CeRTEV - Center for Research, Technology and Education in Vitreous Materials

Report July 2019 – June 2020, Fapesp grant #2013/007796-3

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RESEARCH PROGRESS

1. Introduction and overview.

The Center of Research, Technology, and Education in Vitreous Materials (CeRTEV) was founded with resources from the Research Foundation of the State of São Paulo to advance fundamental research and technological development in the area of glass and glass-ceramic science. It comprises 10 principal investigators, 4 permanent collaborators and their co-workers at the Federal University of São Carlos (UFSCar), the University of São Paulo (USP), (both located in São Carlos) and the State University of São Paulo (UNESP, Araraquara), located at a distance of 30 km from São Carlos. The principal investigators heading these groups are experts in vitreous materials, in their crystallization towards glass-ceramics, and in a wide range of structural and functional characterization techniques. They advise about 60 graduate students and post-docs engaging in glass and glass-ceramic research, and are embedded in a large Brazilian and international collaboration network. As part of the joint CeRTEV research agenda, these groups work together to develop new active glasses and glass-ceramics, presenting application-relevant functionalities such as high mechanical strength, electrical conductivity, biological, optical or catalytic activity, and/or combinations of these properties.

Developing a glassy or glass-ceramic material with promising physical properties into an application-relevant functional device involves a process of multi-parameter optimization. For this objective, glasses are the perfect materials base: we can modify the physical properties of a glass over wide regions by adjusting its chemical composition, by adding new constituents and even by changing the way they are being made and processed after their synthesis. Thus, glasses offer a vast parameter space for *fine-tuning* a solid material for its desired application. Previously, much of this work had to be done empirically, by trial and error (*melting and testing*) which is costly, time-consuming, and obviously extremely inefficient. During the past few years, the ultimate goal of predicting the perfect glass composition for a given application, has been coming within reach. Three key developments are responsible for this paradigm shift: (1) results from 60 years of modern fundamental research on glasses have been organized in a comprehensive database (SciGlass), (2) highly effective artificial intelligence (neural networks) has been developed for mining this database, and (3) powerful theory-based and computational techniques allow the prediction of structures from molecular dynamics simulations, and the calculation of physical properties from density functional theory. With this enormously powerful arsenal available for the functional design of glasses for desired applications we are currently entering an exciting and challenging decade of research and innovation.

On the side of knowledge-driven fundamental research we attack cutting-edge

fundamental research questions dealing with the thermodynamic and kinetic foundations of glass formation, relaxation, and crystallization towards glass-ceramics. We want to *understand* and predict *glass-forming ability*, and how and why crystallization is suppressed upon cooling. We want to learn how to *control* the *degree of crystallinity and the microstructure of glass-ceramics*. Exercising such control is of utmost importance for realizing desired physical-chemical properties such as *high compressive strength* (for impact resistant glasses), *maximum ionic conductivity* (for high-power density batteries), and *bioactive response* (for osteo-inductive glassy scaffolds optimally adapted to their physiological environment).
On the side of application-oriented research we use our insights on composition-structure-property relationships to develop new and improved glasses and glass-ceramics for five principal high-end technology application areas: (1) *structural reinforcement materials* for architecture and construction, glasses with higher scratch- and impact resistance for TV and smartphone displays, for armor (*bullet-proof windows*), as well as for dental restoration, (2) *bioactive glasses and glass-ceramics* for implants (*spare body parts*) and to serve as scaffolds stimulating bone growth and tissue healing, (3) *fast glass-ceramic ion-conductive materials* enabling the design of lithium and sodium ion batteries with higher capacities and higher power-densities as required for electromotion, and (4) *photonic glasses and glass-ceramics* for high-power lasers and signal transmission conduits, for white-light emission, electroluminescent devices and a plethora of chemo- and biosensor applications. During the 2019-2020 funding period, CeRTEV investigators published approximately 60 articles dealing with fundamental and applied issues on glasses and glass-ceramics. These include numerous review articles on fundamental issues such as glass characterization, structure-property relations studied by advanced spectroscopic techniques, and various timely application fields as detailed below.

2. Fundamental research issues and progress.

2.1. Glass property predictions

Glass-forming ability (GFA) is a property of utmost importance in glass science and technology. In the search for suitable predictors, a statistical methodology was applied to develop reliable criteria based on the various characteristic temperatures published for a wide range of glass compositions: glass transition temperature (T_g), the onset of crystallization temperature (T_x), the temperature of the crystallization peak (T_c) and the liquidus temperature, (T_L). The Weinberg parameter $K_w = (T_c - T_g)/T_L$ was found to hold the strongest predictive power of glass forming ability [1]. Predicting the GFA of substances that have never been vitrified is even of greater interest. We have developed a new parameter that can predict the glass forming ability of oxide mixtures, given by $[U(T_{max}) \times T_L]^{-1}$, where $U(T_{max})$ is the maximum crystal growth rate. This parameter strongly correlates with the experimental critical cooling rates of oxide glass-formers. As crystal growth rate data are scarce, a new criterion was developed, which relates to the viscosity, η, and the liquidus temperature: $GFA \propto \eta(T_L)/T_L^2$. This parameter reflects the widespread experience that substances having high viscosity at T_L, and a low T_L value form glasses easily [2]. In this endeavor, Artificial Intelligence and Machine Learning (ML) algorithms have yielded new insights into composition-property maps. Our most recent effort in this regard has been the successful prediction of T_g based on a dataset of 43,240 oxide glass compositions. One of the main challenges in this task is the prediction of extreme T_g values. The top-performing algorithm predicted extreme values of T_g with a relative deviation (RD) of 3.5% for glasses with high T_g (≥ 1150 K), and RD of 7.5% for glasses with very low T_g (≤ 450 K) [3].

2.2. Alternative Preparation Methods of Glasses and Glass-Ceramics.

CeRTEV's activities dedicated to the development of alternative glass preparation methods, which was proposed as an integral part of our grant renewal period, included an extensive study of polyphosphate coacervates (CPPs) [4] and innovative applications of laser heating [5,6]. CPPs have been extensively studied in recent years as a glass precursor for the preparation of glasses at room temperature to preserve physicochemical properties useful in controlled drug-delivery systems. An extensive study discusses the potential use of CPPs as a potential biomaterial that offers excellent properties with a wide range of biomedical applications [4]. In another effort, a CO_2 laser has been used as a heating source for glass melting on a milligram scale. A sample of lead metasilicate glass was prepared by melting at 820 °C in 3 minutes. Extensive spectroscopic characterization revealed that the glass possesses the same structural features as conventionally prepared materials [5]. The use of CO_2 laser heating was also demonstrated for surface crystallization of a eutectic lithium metasilicate-calcium metasilicate glass, where the morphology of the crystals could be controlled by the irradiation rate applied [6].

2.3 Mechanistic investigations of nucleation and growth.

One of the most important experimental tools of investigating glasses and their crystallization processes is differential scanning calorimetry, DSC. Its utility spans across all glass-forming systems, including oxide, chalcogenide, metallic, and organic systems, as well as recently discovered metal-organic framework glasses. In a landmark comprehensive review article on the subject, the many applications of DSC in glass science have been discussed with focus on glass transition, relaxation, polyamorphism, and crystallization phenomena [7]. The review demonstrates how DSC studies have led to a multitude of relevant advances in the understanding of glass physics, chemistry, and materials technology. Regarding the subject of glass-ceramics, the shape of the crystallization peak observed in DSC contains important mechanistic information, as can be extracted with suitable simulation routines. The common case of surface crystallization in irregularly shaped particles manifests itself in a rather characteristic shape of the DSC peak, reflecting details of crystal impingement and pore formation [8]. DSC peak shape analysis also was able to reveal details of the internal crystallization of AgCl in a series of heavy metal germanate photonic glasses [9]. Our experimental studies are accompanied by molecular dynamics (MD) simulations of both the nucleation and crystal growth steps. For the model system barium sulfide (BaS) a remarkably good order-of-magnitude agreement of the simulated MD pre-exponential factor with the theoretical value predicted by the classical nucleation theory (CNT) was noted [10]. Further encouraging results have been obtained on a supercooled NiTi alloy model system [11].
On the application side, differential scanning calorimetry, in combination with X-ray diffraction, vibrational spectroscopy and solid-state NMR have been used extensively to clarify the detailed ceramization pathways for a special group of glasses, which crystallize via homogeneous nucleation rather than via the thermodynamically preferred pathway of surface crystallization. This group includes barium silicates [12], diopside, CaO-MgO-$2SiO_2$, where homogeneous nucleation was catalyzed by the

presence of 8.26 mole % of Fe_2O_3 [13] and the sodium calcium metasilicates Na_2O-2CaO-3SiO_2 (1-2-3) and 2Na_2O-CaO-3SiO_2 (2-1-3) [14]. For the latter system, the structural resemblance of the glasses and their isochemical crystals was probed on different length scales, following a previously formulated working hypothesis. Definitive evidence of structural similarity at the level of intermediate-range order is obtained from ^{23}Na spin echo decay experiments, which are sensitive to the spatial distribution of the sodium nuclei. In contrast, the glasses contain a distribution of Q^1, Q^2, and Q^3 network former units (NFU) which contrasts the situation (Q^2 only) in the crystalline states. These results confirm the conclusion from previous experimental studies that a structural resemblance of the short- and intermediate-range order of the network modifiers rather than the NFUs may be a key feature of homogeneously nucleating glasses [14].

Although non-stoichiometric glasses (NSG) are much more common than stoichiometric compositions, fundamental studies of crystallization kinetics in them are more complex and are therefore much less frequent. To shed light on the crystal nucleation and growth kinetics of NSG, we adopted a nucleation kinetics model, leaving the interfacial energy and diffusion coefficient as free parameters, to explain experimental (homogeneous) nucleation data of glasses of three compositions in the pseudo-binary $Li_2O\cdot 2SiO_2$–$BaO\cdot 2SiO_2$ model system [15]. We show that, as the glass composition approaches the eutectic, the nucleation rates drop drastically, mainly due to an increase in the interfacial energy. This result confirms the common empirical observation that eutectic compositions tend to show good glass-forming ability.

3. Strong glasses and glass-ceramics

The military ballistic protection market has reached approximately US$ 10 billion/year, and the civil market is also very significant and is steadily increasing, which drives research for new ballistic protection alternatives. Materials currently used and under development as transparent ballistic protection devices include glasses, glass-ceramics, single and polycrystalline ceramics, and polymer-composites. A new CeRTEV review article discusses the most important materials, indicates the pathways that research on TGC for ballistic protection have taken, and outlines the frontiers for future research in this area [16]. Work during the 2019/2020 funding period includes the development of new formulations and a further fundamental understanding of their properties on a structural basis.

3.1. New formulations and functionalities.

A novel hard, strong and tough enstatite-zirconia ($MgSiO_3$-ZrO_2) glass-ceramic derived from a 51SiO_2–35MgO–6Na_2O–4ZrO_2–4TiO_2 (mol%) glass was developed by treating glass samples for nucleation at 700°C for 12 hours, followed by crystal growth at 1090°C for 3 minutes. The ball-on-three-balls strength, elastic modulus, and Vickers micro-hardness of the GC are 323 ± 26 MPa, 146 ± 13 GPa, and 6.9 ± 0.1 GPa (load = 5N), respectively. The indentation (K_C), single-edge notched beam bending (K_{IC}), and crack tip (K_{tip}) fracture toughness values are 2.8 ± 0.6 MPa·m$^{0.5}$, 2.2 ± 0.3 MPa·m$^{0.5}$, and 1.9 ± 0.3 MPa·m$^{0.5}$, respectively. The enstatite and zirconia crystals enhance crack deflection, bridging and branching, hindering crack propagation. Due to this positive combination of high strength, toughness, hardness, and chemical durability, this new glass-ceramic is envisioned as a candidate for memory disc substrates, architectural cladding and tiles, ceramic glazes, and dental materials [17].

