course playlist** - *Complete course playlist.*
https://www.youtube.com/playlist?list=PLYkqBrOsu1yA2-K5wQZjn1WSs8U7BtJ-5

54. **Aula 1 - Introdução**
https://www.youtube.com/watch?v=AB9H6v3Ctew

55. **Aula 2 - Relaxação Estrutural e Estrutura**
https://www.youtube.com/watch?v=FFp9-VVKOWk

56. **Aula 3 - Separação de Fases Amorfas**
https://www.youtube.com/watch?v=sqR3d1rNibo

57. **Aula 4 - Nucleação de Cristais em Vidros**
https://www.youtube.com/watch?v=VS73bnz5_og

58. **Aula 5 - Nucleação, Part 2**
https://www.youtube.com/watch?v=CnZmpKTts7Q

59. **Aula 6 - Nucleação, Part 3**
https://www.youtube.com/watch?v=nKAIclFUPnk

60. **Aula 7 - Nucleação, Part 4**
https://www.youtube.com/watch?v=UmHHqco9cWA

61. **Fundamentals of Crystal Nucleation in Glasses**
https://www.youtube.com/watch?v=k4StIrP1CsA

62. **Aula 8 - Crescimento de Cristais**
https://www.youtube.com/watch?v=mPwnw_Z4yaE

63. **Aula 9 - Crescimento de Cristais, Part 2**
https://www.youtube.com/watch?v=HmCl7FAcQXc

64. **Aula 10 - Cristalização Total**
https://www.youtube.com/watch?v=lNWYPrsFaQI

65. **Aula 11 - Vitrocerâmicos**
https://www.youtube.com/watch?v=6Ir981BxaNg

66. **Aula 12 - Glass-Ceramics, Part 1**
https://www.youtube.com/watch?v=hoxCgVotUy8

67. **Aula 13 - Glass-Ceramics, Part 2**
https://www.youtube.com/watch?v=hquVv1vyaSM

68. **Aula 14 - Glass-Ceramics, Part 3**
https://www.youtube.com/watch?v=3gR12bamkTU

Recorded course: Estrutura e Propriedades de Vidros

69. **Estrutura e Propriedades de Vidros - complete undergraduate-course playlist** - *Complete course playlist.*
https://www.youtube.com/playlist?list=PLYkqBrOsu1yCxMLTcb7Y6zwj_smIb5w5x
70. **History, Properties and Applications**
https://www.youtube.com/watch?v=6U0IIodQujs
71. **Relaxação e Transição Vítrea**
https://www.youtube.com/watch?v=BWeQYfloCoc
72. **Relaxação e Estrutura**
https://www.youtube.com/watch?v=lpb_SiQclus
73. **Estrutura e Separação de Fases**
https://www.youtube.com/watch?v=VM9Oa8ykrfc
74. **Nucleação de Cristais**
https://www.youtube.com/watch?v=EFo-2NTkFoY
75. **Crescimento de Cristais e GFA**
https://www.youtube.com/watch?v=wSPK3n5a_hc
76. **GFA e Viscosidade**
https://www.youtube.com/watch?v=9_bJPSWCvJE
77. **Propriedades Reológicas**
https://www.youtube.com/watch?v=Ert5bRQxvjY
78. **Propriedades Térmicas**
https://www.youtube.com/watch?v=izHJaxW9wLU
79. **Propriedades Mecânicas**
https://www.youtube.com/watch?v=FTzzgVFJKCg
80. **Propriedades Elétricas**
https://www.youtube.com/watch?v=RjwLUSx99PY
81. **Choque Térmico**
https://www.youtube.com/watch?v=YZqSMj5QyJo
82. **Propriedades Ópticas, Part 1**
https://www.youtube.com/watch?v=g0MlwPRicIE
83. **Propriedades Ópticas, Part 2**
https://www.youtube.com/watch?v=tw8fPbJvNzQ

Recorded course: Formulação, Equilíbrio e Cinética entre Fases Cerâmicas

84. **Formulação, Equilíbrio e Cinética entre Fases Cerâmicas - complete playlist** - *Complete course playlist.*
https://www.youtube.com/playlist?list=PLYkqBrOsu1yDtobp84F0FUqYHVD00Dqj-
85. **Introdução, ementa, cronograma e definições**
https://www.youtube.com/watch?v=mTZQWTRp4uU