Engineered stones are promising materials for kitchen countertops, floor and facade tiles and other application in construction. They consist of approximately 70–95 wt.% of mineral particles (usually quartz) dispersed in a matrix made of cement, ceramics or, much more often, polymer resins. New low-porosity composites with promising mechanical properties were developed based on recycled window glass containing up to 70 wt.% of albite, alumina, and petalite. For instance, an alumina/glass composite showed a (4-point) flexural strength of approximately 115 MPa and a hardness of 9 GPa. The petalite/glass composite exhibited high thermal shock resistance ($\Delta T_c \sim 330$ °C); whereas the Albite/glass composite showed excellent chemical stability against concentrated acids and bases [18].

3.2 Structure/Property Correlations.

Ultrastrong glasses with high crack resistance are of great interest for the optimization of low-weight flat displays in modern handheld electronic devices. In this context intense development efforts are devoted to new oxide glass formulations for improving the mechanical strengths without compromising other physical properties. An important issue in this regard has been the conflicting demand of hardness and crack resistance upon the glass composition. The beneficial effect of magnesium oxide upon the performance of crack resistant oxide glasses has been explored in a series of aluminoborosilicate glasses with the compositions $60SiO_2$-$(20\text{-}x)Al_2O_3$-xB_2O_3-$20Na_2O$ and $60SiO_2$-$(20\text{-}x)Al_2O_3$-xB_2O_3-$10Na_2O$-$10MgO$. The simultaneous presence of both boron and aluminum oxides in these glasses produces a synergistic effect upon the crack resistance, whose structural origins were explored by detailed ^{11}B, ^{23}Na, ^{27}Al, and ^{29}Si single and double resonance solid state NMR studies. The Mg-driven enhancement of crack resistance in Na-Mg boroaluminosilicate glasses in comparison to analogous Mg-free glasses can be related to a reduction in the fraction of four-coordinate boron (N_4), producing higher concentrations of non-bridging oxygen species [19]. For boron-rich glasses (x = 20, 15, 10), this trend is accompanied by the expected decrease in E-modulus. For low-boron glasses, however, the reduction of E-modulus owing to the decrease in N_4 is over-compensated by the strong interaction of the non-bridging oxygen species with the high-field strength cation Mg^{2+}. Finally, in the boron-free aluminosilicate endmember series, the formation of higher-coordinated aluminum contributes to a *simultaneous* increase in both crack resistance and E-modulus [19]. Recent systematic work on alkaline-earth containing aluminoborosilicate glasses indicates that that both crack resistance and solid-state NMR observables can be universally correlated with the average ionic potential of the network former cations [20].

The effect of residual stresses (as measured by synchrotron X-ray diffraction) upon fracture toughness was investigated on a variety of lithium disilicate glass-ceramics with different microstructures generated from different crystallization protocols. Within the crystal size range from 1 to 5 µm, a highly crystallized volume fraction coupled to relatively large crystals (5 µm) of high elastic modulus improved the glass-ceramic fracture toughness [21]. This result can guide the microstructural design of novel tough GCs.

4. Bioactive glasses

Research in bioactive glasses (BGs), traditionally performed through trial-and-error experimentation, has been accelerated by the incorporation of molecular dynamics simulations, machine learning approaches, and other modelling techniques. The current challenges in this field have been reviewed. They include modelling the biological response to biomaterials, such as their ability to foster protein adsorption, cell adhesion, cell proliferation, osteogenesis, angiogenesis, and bactericidal effects [22]. The development of databases integrated with robust computational tools will become indispensable for the compositional design of new materials with enhanced performances [22].

4.1. New functionalities and application fields

A series of recent studies has been devoted to the application of bioactive glasses in dental therapy. In the range of procedures motivated by the *minimal intervention dentistry (MID) practice*, enamel and dentine remineralization has been consolidated as an effective strategy to prevent caries and dental erosion. The use of bioactive glasses (BGs) has proven to be more effective in enamel remineralization than other classical topical agents, such as fluoride or casein phosphopeptide-amorphous calcium phosphate (CPPACP). Bioactive glasses are capable of continuously releasing calcium and phosphate ions into the local environment, leading to the precipitation of a hydroxy carbonate apatite (HCA) layer, which provides long-term protection for the enamel and dentinal tubules. Tailoring bioactive glass compositions by incorporating different ions to the original formula has been effective on granting positive outcomes regarding biomineralization. A new CeRTEV review provides an update on bioactive glasses used for enamel remineralization and the influence of composition changes on their biomineralization potential [23]. In a new experimental study, the kinetics of post-bleaching dentin remineralization stimulated by Bioglass 45S5 (BG) and Biosilicate (BS) was investigated. Micro-Raman spectroscopy of the fractured dentin beam showed that the remineralization treatment significantly increased the dentin relative mineral concentration and promoted the appearance of new interface peaks, indicating a chemical interaction [24].

Antibacterial effects of Biosilicate and 45S5 Bioglass-ceramics doped with up to 3 mol% of Ag, Mg, Sr, Zn, and Ga was confirmed against 23 oral bacteria, related to caries and endodontic infections, by employing three different methodologies, e.g. agar dilution method, biofilm formation, and direct contact assay. All the tested materials demonstrated a considerable antibacterial effect stimulating future studies involving their application as topical endodontic disinfectants or in dental prophylaxis procedures [25]. At the same time, those ceramics containing up to 0.5 mol% dopant exhibited hydroxycarbonate apatite (HCA) layer formation on their surfaces in a 24-h in vitro assay [25]. This is the same time as observed for Bioglass® which is the material considered to be the “gold standard” in terms of bioactivity.

The application of bioactive glasses and glass-ceramics in the field of *orbital implants* for ocular surgery [26] is relatively novel and less popular compared to the applications in orthopedics and dentistry for the repair of bone and teeth. A new CeRTEV review article discusses the suitability of bioactive glasses and glass-ceramics in contact with soft tissues for promoting additional effects associated to the release of therapeutic inorganic ions. Specifically, the angiogenic and antibacterial actions that may be elicited by selected glass compositions are highly appealing for the development of new-generation orbital implants, since improved vascularization and antiseptic properties are the key for a higher success rate of anophthalmic socket procedures. The article provides an overall picture of existing orbital implants based on bioactive glasses and discusses further potential and open challenges for future research in this field [26].

Other recent studies include the use of *composites*, combining the bioactivity of biosilicate with the beneficial effects imparted to the material by additional components such as iron oxides (for magnetic hyperthermia therapy) [27] and marine spongine/biosilicate composites, for enhanced fibroblast proliferation [28]. Also, further applications of the new F18 bioactive glass formulation, a recent CeRTEV development, have been explored. Recently we could show that F18 is active in NO release by a NOS activation-dependent mechanism, offering a promising alternative for biomedical applications that aim at rapid tissue regeneration [29].

4.2. Structure/property correlations

In close feedback with results from structural characterization methods, we are continuing to explore compositional effects on various aspects of bioactivity performance, in particular with regard to the incorporation of boron and the substitution of calcium by its homologs magnesium or strontium. The bioactivity, as measured by the dissolution kinetics in simulated body fluids (SBF) is closely linked to the structural organization of the bioglasses, i.e. the binding sites of alkaline and alkaline-earth network modifier cations and the state of the (de)polymerization of the phosphate species. B_2O_3-doped (0.5-15 mol%) ordered mesoporous bioactive glasses (MBG) with the composition 80% SiO_2-15% CaO-5% P_2O_5 were synthesized via a sol-gel based evaporation-induced self-assembly process using the block-copolymer P123 as a structure directing agent and characterized by biokinetic, mechanical and structural investigations. Boron incorporation increases both the bulk modulus and hardness of the glasses, while maintaining the mesoporous organization. Contrary to the tight incorporation of Al in Al-doped MBGs, the rapid release of borate species into simulated-body-fluid suggests loosely bound borate species localized at the internal surfaces of the mesopores. The need for charge compensation of the anionic four-coordinate boron species leads to an increase in the average degree of polymerization of the phosphate species for high boron contents, however, no B-O-P linkages are detectable. The structural conclusions obtained from the NMR spectra explain the rapid release of borate and the enhanced dissolution kinetics of the Ca^{2+} and phosphate species [30].

In the area of binary and quasi-binary phosphate glasses solid state ^{31}P NMR results have helped to rationalize dissolution properties as well. Mixed Na-Sr and Na-Ca polyphosphate glasses of composition $(0.57-x)Na_2O$-$x/2SrO \cdot x/2CaO$-$0.43P_2O_5$ ($0 \leq x \leq 0.30$ molar fraction) exhibit definite bonding preferences of the stronger cations to non-bridging oxygen species of doubly-charged chain-end phosphates (Q^1) rather than of the singly-charged metaphosphate (Q^2) units. In addition, ^{31}P-double-quantum NMR results suggest enhanced Q^2 self-connectivity (as opposed to Q^1-Q^2 cross-connectivity) with increasing alkaline-earth content, consistent with an increase of the fraction of longer-chain fragments or ring structures [31]. Rare earth (RE)-containing bioactive glasses are promising materials for biomedical applications like brachytherapy, luminescence-based imaging, magnetic resonance imaging, among others, based on their 4f open-shell electron configuration. NMR and XPS results indicate that incorporation of the RE species increases the fraction of non-bridging oxygen atoms, consistent with the expected role of the RE oxide as a network modifier [32].

5. Fast ion-conducting glasses and glass-ceramics

Ion conducting glass-ceramics have shown significant promise for applications as solid electrolytes in high energy storage devices. The highest cationic mobilities in the solid state are generally encountered in crystalline compounds with highly disordered cation sub-lattices, termed *superionic crystals*. Nevertheless, ion conducting glasses have the advantage of not suffering from grain boundary effects and hence form more homogeneous interfaces with the anode and cathode compartments of a solid-state electrochemical cell. Thus, dense glass-ceramics based on the crystallization of suitable precursor glasses offer the promise of combining both favorable features. The CeRTEV research agenda focuses on the further development of such systems, based on a solid understanding of composition – structure – performance relationships. In addition, fundamental research conducted in this CeRTEV sub-area is aimed at the understanding of non-linear composition/function relationships in new ion conducting glasses.

5.1 Glass-ceramics based on the NASICON structure.

The development of new and improved glass-ceramics based on the NASICON structure has been a long-standing topic in CeRTEV's research agenda. Our most recent efforts in this area aim at the optimization of materials with longer-term sustainability. Motivated by the much larger natural abundance of the element sodium in comparison to lithium we are now focusing on the development of sodium-based (rather than lithium-based) compositions. Currently we are therefore exploring phase relations and ionic conductivity/structure relations of glass-ceramics generated from aliovalent substitution of the framework constituents in sodium titanium phosphate, $NaTi_2(PO_4)_3$, NTP, and sodium germanium phosphate, $NaGe_2(PO_4)_3$, NGP. Significantly enhanced electrical conductivities can be accomplished by aliovalent substitution of x equivalents Ge^{4+} and Ti^{4+} by equimolar quantities of Na^+ and Al^{3+} (Ga^{3+} or Sc^{3+}) or alternatively of x moles of PO_4^{3-} by equal amounts of Na^+ and SiO_4^{4-} ions [33-36]. The best sodium-conductive glass-ceramic is obtained by Ti for Na+Al substitution at the level of x = 1.0 with a total ionic conductivity of 3.2×10^{-3} Scm^{-1} at 300 °C and an activation energy of 0.47 eV. The effect of isothermal annealing upon the composition and structure of NAGP glass-ceramic was investigated using comprehensive XRD and solid-state NMR studies [37]. Extended annealing results in a gradual reduction of Al content, possibly arising from an equilibration of a supersaturated solid solution. In the $Na_{1+x}Ti_2Si_xP_{3-x}O_{12}$ system, a new, NASICON-unrelated phase is found at high substitution levels (x=1), featuring a surprisingly high electrical conductivity of 10^{-4} Scm^{-1} at room temperature [38]. The structural origins of this exciting result are still under investigation.

5.2. Network former mixing effects in ion-conducting glasses.

The glass system $(Li_2O)_y$-$[(2TeO_2)_x$-$(B_2O_3)_{1-x}]_{1-y}$ (y = 0.33 and 0.40 and $0 \le x \le 1$) is known for its negative network former mixing effect. The structural aspects of this effect were previously investigated by solid-state NMR, indicating that the fraction of four-coordinated boron increases with increasing TeO_2 content. This conclusion is confirmed by the FTIR absorption spectra obtained in a follow-up study by vibrational spectroscopy [39]. In addition, Raman spectra confirm the presence of both TeO_4 trigonal bipyramidal units and TeO_3 trigonal pyramidal environments in these glasses. With increasing TeO_2 content of these glasses, the fraction of four-coordinated Te species increases. While these results give evidence for a certain degree of heteroatomic TeO_3-BO_4 connectivity, the homo-atomic connectivity seems to dominate. Evidently, the relatively weak interaction between the two network formers B_2O_3 and TeO_2 does not create energetically favorable target sites for the alkaline metal ions and thus disfavors cationic mobility as compared to the binary endmember glasses.

6. Photonic glasses and glass-ceramics

The design and photophysical characterization of highly efficient luminescent glasses and glass-ceramics for photonic devices is at the core of the CeRTEV research agenda. These systems are based on luminescent rare-earth ions which must be well-dispersed within low-phonon environments to minimize vibrational de-excitation. Their properties of these materials can be enhanced and modified by the presence of metallic nanoclusters and –particles. Research of the 2019/2020 funding period included novel design strategies of such nanocomposites and the characterization of their functional properties. Structure-property correlations have been sought on the basis of a comprehensive spectroscopic strategy, based on the combination of NMR, EPR, Raman, and optical absorption and emission spectroscopies.

6.1. New rare-earth doped glass formulations.

A variety of new, promising glass formulations were developed and their optical and luminescent properties were analyzed in detail in terms of Judd-Ofelt theory, as detailed below:

(1) Sodium zinc phosphate (PNZ) glasses doped with MnO, featuring the manganese ions in a mixed valence state [40],

(2) Glasses in the system $NaPO_3$-WO_3-xRE_2O_3, (RE = Er, Eu, Nd, Tb) [41,42]. Measurements of photophysical parameters, EPR spectra, and ^{31}P and ^{23}Na NMR linewidths and relaxation rates on 90$NaPO_3$-10WO_3 glasses as a function of rare-earth ion concentrations indicate that up to 5 mole% of Nd^{3+} and Tm^{3+} dopants can be homogeneously dispersed [42].

(3) Niobium alkali germanate glasses doped with Er^{3+}, Eu^{3+}, and Er^{3+}/Yb^{3+} up to 4.0 mol%. These glasses are characterized by a wide transmission window, high thermal stability and strong enhancement of upconversion emission. Upon annealing, $K_2Nb_{14}O_{36}$ nanocrystals are formed, in which the rare-earth ions occupy higher symmetry sites resulting in inhomogeneous broadband emissions. Depending on erbium content and heat treatment conditions forming glass-ceramics, this system allows the design of visible tunable phosphors emitting in the red-to-green wavelength region [43,44].

(4) Optimized borosilicate scintillator glasses for radiation dosimetry. Addition of small amounts of P_2O_5 (0.1 mol%) led to significantly enhanced performance characteristics, producing superior ultraviolet transparency, reduced self-absorption of Ce^{3+} emission, and brighter scintillation under X-ray irradiation [45]. In another contribution related to this area the linear-response regions for some alkali borate glasses were evaluated [46].

6.2. Glass/nanoparticle nanocomposites.

The incorporation of metallic nanoclusters (NCs) and nanoparticles (NPs) into glass matrices has led to a new family of nanocomposites that preserves the integrity (and hence the physical properties) of the nanocrystals, enabling application in photonics, catalysis, and chemical sensing. Significant work done during the past review period has been devoted to the creation of Ag NCs in fluorophosphate glass batches containing 5 mol% silver nitrate and to subsequent studies of their optical properties [47-49]. For example, multi-energy transfer mechanisms were observed between silver and Yb^{3+}/Pr^{3+} co-doped glasses [47] and blue and red emission belonging to Tm^{3+} (470 to 490 nm) and Mn^{2+} (550 to 750 nm) ions could be obtained via non-resonant excitation [48]. The main mechanism for blue and red emission is Förster Resonance Energy Transfer

(FRET) over a typical distance of 10 Å. The material has potential application for multicolor generation as a luminophore in white light emitting diodes (W-LEDs) [48]. Using femtosecond laser irradiation, silver NCs may also be tailored into three-dimensional fluorescent micro-structures. Their spectroscopic properties reveal not only the creation of silver nanoclusters but also of nanoparticles during laser irradiation [49].

Besides generating the nanoparticles from chemical precursor species already included in the glass formulations, increasing efforts are also being directed towards preparing and optimizing monodisperse nanoparticles in a separate step, followed by non-destructive incorporation into the glassy matrices. For example, (1) self-assembly of mesoporous silica in CdTe nanoparticle suspensions has produced Silica-CdTe nanocomposites with promising applications for oxygen sensing [50]. In another study, iron oxide nanoparticles have been decorated with a silica shell before introducing them into a sodium calcium phosphate glass melt at 1000 °C. The crucial parameter determining the success of this approach is the melting time: for 15 min melting time, the size distribution of the particles can be maintained and the silica shell is still identifiable. However, partial oxidation of the magnetite to maghemite in the melt altered their magnetic properties significantly, resulting in a loss of cooperativity [51].

6.3. Structure-property correlations in oxyfluoride glasses and glass-ceramics.

Both fluoride and phosphate glass matrices play an important role in laser design, because of their well-documented ability to effectively disperse large concentrations of luminescent rare-earth ions. Each one of these systems has important drawbacks, however: in oxide glasses luminescence quantum yields are limited because the optical excited state relaxes quickly due to the high-phonon environment of the network, while fluoride glasses have poor mechanical stability and fiber drawing properties. With the objective of creating some synergy between both types of hosts, the photophysical properties of a variety of oxyfluoride glass systems have been tested and interpreted, on a fundamental structural basis, using advanced solid-state NMR and EPR methodologies [52-54]. Using scandium as a diamagnetic mimic for the rare-earth ions, a quantitative analysis of $^{45}Sc\{^{31}P\}$ rotational echo double resonance (REDOR) data offers the possibility to estimate average ratios of fluoride/phosphate ligands at the metal center. Analogous information can be drawn from average g-factors and electron-spin echo envelope modulation (ESEEM) experiments on Yb^{3+} doped glasses. Robust correlations of these magnetic resonance observables with the photophysical properties of these glasses suggest that indium fluoride phosphate glasses with composition $20BaF_2$-$20SrF_2$-$20ZnF_2$-$10ScF_3(30\text{-}w)In(PO_3)_3$-$wInF_3$-$zREF_3$ are the best current choice for strongly emitting oxyfluoride glasses, as the rare-earth ions are dominantly coordinated by fluoride ions in this system [53]. Similar studies were conducted with lead fluoroborate and -germanate glasses [54] and glass-ceramics [55]. Detailed crystallization studies were carried out on the fluorometaborate glass systems MO-B_2O_3-PbF_2 (M: Ca, Ba, Sr containing 10, 20, and 30 mol% PbF_2). In glasses with M = Ba it was possible to separate the crystallization of fluoride and oxide components within separate temperature regions, producing a rare-earth doped barium fluoride phase embedded within an oxide glass matrix. Based on this finding this glass composition is a good starting point for obtaining new rare-earth doped glass-ceramics for laser applications.

7. References (55 publications, July 2019 – June 2020. **Bold =** CeRTEV faculty).
Blue = International collaborators

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EDUCATION AND OUTREACH

Ana CM Rodrigues (Coordinator) and Karina Lupetti (Researcher)

1. Development of professional qualification strategies in glass science and technology

In July 2019, the first cohort of the course "Technician in Glass Production", a project conceived and realized in partnership with the Paula Souza Center, Abividro and the glass company Nadir Figueiredo, has graduated. Of the 40 students who were enrolled in the course, 32 received their degree. And, according to Centro Paula Souza, 70% of our graduates are now working in glass companies, which is a highly successful outcome in the current economic crisis. Thus, CeRTEV´s mission of contributing to the Brazilian glass industry by training qualified professionals, has already achieved its goal. However, this project continues. In fact, the second cohort started in August 2019 with 40 new students, selected from 80 applicants via admission exam. Because of the COVID-19 pandemic, students and professors had their holidays anticipated in March 2020, and subsequently face-to-face lectures on the theoretical content were substituted by on-line (video) classes. All the practical training classes have been postponed until September 2020. It is expected that, from September on, practical classes will start, respecting all the necessary security standards – fewer students per classroom, use of masks, special sanitary measures, etc. Thus, it is also expected that students will be able to finish the course and have their diploma at the end of December, as planned by the original curriculum of the course

The training sessions to the teachers of the Paula Souza Center involved in the course also continue. In July 2019, there was a special training in the AGC glass company. 20 teachers from the Centro Paula Souza visited AGC and received "in loco" 2h instruction on the production of float glass.

Further training sessions in the first semester of 2020, had to be cancelled due the COVID-19 pandemic.

The "CeRTEV Glass Technology Course 2020" was planned to be held in São Carlos, from March, 30th to April, 4th, with 14 enrolled participants from different glass industries from all Brazil. This training course was also canceled due to the pandemic.

2. Diffusion of basic and glass science

ORGANIZED EVENTS

From July 2019 to June 2020, scientific dissemination events were organized in partnership with other universities, the UFSCar Pro-rectories of Research and Teaching, the UFSCar Chemistry Department's graduate program (PPGQ-UFSCar), and the Municipal Secretariat for the Environment, Science, Technology and Innovation (São Carlos), with support from CeRTEV-FAPESP.

Some of these events are listed below:

Visit to "Espaço Ventura" (~100 people/year); **Vacation Project "Educare"** (July, 22nd - 26th) - 50 children/day; **Open University** (October 2nd-3rd) – with the UFSCar Chemistry Department - (150 people); **Exhibition "Olhares"** (a group dedicated to science dissemination and the inclusion of vision impaired people)- **10 years of Art, Science and Inclusion and Ouroboros Exhibition** - 15 years at the UFSCar Community; UFScar Library, October 1st- 31st, ~ 150 visitors; **Inauguration of the "Patamar periódico**" dedicated to the periodic table (October, 15th,) (50 people).