86. **Reformulação de Massas Cerâmicas**
https://www.youtube.com/watch?v=E74cZQBQlW8
87. **Formulação de Massas Cerâmicas**
https://www.youtube.com/watch?v=GrMQspvRSes
88. **Transformações Térmicas**
https://www.youtube.com/watch?v=LuQX4arrJQc
89. **Transformações Térmicas, Part 2, and review**
https://www.youtube.com/watch?v=nttFZSnIZuM
90. **Diagramas de Equilíbrio, Part 1**
https://www.youtube.com/watch?v=596j7HcdJNU
91. **Diagramas de Equilíbrio, Part 2**
https://www.youtube.com/watch?v=JjnqmTPuu_0
92. **Diagramas de Equilíbrio, Part 3**
https://www.youtube.com/watch?v=5ev_2Go5TA8

Recorded course: Fundamentals of the Vitreous State

93. **Fundamentals of the Vitreous State - complete English-language playlist** - *Complete course playlist.*
https://www.youtube.com/playlist?list=PLYkqBrOsu1yCeZ2n1TRUiDg_wJOpy_-TO
94. **Viscosity of Oxide Liquids, Part 1**
https://www.youtube.com/watch?v=pGTMnFKyfuQ
95. **Viscosity of Oxide Liquids, Part 2**
https://www.youtube.com/watch?v=3O04bUXHnRo
96. **Relaxation and Definition of Glass**
https://www.youtube.com/watch?v=zJILOJ0TTgw
97. **Oxide Glass Structure**
https://www.youtube.com/watch?v=8ntG40E30OE
98. **Liquid Phase Separation**
https://www.youtube.com/watch?v=5sxJbSddABg
99. **Crystal Nucleation, Part 1**
https://www.youtube.com/watch?v=UO7c6-5W9w8
100. **Crystal Nucleation, Part 2**
https://www.youtube.com/watch?v=PgENrpxDBcM
101. **Crystal Nucleation, Part 3**
https://www.youtube.com/watch?v=f5MtNOPPTu0
102. **Crystal Growth**
https://www.youtube.com/watch?v=tIX0QoR0QPg
103. **Crystallization of Glasses**
https://www.youtube.com/watch?v=e3oxjBUUzi0

104. **Glass-Ceramics: Nature, Properties and Processing**
   https://www.youtube.com/watch?v=58-BDq-jxa8

Research discoveries and science-communication films

105. **CeRTEV research and educational-video playlist** - *Collection link.*
   https://www.youtube.com/playlist?list=PLYkqBrOsu1yAE46XTh-Z7icAoJRhkE9Mt
106. **Materiais vitrocerâmicos são tema de pesquisas na UFSCar**
   https://www.youtube.com/watch?v=zqtoSWcELvA
107. **CEPID CeRTEV - Center for Research, Technology and Education in Vitreous Materials**
   https://www.youtube.com/watch?v=R9dQe_OLub8
108. **Bioglass for ocular implants and middle-ear ossicles**
   https://www.youtube.com/watch?v=x9ClPf1Amh0
109. **CeRTEV institutional research film - English**
   https://www.youtube.com/watch?v=-5OK37M0SAk
110. **Glass Fibres and Fabrics**
   https://www.youtube.com/watch?v=LqAN_XXg5qg
111. **GOMD Calls for Glass Research Group Videos**
   https://www.youtube.com/watch?v=dYXtewe3xoA
112. **Glass Structure and Properties - investigations at UFSCar**
   https://www.youtube.com/watch?v=lbxpEvDA-2w
113. **Orquestra de Vidro - EPTV report**
   https://www.youtube.com/watch?v=oXZqD6vqXas
114. **Fique Vidrado - existe vidro inquebrável?**
   https://www.youtube.com/watch?v=Q3JizJgFOiM
115. **CeRTEV Education and Dissemination, 2015-2017**
   https://www.youtube.com/watch?v=cufB3dl4OaM
116. **Glass Transition Unveiled - original version**
   https://www.youtube.com/watch?v=F-EJ4bgQ6dc
117. **Glass Transition Unveiled - alternate version**
   https://www.youtube.com/watch?v=eYIWiFeKt5o
118. **The Mystery of the Saint** - *Produced by E. D. Zanotto and team.*
   https://www.youtube.com/watch?v=u6wdAh9S6lI
119. **International Year of Glass 2022 - CeRTEV film**
   https://www.youtube.com/watch?v=mClgNwCvBuU
120. **Vidro: Ciência, Tecnologia e Arte**
   https://www.youtube.com/watch?v=CCWmck4Syek
121. **Tecnologia Vidreira**
   https://www.youtube.com/watch?v=af1lHOx-8bc

Biosilicate and research-related social-media videos

These include institutional and third-party reposts; some footage is duplicated.