During the **XVI National Week of Science and Technology** (SNCT, October 21st to 27th), organized by the Ministry of Science, Technology, Innovation and Communication, CeRTEV and Ouroboros Group organized two events: **- XVI Science Circus** at São Carlos Educational Foundation (FESC) October 27th (~100 people); and **Science Bus**, October 21st-23rd (500 people). The latter interactive project involved theater performances, explanations and demonstrations of scientific concepts and curiosities to the public transport passengers in a circular bus in partnership with the São Carlos Municipal Secretariat for the Environment, Science, Technology and Innovation.
https://www.facebook.com/tvufscar/videos/522701774959080/UzpfSTEwMDAwMDAxMjQyMTc3MjozMDYwNjExMjk0OTk0MTQ6MTA6MTU0NjMyOTYwMDoxNTc3ODY1NTk5OjE0NjQ1MTk2NzE5MzQ1NjI3MTY/
CeRTEV booth at the XXVII Young Researchers' Conference of the Association of Montevideo Group Universities (AUGM) October, 23rd-25th (~100 people) -
Halloween, October, 31st: Educare Project in the Samambaia Residencial area with scientific experimental demonstrations from Ouroboros Group and performances from Olhares Group (~100 people); **V Workshop on Scientific Dissemination and Playful Activities** , December, 1st (25 people); **Tributes to Professors from DQ UFSCar** who retired December, 12th (50 people).
Vacation Project "Educare" January, 20-24, 2020 (60 children/day); Educare was held for the first time at UFSCar, at Praça da Ciência - Teacher Training Center (NFP) and included between 60 and 70 children aged 3 to 14 years per activity day;
ACIEPE (Atividade Curricular de Integração Ensino, Pesquisa e Extensão da UFSCar) (UFSCar´s Curricular Activity for Integration of Teaching, Research and Extension)
Two ACIEPES were offered:
- Engineers and Scientists of the Future (offered semesterly) and - Chemicals in the kitchen: the science and art of cooking "in house" (75 people) (60 hours)
Olhares Group: 11 years spreading science through inclusive art, June, 12, 2020 (25 people); Because of Covid-19, this was an on-line event, which had the participation testimony of several members, professors, and scholarship holders from the Ouroboros nucleus of the Science Dissemination project since 2009. This event allowed for reflections on the current situation of physical isolation, emphasized once again the resilient characteristic of this group, and illustrated new possibilities of interactions from a distance. In a similar vein, the **II Soiree Scientist Artists "at home"** celebrations of the 50th anniversary of the UFSCar Chemistry Department, held on June 19, 2020, featured synchronized interactions between scientists in an on-line event. Several videos were recorded with scientists showing their artistic side: https://www.youtube.com/watch?v=siMNI0-s454

THEATER AND MUSICAL PRESENTATIONS, created and presented by Ouroboros Group, reaching approximately 4200 people
Clepsidra: the case of water: 4 presentations: July, 7th, September, 11th, October 19th, December, 1st
Science that laughs: The world of glass, 14 presentations at Public Municipal School in São Carlos, and 8 more presentations in several different events in Sao Carlos and including a presentation at the "Provisional Detention House" - Pontal-SP, 140 km from São Carlos (30 people)
Vitreous Sounds. Between June 2019 and March 2020, the musical group performed several invited presentations at different events: June, 29th: Soirée Olhares (40 people);

July, 6 and 7th: Circus Station School, (200 people), August, 31st: L'AQUA- INOVA (50 people), October 10th: L'AQUA, Florestan Fernandes Theater, UFSCar, Mental Health Congress (20 people); December, 15th: "Chorando sem parar" Festival, 100 people; March, 09, 2020, Florestan Fernandes Theater, UFSCar, Celebrating 50 years of UFSCar.

WORKSHOPS AND LECTURES

Activities included:

12 workshops with diverse themes like, "Macramê" or Molecular Cuisine, held by the Ouroboros Group;

Welcome lecture to the freshmen from the UFSCar Chemistry department (50 people), March, 03rd, 2020;

Lecture: Comics Story - manga (ESALQ- Piracicaba) (15 people) online. (Adriana Iwata and Karina Lupetti), 06/09/2020;

Lecture: Scientific Dissemination and Chemistry Teaching (UNIFESP- Chemistry Week- online), 06/17.

Round Table - Dialog: Scientific Dissemination (Chemist Day, UECE- Itapipoca -Ceará (online), 06/18.

SCIENTIFIC DISSEMINATION PRODUCTS:

Twenty-two 1 min pod-casts recorded by Radio UFSCar 95.3 FM being part of the activities of the Scientific Journalism scholarship IV –FAPESP by Karina Omuro Lupetti.

American Glass: https://www.radio.ufscar.br/podcast/minutovitreo-14-08-2019/

Baccarat glass and crystal company: https://www.radio.ufscar.br/podcast/minutovitreo-21-08-2019/

The art of glass blowing: https://www.radio.ufscar.br/podcast/minutovitreo-28-08-2019/

Is glass more valuable than gold? https://www.radio.ufscar.br/podcast/minutovitreo-04-09-2019/

Dichroic glass: https://www.radio.ufscar.br/podcast/minutovitreo-11-09-2019/

Curiosities about mirrors: https://www.radio.ufscar.br/podcast/minutovitreo-18-09-2019/

Sir Newton and the glass: https://www.radio.ufscar.br/podcast/minutovitreo-02-10-2019/

Vision beyond reach: https://www.radio.ufscar.br/podcast/minutovitreo-09-10-2019/

Chocolate x Glass: https://www.radio.ufscar.br/podcast/minutovitreo-16-10-2019/

Gorilla Glass in cars: https://www.radio.ufscar.br/podcast/minutovitreo-23-10-2019/

Silicon, silica, silicate or silicone: https://www.radio.ufscar.br/podcast/minutovitreo-30-10-2019/

How to conserve your glass: https://www.radio.ufscar.br/podcast/minutovitreo-06-11-2019/

What if the glass breaks? https://www.radio.ufscar.br/podcast/minutovitreo-13-11-2019/

Mysteries involving glass: https://www.radio.ufscar.br/podcast/minutovitreo-20-11-2019/

Obsidian: https://www.radio.ufscar.br/podcast/minutovitreo-27-11-2019/

Fulgurites in volcanoes?: https://www.radio.ufscar.br/podcast/minutovitreo-04-12-2019/

Transparent Solar Panels? https://www.radio.ufscar.br/podcast/minutovitreo-11-12-2019/
Magnetic Optical Fiber? (Interviewed Prof. Dr Marcelo Nalin):
https://www.radio.ufscar.br/podcast/minutovitreo-11-03-2020/
Glass-fiber Muscles? (Interviewed Prof. Dr. Oscar Peitl)
https://www.radio.ufscar.br/podcast/minutovitreo-18-03-2020/
Glasses that transform energy?? (Interviewed Profa. Dra. Andrea de Camargo)
https://www.radio.ufscar.br/podcast/minutovitreo-25-03-2020/
Magnetic fields and microwaves to take pictures? (Interviewed Prof. Dr. Claudio Magon)
https://www.radio.ufscar.br/podcast/minutovitreo-03-06-2020/
Batteries made of glass? (Interviewed Profa. Dra. Ana Cândida Martins Rodrigues)
https://www.radio.ufscar.br/podcast/minutovitreo-10-06-2020/

Due to the pandemic, Radio UFSCar's programming was interrupted from March to June, but 12 programs were produced for this season. Following are those that have not yet aired:
Programmed glasses (Interviewed Prof. Dr. Edgar Zanotto)
Glass X-rays? (Interviewed Prof. Dr. Valmor Mastelaro)
Simulate a glass? (Interviewed Prof. Dr. Pedro Rino)
Spy cores within matter? (Interviewed Prof. Dr. José Schneider)
Sustainable glass (Interviewed Prof. Dr. Hellmut Eckert)
Is it just glass powder? (Interviewed Prof. Dr. Eduardo Bellini)
Glass sensors made from Laser? (Interviewed Prof. Dr. Marcelo Andreeta)

Collection: Glass comic stories produced by students of the 3rd year of elementary school in the municipal school system of São Carlos. The children collectively created and illustrated their stories. The pictographic records were digitalized and produced as an illustration of an original narrative created based on the collective imagination of the children.

Glass Comics
The 4 volumes of the glass comic books have been translated into English and can be found on the websites "vidro" from UFScar, International Commission on Glass and also on the website "Communicating Science" from the American Ceramic Society
http://www.vidro.ufscar.br/,http://www.icglass.org/home/education/,
https://ceramics.org/professional-resources/career-development/communicating-science

Comics n. 5: "The age of glass"
The play "The age of glass" from the Ouroboros Group was illustrated and made in the form of Comic in "Mangá" style.
PhD at Chemistry Graduate Program, UFSCar: Adriana Yumi Iwata has defended (May, 27th, 2020) her PhD "Scientific Dissemination Methodologies through Research and Production based on Manga"

3. The EduSCar project
Aside from promoting science divulgation with a focus on glass, CeRTEV also actively participates in the UFSCar`s overall mission of educational outreach to the general

public. Thus, the idea came to unite all existing educational efforts of CEPIDS and INCT (Institutos Nacionais de Ciencia e Tecnologia – CNPq) based on São Carlos City with the mission of improving basic and fundamental public education in the municipality. The main message to get across was that São Carlos has two public and very important universities (UFSCar and USP), with several Internationally recognized research groups, and very qualified researchers. On the other hand, the fundamental and elementary public school are not distinguished from others across Brazil and suffer from the same problems. Thus, how can these two universities contribute to raising the level of public schools and the degree of success of their students? To answer this question, the EduScar project was created. The EduSCar Project is then, an initiative of coordinators and professors who develop large projects in public universities in São Carlos, SP, together with the Coordinators of the Regional Teaching Directorate (State) and the Municipal Teaching Secretariat. EduSCar's mission is to actively interact with schools in the region in order to help improve the education system, disseminate science and technology and promote scientific education. Research centers linked to FAPESP and CNPq already promote numerous activities in science dissemination and popularization. The integration of all these activities tends to promote a synergistic effect that will benefit the education system of São Carlos in a more professional and forceful way.

EduSCar actions developed in the last 12 months:

- **Training in the LEON (**Leon is the acronym for Leitura on Line, On-line Literacy), in order to promote the children's literacy initiative, by using computational resources.
- **Training of teachers in the Digital Inclusion Program** through the “Arduino for All” project and through classes and challenges developed virtually for contexts of the coronavirus pandemic.
- **Production of educational videos and kits** from different areas of science.
- **Organization of a pedagogical project in Public Schools** at EMEB Ulysses Ferreira Picollo (Elementary School - Early Years) and EEEI Profa. Maria Ramos, both installed in São Carlos neighborhoods, which receive students from highly vulnerable social conditions. Through these projects, EduSCar educators have helped in the structuring and execution of the schools' pedagogical process, as well as taught classes and short courses and assisted in projects for structuring the internet and environmental physical spaces.
- **Organization and realization of events:** Chief Scientist Program in Basic Education of the State of Ceará: with Prof. Jorge Lira, Chief Scientist of Basic Education in Ceará
- **Science dissemination by digital means**: Constant interaction with teachers and students from state and municipal schools through Facebook Pages, Whatsapp Groups and EduSCar website.
- **Environmental Education projects in public schools**, through the “Knowing the Hot Water Hydrographic Basin” and “Walking on Water” projects.

EduSCar Coordinators:

Prof. Dr. Edgar Zanotto – CEPID-CeRTEV, DEMa, UFSCar
Prof. Dr. Elson Longo – CEPID Department of Chemistry - UFSCar
Prof. Dr. Vanderlei Salvador Bagnato CEPID-CEPOF / IFSC / USP
Prof. Dr. Glaucius Oliva - CEPID IFSC, USP
Prof. Dr. José Alberto Cuminato ICMC CEPID / CEMEAI / USP
Profa. Dr. Deisy das Graças de Souza - PPGPsi-UFSCar
Profa. Dra. Arlene Gonçalves Correa - DQ-UFSCar / CERSUSCHEM
Profa. Debora G. C. Blanco - Director of the State Board of Education
Prof. Orlando Menegati - Municipal Secretary of Education
Profa. Dra. Wilma R. Barrionuevo: Executive Coordinator of EduSCar

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INNOVATION AND TECH TRANSFER

Eduardo Bellini Ferreira – EESC / USP (Coordinator), Sergio Luis da Silva – UFSCar (Tech Transfer Manager), Edgar Dutra Zanotto – DEMa /UFSCar and Oscar Peitl – DEMa /UFSCar

In all these years of CeRTEV, we have restated our approach of pursuing new technologies in all the fields of our main plan and their transfer to the productive sector, basing our strategy on three pillars: i) establishment of cooperation agreements and licensing of on-demand technologies commissioned by industry, focusing the skills of our group to bring the industry close to our academic institutions, connecting universities, companies, and other institutions through cooperation programs as PITE and PPP/FAPESP, and FINEP; ii) nucleation of spin-off companies from the group activities, stimulating entrepreneurship, and encouraging engagement in applications such as PIPE/FAPESP; and iii) extensive promotion of innovation and technology transfer, accomplished by our extensive know-how in these subject areas combined with the assistance of agencies at UFSCar (www.inovacao.ufscar.br) and USP (www.inovacao.usp.br). Below we report the activities related to our Innovation and Tech-transfer effort to channel the CeRTEV's research achievements into innovation.

Establishment of cooperation agreements and licensing of on-demand technologies commissioned by industry in this period

E.D. Zanotto has carried out joint projects with the companies **AGC (Japan)** (11/2019-10/2020): (76,200 €), and **IVOCLAR AG (Liechtenstein)** (11/2019-10/2020): dental materials (54,000 €).

E.D. Zanotto has a project with **CBMM (Brazil)**: optical glasses (R$ 230.000), IP in negotiation with UFSCar; and a project approved with **EMBRAPII (Brazil)**: budget for CeRTEV in negotiation.

H. Eckert has ongoing projects with **Nippon Electric Glass (Japan)** (01/2019-12/2020) on the structure-property relations for crack-resistant glasses (40,000 €); and **Schott Glass Company (Germany)** (04/2020-04/2021) on structural characterization of fluorophosphate glasses (30,000 €)

M.R.B. Andreeta has an ongoing project with the company **Alacer Biomédica (Brazil)** 01/2019-09/2020 (R$ 244,340.40) on the *Development of solid-state pH sensors*, a systematic study on the preparation of new vitreous and glass-ceramic systems based on borosilicates as solid-state pH sensors.

M.R.B. Andreeta has a PIPE in the final stage of analysis by FAPESP with the company **Engecer (Brazil).**

A.C.M. Rodrigues has an ongoing project with the International Commission on Glass (ICG) (2.000 €) to be extended.

A.S.S. De Camargo finished (12/2019) a project with **Nippon Sheet Glass Foundation (Japan)**, "Design, obtainment and structure-property characterization of rare-earth ion-doped glasses and glass ceramics for technological applications" (US$ 3,000).

Further actions for the establishment of cooperation agreements will be considered according to the research advances made in each area.

Nucleation of spin-off companies from the group activities
VETRA High-Tech Ceramic Products, a CeRTEV spin-off company, was established in São Carlos in August 2014 to offer glass and GC biomaterials combining unique features of biodegradability, bioactivity and bactericidal action. The company has actively participated in outreach activities promoted by CeRTEV and collaborated in pre-clinical and clinical research with several departments from various universities (Unicamp, UNIFESP, UNESP, USP, UFABC). The company is currently incubated at Supera Parque (Ribeirão Preto-SP) and has established its lean production plant. A FAPESP project (PIPE 2019/09099-6) is running, and another one will be submitted to FAPESP in July/2020. The company also has a FAPESP project in collaboration with the Department of Medicine at USP. VETRA obtained a license for the patent BR 10 2017 01064 "Implant for volume reposition in anophthalmic cavities in humans or animal, process for obtaining it, device for implant machining and its use" and this product is being analyzed by the Brazilian Health Regulatory Agency (Anvisa). Another patent PI0300644-1 "Process and compositions for preparing particulate, bioactive or resorbable biosilicates for use in the treatment of oral ailments" is in the process for licensing. Vetra recently closed supply contract deals with two national companies and is developing new technologies for dentistry and medical use.

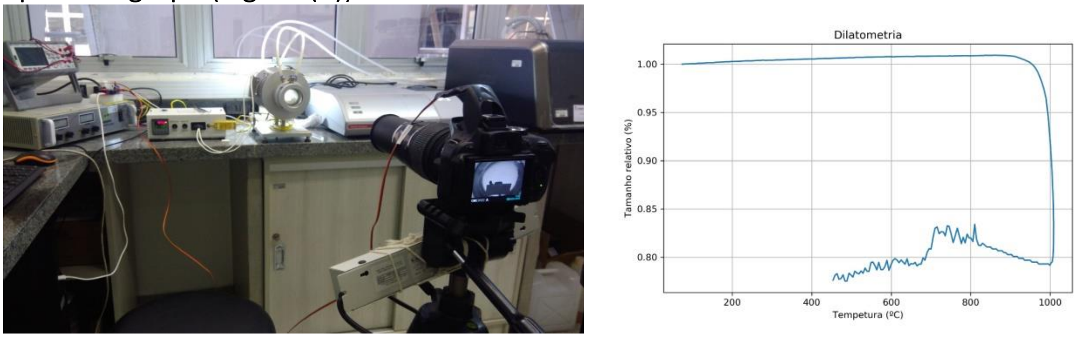
Extensive promotion of innovation and technology transfer
As results of our scientific & technological efforts, the following patent applications are on the way or have been filed with the Brazilian National Institute of Industrial Property (INPI):

- C.V.R. MACHADO, **E.D. ZANOTTO**, M.C. CROVACE & **O. PEITL** approved the patent proposal "Bioactive glass-ceramic based cement (biosilicate) for applications in orthopedics and dentistry," (in Portuguese) on April 30, 2020, at UFSCar, process AIn PI 2020/004, for submission to the INPI.
- C.P.M. ABADIA, M.C. CROVACE, **E.D. ZANOTTO**, M.T. SOUZA & C.R. CHINAGLIA approved the patent proposal "Method of preparing scaffolds of biosilicate/bioglass F18 and scaffolds obtained for applications in medicine and dentistry", (in Portuguese) on June 04, 2020, at UFSCar, process AIn PI 2020/009, for submission to the Brazilian National Institute of Industrial Property (INPI).
- BR 10 2019 027233-3 "Process for obtaining calcium and strontium polyphosphate coacervates with radiopaque properties" (in Portuguese), Titular: UNESP; Inventors: D.F. FRANCO, H. BARUD, S.J.L. RIBEIRO, **M. NALIN**, 12/2019.
- BR 10 2019 027220-1 "Product and process for preparing glasses and optical fibers for use in Faraday rotators" (in Portuguese), Titular: UNESP; Inventors: D.F.FRANCO, J.R. ORIVES, **M. NALIN**, 12/2019.

The analysis at INPI, unfortunately, may take from 7 to 10 years.

Other actions for the promotion of innovation and technology transfer
Developing of equipment & scientific instrumentation devices carried out by the CeRTEV researchers:

- The flash-sintering team has upgraded the system for flash sintering. During the M.Sc. course of J.M. Murdiga at USP-São Carlos, supervised by E.B. Ferreira (EESC-USP) and C. Magon (IFSC-USP), an automatic optical dilatometry apparatus (Figure (a)) was assembled and the electronic system updated. The new system works by connecting a camera to an LDR (Light Dependent Resistor), making it possible to combine a photo and the oven temperature automatically. The software was also developed to import the images of the sample during sintering, make the analysis, and export a thermal expansion graph (Figure (b)).



(a) (b)

Figures. (a) New apparatus for flash sintering and optical dilatometry. (b) Resulting dilatometric curve.

o I.N. Piccirillo is developing a Ph.D. thesis at the Industrial Engineering Department at USP supervised by D.C. Amaral (USP-São Carlos) and intended to create and validate a platform model for collaborative technology development with the industry, in the CeRTEV environment. The work is based on roadmapping and blockchain technology to facilitate the product and technology development process, as well as manage Intellectual Property. The proposal aims to increase the agility of the technological cooperation process by minimizing risks regarding the exposure of sensitive data, reducing transaction costs for licensors and licensees, making this process more efficient. I.N. Piccirillo traveled to Cambridge, UK, in November 2019, to participate in a closed event with companies (Strategic Technology & Innovation Management Consortium), and conduct field research through interviews (researchers and company employees) on the blockchain, intellectual property, the Ph.D.'s conceptual model and roadmapping. This project has the potential to generate a spin-off to exploit the resulting collaborative platform.

o **A.C.M. Rodrigues** organized the CeRTEV Course on Glass Technology for glass professionals, with lecturers from the Glass Industry and University. The "CeRTEV Glass Technology Course 2020" was planned to be held in São Carlos, from March 30th to April 4th, with 14 enrolled participants from different glass industries from the whole country. Unfortunately, this training course was also canceled due to the pandemic.

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Some glass-technology related articles

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o SANTOS, G.G., CROVACE, M.C., **ZANOTTO, E.D.,** "New engineered stones: Development and characterization of mineral-glass composites", *Composites Part B: Engineering* 167 (2019) 556-565.

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Plan for the next period

Besides the general plan of pursuing new technologies in all the fields of our CeRTEV project and their transfer to the productive sector, based on our strategy given at the beginning of this report, we will also invest effort on the following goals:

o The ***3rd Workshop University-Industry on Glass Materials*** was postponed to November 2020 and will be held virtually due to the pandemic and, if possible, at EESC-

USP in São Carlos, aiming to probe demands on glass science and technology from the national glass industry. The event is organized in cooperation with our National Advisory Board, most of whose members also make the Commission on Glass of the Brazilian Ceramic Society. The focal theme of this workshop is the glass bulk, and this time it will have an original format: five topics were chosen, listed below:

- Foam in glasses (foaming)
- Inclusions (glass defects)
- Optimization of batch formulation for glass forming
- Raw material
- Glass homogeneity

For each subject, we will have two coordinators, one from academia and the other from industry or related occupation. The coordinators will have the following functions: 1) search for and explore matters of interest within the broad theme; 2) form a team to develop these issues; 3) make a summary on the topic, for immediate dissemination; 4) advance a schedule with the team members; 5) define milestones, distribute work within the team, schedule status meetings; 6) create a TRM (Technology Roadmap) to develop of activities in the short, medium and long term; 7) make a presentation on the theme on the day of the event (November 2020); 8) organize the results in the form of a (pedagogical) text for publication in media to be determined. A roadmap available to glassmakers will be delivered on how to deal with these issues in the production lines and how the interaction with universities can benefit industries. We aim to produce a publication, and we hope that the groups will continue developing these themes after the end of the III Workshop.

○ We will continue our efforts to boost the **Wikividros**, the Web-based content on glass science & technology, created by CeRTEV as an open collaboration platform hosted at https://wikividros.eesc.usp.br/.

○ Even though economic and political issues prevented us from making significant progress on this matter, we maintain our plan of launching a program of internship training and vacation school of undergrad and graduate students from CeRTEV with partners from the glass industry, following the suggestion of H. Jain, member of CeRTEV's IAB.