122. **Biosilicate educational reel**
    https://www.instagram.com/reel/DYCVTEExblt/
123. **Biosilicate repost 1**
    https://www.instagram.com/reel/DYIxdaNNDWn/
124. **Biosilicate repost 2**
    https://www.instagram.com/reel/DYPizYcR-d1/
125. **Biosilicate repost 3**
    https://www.instagram.com/reel/DbvSki5OqwE/
126. **Biosilicate repost 4**
    https://www.instagram.com/reel/DXfTB4iDrjD/
127. **Facebook video concerning the UFSCar Biosilicate research**
    https://www.facebook.com/61575823319165/videos/fant%C3%A1stico-pesquisadores-da-universidade-federal-de-s%C3%A3o-carlos-ufscar-liderados-/1529446705262937/
128. **Cobermed video explaining bioglass**
    https://www.facebook.com/cobermedsaude/videos/-biovidro-inova%C3%A7%C3%A3o-que-transforma-resultadoso-biovidro-%C3%A9-um-material-avan%C3%A7ado-qu/1599126511505689/
129. **Brief third-party bioglass research excerpt**
    https://www.facebook.com/naturespace21/videos/-tatiana-sampaio-cientista-da-ufrj-descobre-prote%C3%ADna-capaz-de-reverter-les%C3%A3o-da-/751241321123660/
130. **CeRTEV Facebook mirror - Estrutura e Propriedade de Vidros**
    https://www.facebook.com/CeRTEVUFSCar/videos/edgar-d-zanotto-estrutura-e-propriedade-de-vidros/471119599724934/

Historical recordings made before 2013

Historical dates refer to the original recording or broadcast when an authoritative archive identifies it. A later upload date is noted where relevant. Direct WMV links were checked and still returned public video files.

131. **2012 - LaMaV no Globo Universidade** - *Published online 25 June 2012 and still embedded on LaMaV's official historical site.*
    https://www.youtube.com/watch?v=gZ0iE4RL4Uk
132. **2012 - Biovitroceramics research on Jornal Nacional** - *Direct WMV archive file dated 15 September 2012; it may download rather than play in a browser.*
    https://lamav.weebly.com/uploads/5/9/0/2/5902800/enxertos_osseos_jornalnacional_2012_09_15_r.wmv
133. **2012 - Biovitroceramics research on EPTV** - *Direct WMV archive file dated 13 September 2012; it may download rather than play in a browser.*
    https://lamav.weebly.com/uploads/5/9/0/2/5902800/enxertos_osseos_eptv_2012_09_13_r.wmv

134. **2008 - Globo Universidade: UFSCar Materials Engineering - Part 1** - *The official LaMaV archive dates Prof. Zanotto's appearance to 1 November 2008; this copy was uploaded in 2010.* https://www.youtube.com/watch?v=mGkZhDTpY7I
135. **2008 - Globo Universidade: UFSCar Materials Engineering - Part 2** - *Continuation of the historical feature; uploaded in 2010.* https://www.youtube.com/watch?v=RuHfqGC9h4Y
136. **2008 - Globo Universidade: UFSCar Materials Engineering - Part 3** - *Continuation of the historical feature; uploaded in 2010.* https://www.youtube.com/watch?v=6LRI6yAcLxk
137. **2002 - Globo News: Espaço Aberto - LaMaV/UFSCar - Part 1** - *The recording year is stated in the video title; the surviving copy was uploaded in 2013.* https://www.youtube.com/watch?v=vscLsXOanRM
138. **2002 - Globo News: Espaço Aberto - LaMaV/UFSCar - Part 2** - *The recording year is stated in the video title; the surviving copy was uploaded in 2013.* https://www.youtube.com/watch?v=A-xxCsFaKEk
139. **2002 - Globo News: Espaço Aberto - LaMaV/UFSCar - Part 3** - *The recording year is stated in the video title; the surviving copy was uploaded in 2013.* https://www.youtube.com/watch?v=Bbx2wmrHxyM

Other relevant early recordings, 2013-2015

140. **2013 - Prêmio Almirante Álvaro Alberto lecture** https://www.youtube.com/watch?v=sYRfNJgo81I
141. **2013 - Prof. Zanotto comments on an innovation symposium** - *Uploaded 23 September 2013.* https://www.youtube.com/watch?v=SLJd2cKcs7I
142. **2015 - Editorial retrospective concerning Edgar Zanotto** - *Uploaded 8 April 2015.* https://www.youtube.com/watch?v=0jCnGmgQxsM

Announced events for which no public recording was found

Announcements or programmes were located, but no publicly accessible recording was identified for:

143. The 2024 Varshneya Frontiers of Glass Science Award Lecture.
144. The 2025 S. Banerjee Memorial Lecture.
145. A full recording of the 2025 ICG President's Award ceremony beyond UFSCar's short announcement video.
146. The announced 2026 SGT lecture, Cracking the Kauzmann Paradox.