COVID-19 Efforts for 2020-2021

To attend FAPESP call to the scientific community for studying, understanding and perhaps mitigating the Covid-19 pandemic, we are initiating six pilot projects relating to CeRTEV's expertise:

Solid state sensor for monitoring COVID-19 patients

Marcello Andreeta (DEMa-UFSCar/ CeRTEV)

Since the SARS-CoV-19 busted into our society, there has been a great deal of effort worldwide to contain or exterminate the virus. However, there is a strong possibility that we might need to coexist with SARS-COV-2 for a long time, such as we have been living with the HIV and Influenza. In this way, to treat patients with maximum efficiency, there is a need to monitor them in real-time, since the COVID-19 could change very fast a patient condition from controlled to critical. One way to fulfill this need is to provide portable sensors to measure the vital signs of affected organs. One example is the kidney functions, which could be strongly affected by the COVID-19[1–4]. The importance of knowing all possible parameters of the effect of COVID-19 on the patient has been shown by Liu et al.3, who proved that, although small, the pH of the urine of COVID-19 patients can provide an indication of the disease´s evolution. They have shown that, among other factors, the urine pH changes were statistically significant ($p=0.004$). In this way, the development of all-solid-state sensors can surely help physicians get access to patient´s data that could help in the development of new treatments, and feed artificial intelligent devices, based on machine learning methodology4. Glasses can play an important role in all-solid-state pH sensing elements, avoiding other devices' drawbacks, such as phosphate and citrate interference in the measurements, problems that are common to the most traditional pH solid-state sensors, such as antimony crystals.

Research

Regarding the previous motivation, in this research project we propose is the systematic study of glass preparation and also the crystal growth process in the Li_2O- $(La,Y)_2O_3$-TiO_2-SiO_2 system. This project aims to correlate the sensitivity for pH detection with the respective compositions and microstructures of the glass-ceramics. We expect to prepare materials that result in the miniaturization of a solid-state pH sensor device. To achieve these objectives, the samples will be prepared in spherical geometry by laser melting in an aerodynamic levitation system. Half of the surface will be covered by silver paste electrodes. The system will be encapsulated in epoxy resin. Voltage measurements (against a AgCl solid reference electrode) will be measured as a function of the pH of certain solutions. The effect of phosphate and citric acid will also be investigated. In this way, we intend to advance in the miniaturization of all-solid-sate sensors that can be used to monitor COVID-19 patients as well as other types of diseases.

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An alternative biomaterial approach against COVID-19

Oscar Peitl and E.D. Zanotto (DEMa-UFSCar / CeRTEV)

Marina Trevelin (UFSCar) and Juliana Daguano (UFABC) collaborators

Respiratory diseases due to human coronaviruses SARS-CoV-2 are currently one of the main causes of morbidity and mortality worldwide. As there are currently no effective drugs targeting this virus, the development and study of alternative substances or materials for disease control and to avoid the virus spread are crucial activities. Taking into account the relevance of this matter, our CeRTEV team is currently establishing collaborations with several experts from CTI Renato Archer, IPEN, UFABC and a bioactive glass national company. Namely, Dr. Jorge Silva (CTI), Dr. Daniel Perez and Prof. Janaína Dernowsek (IPEN), Prof. Juliana Daguano (UFABC) and Vetra.
Our main objective is to explore how the virus responds when exposed to bioactive glasses and bio glass-ceramics in different concentrations and bioavailability means.
The viral production is intended to be done in three-dimensional lung multicellular spheroids in air- and liquid-interface using Calu-3 cells (American type culture collection ATCC® HTB55™) in DMEM with 4% of fetal bovine serum and 1% glutamine. Cytopathic effects will be monitored daily under an inverted microscope and after nearly complete cell lysis (approximately 96 h), viral supernatant will be used for inoculation on a 96-well plate with 104 cells/mL. Materials extracts and direct contact will be tested. The chosen concentrations will be 12.5, 25 and 50 mg/ml for two different materials: F18 bioactive glass and Biosilicate (a biphasic glass-ceramic material). The extraction will be done using the manual High Pure RNA Isolation Kit (Roche Life Science), following the recommended procedures and the RT-PCR, using the Roche RealTime PCR Ready RNA Virus Master Kit, will be carried out for relative viral quantification. Tests are intended to be done in triplicate.
To test bioactive materials as a possible treatment, based on “false negative” results, we speculate on the concomitant analysis of the inflammatory response, with macrophage addition to the spheroids. Thus, the infection processes will be monitored every 3 days by the measurement of IL-8, IL-1β and TGF-β from the culture medium, for 15 days (maximum time for virus infection). Since this kind of investigation has no precedent, the outcome is unclear, however, we expect that this investigation can provide some evidence for the potential use of bioactive materials on controlling viruses and cell lysis.

Hidden deaths, propagation kinetics, and prevalence of Covid-19 in Brazil

Juan Gonzalez (DF-UFMG), Victor Lopez-Richard (DF - UFSCar), Eduardo B. Ferreira (EESC-USP/ CeRTEV) and Edgar D. Zanotto (DEMa - UFSCar/ CeRTEV)

As in most countries, the SARS-Cov-2 virus is inflicting an enormous impact on Brazil's health and economic systems. However, as opposed to all other countries -- except for Belarus, Turkmenistan, and Nicaragua -- the federal government in Brazil has been actively against any form of social distancing (SD), which severely restricted any strategy to decelerate virus spreading. The level of confusion and uncertainty is such that two health ministers have been dismissed in less than 2 months (the first death occurred on March 17) and, at this moment (June, 15) this country has only a temporary health minister. Also, to the astonishment of the science community and media, in the first week of June, the Health Ministry decided to hide all the official cumulative statistics about the COVID-19. They have now stepped back due to strong opposition. The whole situation is very confusing, to say the least.
The reason why 35 to 55% of the population has remained more or less confined -- as shown by daily cell phone and traffic camera statistics -- was the strong resistance of

several state governors and city mayors, which has been supported by most of the media, by frequently advertising the value and importance of SD. Hence, only partial social distancing has happened. Only a few cities have tried a real lockdown for less than one month, without much success.

In this context, it would also be relevant to evaluate the percentage of hidden deaths in this country. It is important to note that, due to the appalling scarcity of tests (especially in the poorer, favela type communities), most respiratory type death causes could be easily confused with COVID-19 induced fatalities and ascribed to these other causes. Hence, in Brazil, a significant fraction of deaths might have been officially attributed to other types of diseases, especially respiratory diseases. As a result, the actual COVID-19 death toll is likely underestimated.

Another relevant issue is how the death toll per capita versus time (the kinetics) in Brazil compares with countries that enforced more severe restrictions. Finally, a third important issue is related to widespread misinformation in social media ascribing only minor importance to COVID-19-related deaths as compared to other virus-related death causes due to, for instance, H1N1, bacterial pneumonia, tuberculosis, dengue and yellow fever, which are still prevalent diseases in Brazil.

Research plan.

We will take advantage of our experience in data mining and analyses (perfected by our recent ML learning research work) to harvest, analyze, and discuss relevant statistics about Brazil's COVID-19 crisis. We will make a realistic estimate of the number of unaccounted deaths, on the kinetics of propagation of the COVID-19, and also of its prevalence versus other important virus inflicted diseases in this country. Finally, we will use two accepted mathematical models to provide lower and upper bound estimates of the temporal evolution of the death toll. We believe our results will be instrumental in revealing the actual COVID-19 situation in this country and in directing actions to mitigate it.

Reusable functional glassy materials focused on nCov-19 annihilation

Andrea de Camargo / LEMAF - Laboratory of Spectroscopy of Functional Materials

The new virus nCoV-2019 is a highly infectious pathogen responsible for the Coronavirus disease that has affected the globe in 2020. Brazil currently occupies the 2nd position in the rank of countries with highest contamination and death figures [1]. Surfaces and objects in general are among the possible transmission channels of the virus. In the absence of effective disinfection methods, the virus can survive from 4h (on paper, for instance) up to 9 days, as it has been observed for ceramic surfaces [2]. Though alcohol and other products can be used for disinfection, they are consumed and only offer short term antimicrobial action. That motivates the development of longer lasting, reusable disinfection methods based, for instance, on glass and glass ceramic materials. To that end, we propose the development of sol gel derived silicate glassy materials functionalized with antiviral agents such as photosensitizing molecules and metallic nanoparticles. The photosensitizers are molecules that can induce chemical change in other molecules through a photochemical process. Their widespread use is in photodynamic therapy (PDT) of cells and microorganisms through the generation of reactive oxygen species (ROS) which, through oxidation of biomolecules such as proteins and lipids are capable of inducing cell death and deactivation of viruses and bacteria [3,4]. The metallic nanoparticles (MNPs) exhibit well known antimicrobial action and have been used for combating both viruses and bacteria. Some examples include NPs of silver, gold, iron, iron oxide, copper oxide, zinc oxide, etc. Their mechanism of action depends on the type of the NP and can include photocatalysis, toxicity or generation of ROS.

PLAN OF ACTION: i) Synthesize glassy silicate and organo-silica matrices via the sol gel method from various precursors and in different morphologies (films, bulk, spheres, pellets); ii) From structural characterization select the most resistant matrices that can be easily functionalized; iii) Synthesize, characterize and optimize the antiviral agents (MNPs, photosensitizers) that will be grafted to the vitreous matrices; iv) Functionalize the matrices with the antiviral agents and submit the final materials to biological testing in collaboration with colleagues with the available expertise and infrastructure in Brazil and abroad; v) Select the most efficient material for combating coronavirus; vi) Extend the work focusing on the development of prototypes of masks and glasses, for individual protection, with low cost and encompassing coverage.

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Optical fibers as fast and cheap sensors for COVID

Marcelo Nalin - LaViE - Laboratório de Vidros Especiais

In order to reduce the use of toxic solvents, decrease the analysis time, and minimize costs, the use of biosensors is an effective option that can provide sensitive analytical responses. Biosensors are characterized by biological recognition using the response driven by an antigen, antibody, or enzyme. [1] When antibodies are used, the biosensor is called an immunosensor, presenting high specificity due to the analyte-antibody bond. [2]

Immunosensors can be prepared using different materials. Portable fiber-based immunosensors used for the monitoring of an evanescent wave absorbance signal offer advantages such as low electromagnetic interference, high transmission bandwidth for optical transfer, fast signal acquisition, and low cost. [3] Enhanced signal transmission can be achieved using conductive polymers such as polyaniline (PANI) or polypyrrole for conversion of the biological signal into an electric signal, from which the analyte concentration is obtained. [4, 5] PANI polymers offer excellent chemical stability and simplicity of synthesis using inexpensive monomers. [6]

U-bent optical fibers have the advantages of robustness, sensitivity, and ease of handling. Furthermore, they can increase sensor sensitivity by up to 10-fold, compared to straight probes. A great advantage of this configuration is increased by the penetration of the evanescent wave field towards the direction of radiation propagation. [7]

The aim of the present project is to develop an ultra-sensitive U-bent optical fiber-based immunosensor for the determination of COVID in blood samples, without any requirement for a sample preparation procedure. The evanescent absorbance can be captured using a low-cost non-hygroscopic silica optical fiber, free from electrical interference and with high signal multiplication capacity, optical transparency, inertness even in aggressive environments, low tendency for laser-induced breakage, and ability to be doped or functionalized by various materials. [8] All these features made this material ideal for use in the present study.
In a recent work (R. Lamarca et al.), Label-free ultrasensitive and environmentally-friendly immunosensor based on a silica optical fiber for determination of ciprofloxacin in wastewater samples, under revision in the journal of Analytical Chemistry (Manuscript ID: ac-2020-02355k)) we demonstrated the versatility of U-bend optical fiber to detect ultra-low concentrations of ciprofloxacin in wastewater samples. We believe that the methodology used in the paper is completely adaptable to develop a cheap sensor to detect COVID virus, however the cooperation with experts in the health field is necessary and is actually under discussion.

References

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[3] CHANDRA, S., BHARADWAJ, R., MUKHERJI, S. Label free ultrasensitive optical sensor decorated with polyaniline nanofibers: Characterization and immunosensing application. Sensors and Actuators B: Chemical 2017, 240, 443-445.
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Preparation of amorphous porous thin films functionalized with bismuth species. Detection of and protection from viruses suspended in the atmosphere of crowded indoor gatherings

H. Eckert, IFSC.

Introduction: Increasing evidence has been showing that the suspended aerosol of crowded indoor gatherings constitutes an important vehicle of the severe acute respiratory syndrome Coronavirus (SARS-CoV-2) transmission. Thus, detection of and

protection from viral contamination of such aerosols will be an important goal. In pursuit of this objective, we propose to develop a line of research within our CeRTEV effort, dedicated to the development of porous amorphous thin films functionalized with bismuth(III) species. The highly efficient antiviral activity of various bismuth(III) complexes was brought into focus following the last SARS crisis of 2002-2004. [1,2]. Complexes such as bismuth nitrilotriacetate, bismuth nitrate, bismuth tricysteine, and ranitidine bismuth citrate (RBC) turned out to be very efficacious inhibitors of the SARS CoV-2 virus, at micromolar concentration levels. RBC in particular was shown to effectively inhibit the ATPase activities of the helicase and to inhibit the duplex-unwinding activity. [1,2].
Approach: The considerable structural and chemical similarity of SARS- viruses involved in the 2002 and 2019 pandemics [3,4] suggest that Bi complexes may have similar efficacy in the current COVID challenge. The mechanism is thought to involve binding of Bi3+ ions to the cysteine-rich metal binding domain that is located at the N terminus of the SCV helicase protein [1]. If there is indeed an analogous binding interaction (yet to be confirmed) between the new SARS-Cov-2 virus and the bismuth species, the preparation of porous glasses functionalized with bismuth(III) species at their surfaces will offer promising prospects, with regard to both the detection and the removal of the virus from the ambient atmosphere of crowded indoor gatherings.
Virus detection can benefit from the fact that bismuth-doped glasses have a very intense and distinctive luminescence spectrum [5], which can be significantly perturbed by the effect of molecular binding. As a result, one may expect a shift of the emission frequency or possibly altogether suppression (quenching) of the fluorescence, which offers the perspective of developing a solid-state breath analyzer. A second potential application of such a material is the implementation of such porous Bi-doped glasses in antiviral breathing filters.
Work plan: Three different preparation strategies will be explored towards the development of Bi-functionalized amorphous porous surfaces: wet impregnation of porous siliceous matrices [6], topotactic modification of sol-gel prepared mesoporous sodium aluminosilicate glasses [7] via ion exchange [8] and in-situ templating of porous inorganic frameworks in the presence of the bismuth species [9]. The luminescence characteristics of these materials will be measured and changes in their luminescence spectra upon the binding of thiolic species (such as cysteine) will be characterized. Once the solid materials have been developed and proven their utility in binding studies of model compounds, a collaboration with a virus molecular biology research laboratory will be sought to study the interaction with SARS-Cov-2 virus.

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Funding from industry 2019 – 2020

HELLMUT ECKERT
Nippon Electric Glass - Euros 40,000 Jan. 2019- Dec. 2020
Schott Glass AG - Euros 30,000 April 2020- March 2021
EDGAR DUTRA ZANOTTO
ACG (Japan) - Euros 76,200 - Nov. 2019 - Oct. 2020
IVOCLAR AG (Liechtenstein) - Euros 54,000 - Nov. 2019 - Oct.2020
CBMM (Brazil) - R$ 230.000 IP in negotiation
EMBRAPI (Brazil) - Project approved, budget for CeRTEV in negotiation
MARCELLO RUBENS BARSI ANDREETA
Alacer Biomédica - R$244.340,40 - Jan. 2019 - Set. 2020
ENGECER - (PIPE - final stage of analysis by FAPESP)
A.S.S. DE CAMARGO
Nippon Sheet Glass Foundation, US$ 3,000 (finished Dez. 2019)

Funding from other agencies: CNPq, CAPES, Internacional agencies
H. Eckert, CNPq, Universal - R$ 37,500 2019-2021
H. Eckert, DFG, SFB858 €156,750, 2019-2021
H. Eckert, DFG, Ec168-20 € 10,000, 2019-2021
E.D. Zanotto, CNPq, Universal - R$ 40.000 2019-2020
A.S.S. de Camargo, CNPq, Universal - R$ 84.000,00 2016-2020 (ended May 2020)
A. S. S. de Camargo, FAPESP, Auxílio Regular - R$ 200.000,00 2020-2022 (submitted)
J.F. Schneider, CNPq, Universal, R$ 20.815,20, 2018-2021
V. R. Mastelaro, CNPq, Universal, R$ 45.000.00 - 2020-2021
M. Nalin, Chamada FAPESP-ANR (França) - R$ 400,000,00 (Submitted)
A.C.M. Rodrigues- ICG - International Commission on Glass - Euro 2,000 Jan. 2019- Sept. 2021

Prestigious CNPq fellowships/grants to the CeRTEV faculty
ECKERT, H., Bolsa CNPq, Nível 1A
ZANOTTO, E.D., Bolsa CNPq, Nível 1A
PIZANI, P.S., Bolsa CNPq, Nível 1B
RINO, J.P. Bolsa CNPq, Nível 1B
MASTELARO, V.R., Bolsa CNPq, Nível 1B
DE CAMARGO, A. S. S., Bolsa CNPq, Nível 1D
SCHNEIDER, J., Bolsa CNPq Nível 2
DONOSO J.P., Bolsa CNPq Nível 2
NALIN, M., Bolsa CNPq Nível 2
RODRIGUES A.C.M. Bolsa CNPq, Nível 2

Overall budget of the Center from <u>other</u> projects, July 2019- June 2020

Funded Projects by CAPES and CNPq	R$ 267.000
International funds including student fellowships	Euro 166,750
CNPq Fellowships to CeRTEV professors - updated	R$ 236.400
Student IC, MSc, Dr, PD / grants from all sources	R$ 850.000
Grants from companies	Euro 202,000 R$ 244.000
Professors salaries USP, UFSCar, UNESP	R$ 3.178.000
Staff salaries UFSCar, USP	R$ 600.000

*1 US$ ~ 5R$ ~ 0.85 Euro

Contracts celebrated with other Institutions

- Rodrigues, Council of Scientific & Industrial Research (CSIR) and Central Glass & Ceramic Research Institute (CSIR-CGCRI), India
- Rodrigues, Zanotto, Peitl, Andreeta - Clausthal University, Germany
- Rodrigues, Zanotto, Institut de Physique du Globe de Paris, France
- Zanotto - CeRTEV with FunGlass Institute, European Union
- Eckert, Westfälische Wilhelms Universität Münster, Germany
- Eckert, Shanghai Institute of Optics and Fine Mechanics (SIOM), China
- Eckert, University Rennes, University Montpellier, TU Munich, LMU Munich, University of Torino, University of Poznan, (EU-MaMaSELF)
- Nalin, Instituto de Química- DAFQI-UNESP - Universidade de Bordeaux, França- Université de Bordeaux- Lionel Canioni -FUNGlass H2020-MSCA-RISE-2018
- Nalin, França - Université de Bordeaux - Thierry Cardinal - Photonics International network - PIN - CAPES-PRINT-Unesp
- Nalin, Instituto de Química- DQGI-UNESP - Universidade de Laval - Quebec Canadá - JIRU (Joint International Research Unit)
- De Camargo, Instituto de Física - WWU Muenster, Alemanha
- Pizani, PS, Université de Lyon, BEPE FAPESP Proc. 2019/11446-6

GENERAL INFORMATION

55 articles published in scientific journals in the period

Listed after the Research Progress, pgs. 11-14

CeRTEV Publications on vitreous materials on Google Scholar since 2013, updated May 30,

https://scholar.google.com/citations?user=jqh7j5sAAAAJ&hl=pt-BR

Summary Jan. 2013 to Dec. 31, 2019

CeRTEV h=31, i10 = 115, 3,350 citations, 307 articles.

Citations/article = 11.5 (excluding the papers of 2020, too early to be cited)

Highlighted articles in 2019 and 2020
*Invited by editors, highly cited, most downloaded, awarded prizes, attracted media attention, etc.

F. Baino, P. Colombo, M. Montazerian and E.D. Zanotto
Journal of the American Ceramic Society, is "Biosilicate® scaffolds produced by 3D-printing and direct foaming using preceramic polymers" (DOI: 10.1111/jace.15948) – ranked among the ten most downloaded articles of the JACerS in 2019.

MOST DOWNLOADED JNCS ARTICLES IN 2019 (~27,000 Articles)

Downloads in 2019	Downloads (lifetime)	Article Title	Authors	Year
3,520 1rst	8,953	Updated definition of glass-ceramics	**Deubener J., Davis M.J., Komatsu T., Nakane S., Zanotto E.D.,** et al.	2018
1,632 6th	10,944	The glassy state of matter: Its definition and ultimate fate	**Zanotto E.D.,** Mauro J.C.	2017
1,302 10th	4,527	Biosilicate® - A multipurpose, highly bioactive glass-ceramic.	Crovace M.C., Souza M.T., Chinaglia C.R., **Peitl O., Zanotto E.D.**	2016

*Names in **bold** = CeRTEV Professors or IAB members

MOST CITED JNCS ARTICLES IN 2019 (Published IF Window 2017-2018)

Citations In 2019	Total Citations	Article Title	Authors	Year
27 (4th)	51 Since 2018	Updated definition of glass-ceramics	**Deubener J., Davis M.J., Komatsu T., Nakane S., Zanotto E.D.,** et al.	2018
26 (5th)	65 Since 2017	The glassy state of matter: Its definit...	**Zanotto E.D.,** Mauro J.C.	2017

*Names in **bold** = CeRTEV Professors or IAB members

JOHN C. MAURO and EDGAR D. ZANOTTO - Two Centuries of Glass Research: Historical Trends, Current Status, and Grand Challenges for the Future - International Journal of Applied Glass Science Pages: 313-327, Published: 28 July 2014 (Most read in 2019, 2nd place - most read article ever)

Examples of CeRTEV research news in the media in the period July 2019-June 2020

- https://ceramics.org/acers-spotlight/a-us-fulbright-scholar-experience-in-brazil
- https://ceramics.org/ceramic-tech-today/glass-1/could-glass-be-used-to-make-reusable-face-masks
- https://ceramics.org/professional-resources/career-development/short-courses/nucleation-growth-and-crystallization-in-glasses
- https://revistapesquisa.fapesp.br/big-data-de-materiais/
- https://sinteses.blogfolha.uol.com.br/2020/02/26/inteligencia-artificial-promete-futuro-com-materiais-sob-medida/
- https://www.diariodasaude.com.br/news.php?article=material-bioativo-tem-multiplas-aplicacoes-medicas-imediatas&id=13510
- http://www.glasspossible.com/glass_facts.html
- https://www.azom.com/news.aspx?newsID=51656
- http://www.inovacao.usp.br/biovidro-e-suas-aplicacoes-na-medicina/

TALKS AT INTERNATIONAL CONGRESSES, WORKSHOPS, AND SYMPOSIA July 2019 - June2020

SCHNEIDER, J.F. - *"The Role of Ion Dispersion and Dynamics in Origin of the Mixed-Ion Effect in DC Conductivity in Phosphate Glasses"* - 15th International Conference on Diffusion in Solids and Liquids, Athens, Greece 2019.

NALIN, M. *"Exploring New possibilities with magnetic glasses"* 7º Symposium Laphia, Bordeaux - France, 12-13 November, 2019. (INVITED)

RINO, J.P. *"Molecular Dynamics Study of Barium Sulfide: An assessment of the Classical Nucleation Theory"* 5th EMN Meeting on Computation and Theory, Mauritius, November, 26 -30 , 2019. (INVITED)

RODRIGUES, A.C.M.: *"Enhancement of Ionic conductivity in NaTi2(PO4)3 glass-ceramics by substituting P with Si: electrical and structural characterization of a new sodium superconductor"* "14th International Conference on the Structure of Non-Crystalline Materials (NCM14)" Kobe-Japan, November, 2019. (INVITED)

RODRIGUES, A.C.M.: *"Advanced Applications of Glass-Ceramics"*, Lecture given at Central Glass and Ceramic Research, Kolkata, by invitation of the Indian Ceramic Society, Kolkata Chapter, January, 2020. (INVITED)

ECKERT, H. *"The Glassy Part of Glass Ceramics. Structural Elucidation by Solid State NMR"*, Spring Meeting, American Chemical Society, Philadelphia, March 2020. (INVITED), Meeting cancelled due to COVID crisis

DE CAMARGO, A. S. S. *"NMR spectroscopy as a powerful tool for the structural elucidation of sol gel materials",* 9ª Escuela de Síntesis de Materiales: Procesos Sol Gel, Buenos Aires, Argentina, October 2019. (INVITED)

DE CAMARGO, A. S. S. *"Luminescent applications of hybrid sol-gel host guest materials"*, 9ª Escuela de Síntesis de Materiales: Procesos Sol Gel, Buenos Aires, Argentina, October 2019. (INVITED)

DE CAMARGO, A. S. S. *"Panorama of the participation of Women in Exact Sciences"*, 9ª Escuela de Síntesis de Materiales: Procesos Sol Gel, Buenos Aires, Argentina, October 2019. (INVITED)

DE CAMARGO, A. S. S. *"Exzellenz verbindet – Be part of a worldwide network"*, 4th Forum for Women in Science without Borders, Rio de Janeiro - RJ, February 2019. (INVITED)
DE CAMARGO, A. S. S. *"Photoactive nanoclay carriers and functionalized upconverting nanoparticles for biophotonic applications"*, CIMTEC - 15th International Ceramics Congress and 9th Forum on New Materials, Montecatini Terme, Italy, June 2020. (INVITED - rescheduled for June 2021 due to Corona)
DE CAMARGO, A. S. S. *"Nanoparticles and nanovessels bearing active molecular species for biophotonic applications",* ICOOPMA - International (INVITED) cancelled
ZANOTTO, E.D. – *"On the ultimate fate of glass"* - 8th Otto-Schott Colloquium/ 4th Entropy workshop, Jena, Germany, September 2019. (INVITED)
ZANOTTO, E.D – Crystal nucleation and nanostructured glass-ceramics, PANNANO 2020, 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 TALK) – postponed to August 2020.
ZANOTTO, E.D., "Digging deeper into crystal nucleation by MD simulations" MD Challenges, Corning, USA, June, 2020. (INVITED TALK) - cancelled (Covid-19)

NATIONAL MEETINGS July 2019 – 2020

RODRIGUES, A.C. M. – *"Substituting P with Si to enhance the ionic conductivity of NaTi2(PO4)3 NASICON glass-ceramics"*. XII BrazGlass, Brazilian Symposium on Glass and related Materials, Federal University of Lavras, Lavras, M.G., October, 2019. (INVITED)
SCHNEIDER, J.F. - *"Mixed-Ion Effect in Phosphate Glasses: Ion Dispersion, Ion Dynamics and DC Conductivity"* - XII Brazilian Symposium on Glass and Related Materials, Federal University of Lavras Lavras-MG, October, 2019.
ZANOTTO, E.D. - *"Experiência do CEPID – CeRTEV no entendimento e desenvolvimento de materiais vítreos funcionais"* I Simpósio de Pesquisa e Inovação em Materiais Funcionais (I SPIMF). Sao Carlos-SP, October, 2019. (PLENARY)
ZANOTTO, E.D. *"Publishing top articles in top journals"* - - XII Brazilian Symposium on Glass and Related Materials, Federal University of Lavras Lavras-MG, October, 2019. (OPENING TALK)
ZANOTTO, E.D. – *"Benvindo à era do vidro"*, I colóquio sobre Materiais da UFCG, June 23, 2020. (PLENARY)
ECKERT, H., *"New insights into six-coordinated silicon in glasses"*, - XII Brazilian Symposium on Glass and Related Materials, Federal University of Lavras Lavras-MG, October, 2019. (INVITED)
ECKERT, H. *"The glassy part of glass ceramics: structural elucidation by solid state NMR*- XII Brazilian Symposium on Glass and Related Materials, Federal University of Lavras Lavras-MG, October, 2019. (INVITED).
DE CAMARGO, A. S. S. *"Vidros, vitrocerâmicas e materiais híbridos luminescentes para aplicações fotônicas e biofotônicas",* Colloquium, Universidade Federal Rural de Pernambuco, Unidade Acadêmica de Cabo de Santo Agostinho, Cabo de Sto. Agostinho - PE, October 2019 (INVITED)
DE CAMARGO, A. S. S. *"Sponsorship opportunities of the Alexander von Humboldt Foundation"*, Comemoração dos 250 anos de Alexander von Humboldt, UFSCar, São Carlos, November 2019 (INVITED)
DE CAMARGO, A. S. S. *"Exciting nano- and mesoscopic host-guest materials for photonic*

and biophotonic applications", SoN - Soft Nanomaterials Center, University of Münster, Alemanha, February 2019. (INVITED)

DE CAMARGO, A. S. S., *"Física para Meninos e Meninas, Escola de Física Contemporânea"*, Instituto de Física de São Carlos IFSC/USP, July 2019. (INVITED)

DE CAMARGO, A. S. S., *"Ciência para Meninos e Meninas",* Projeto Meninas nas Ciências Exatas da Baixada Fluminense, Museu Ciência e Vida, Duque de Caxias - RJ, September 2019. (INVITED)

DE CAMARGO, A. S. S. *"From UV radiation sensing to near infrared laser action - Contributions from LEMAF for the development and characterization of new RE-doped glasses",* XVIII Brazil MRS (SBPMat) Meeting, Balneário Camboriú - SC, September 2019.

DE CAMARGO, A. S. S. *"Hybrid host-guest materials based on luminescent molecules as promising dye and random laser active media",* XIV Simpósio de Lasers e suas Aplicações, Universidade Federal de Pernambuco, Recife - PE, October 2019. (INVITED)

Conferences, workshops and symposia organized or co-organized by Certevians

DE CAMARGO, A. S. S., *Co-organizadora* do Simpósio J - Glasses and Glass Ceramics, Encontro anual da SBPMat - Sociedade Brasileira de Pesquisa em Materiais, Camboriú – SC, September, 2019.

DE CAMARGO, A. S. S., *Co-organizadora* do 4th Forum of Women in Science without borders, Rio de Janeiro – RJ, February, 2020.

DE CAMARGO, A. S. S., *Coordenadora da Área de Óptica* no EOSBF - Encontro de Outono da Sociedade Brasileira de Física, Bonito – MS, May de 2020.(postponed to November)

DE CAMARGO, A. S. S., *Organizadora* do Simpósio Multifunctional Hybrid Materials and Nanocomposites: Development and Applications, Foz do Iguaçu - PR September, 2020. (postponed to September, 2021)

ZANOTTO, E.D. – *"Fundamentals of glass crystallization"*- Symposium during the GOMD, New Orleans, USA, May 2020. (postponed to August)

Awards and distinctions granted to CeRTEV faculty in the period January - July 2019-June 2020

ZANOTTO, E.D. et al. - Two articles ranked among the 6 most downloaded and most cited of the JNCS in 2019 – "Updated definition of glass-ceramics" (published in 2018) and "The glassy state of matter" (2017). Elsevier.

Short courses delivered in the period

ECKERT, H, DE CAMARGO, A.S.S. Solid State Spectroscopy, University of Montevideo, Montevideo, Uruguay, November 2019.

ECKERT, H. Short-Course on Solid State NMR Spectroscopy, IRTG WWU Münster/University of Toronto, Münster, December 2019

DE CAMARGO, A.S.S., Angular momentum spectroscopy applied to characterization of sol gel materials, Buenos Aires, Argentina, October 2019.

ECKERT, H., Spectroscopy and the Structure of Matter, WWU Münster June/July 2019.

ECKERT, H. Solid State NMR Spectroscopy, MaMaSELF (European MSc program in Materials Science), University of Montpellier, January 2020.

Editorship of scientific journals in 2019-2020

ECKERT, H. - *Editorial Board Member*, Solid State Nuclear Magnetic Resonance (Elsevier)
ECKERT, H. - *Editorial Board Member*, Zeitschrift für Naturforschung, (Physics), de Gruyter
ANDREETA, M.R.B. - *Associate Editor*: Open Chemistry Journal (ISSN: 1874-8422)
ANDREETA, M.R.B. - *Editorial Board Member*, EUREKA: Physics and Engineering (ISSN 2461-4254 (Print))
MASTELARO, V. - *Member of the Editorial Commission of Materials Research:* Ibero-american Journal of Materials
MASTELARO, V. - *Associate Editor:* Journal of Alloys and Compounds (Elsevier)
RODRIGUES, A.C.M. - *Associate Editor*, Frontiers in Materials: Glass Science
ZANOTTO, E. D. - *Editor* of the Journal of Non-Crystalline Solids since 2010
ZANOTTO, E. D.- International Materials Reviews (UK) - *Key Reader* and Board member
ZANOTTO, E. D.- *Member of the International Advisory Boards of several other journal:* Springer-Nature Applied Sciences (UK), International Journal of Applied Glass Science (USA), Materials Research (Ibero-American), Biomedical Glasses (Germany), Iranian Journal of Materials Science and Engineering (Iran), Ceramics in Modern Technologies (Italy), Bulletin de la Sociedad Espanhola de Ceramica y Vidrio (Spain), Cerâmica (Brazil).

Administrative and consulting role in scientific societies in 2019 - 2020

DE CAMARGO, A. S. S. – *Membro do Conselho*, Clube Humboldt do Brasil, desde 2014.
DE CAMARGO, A.S.S. *Diretora Científica da SBPMat*- since February 2020.
DE CAMARGO, A.S.S. *Brazilian Ambassador Scientist,* Fundação Alexander von Humboldt, starting July 2020.
MASTELARO, V.R. *Membro do Conselheiro Titular* da SBPMat de 2020 a 2024.
RODRIGUES, A.C.M. – *Chair* of the ICG TC23: Education in Glass.
NALIN, M. - *Member* of the ICG TC20: Optoelectronics
FERREIRA, E. B. – *Glass Committee* of the Brazilian Ceramic Society.
ECKERT, H. - *Advisory Board member*, Network of the French High-Field NMR Facilities.
ECKERT, H. – *Hans - Hellmuth Vits-Prize Committee*, Society of the WWU Münster.
ECKERT, H. - *Awards Committee*, European Research Council.
ECKERT, H. - *Georg-Forster Prize Committee*, Alexander-von-Humboldt Foundation.
ECKERT, H. - *Georg-Forster Fellowship Selection Committee*, Alexander-von-Humboldt Foundation.
ECKERT, H. - *Member, Board of Coordinators*, Physics, FAPESP.
ZANOTTO, E.D. - *President of the Curators Council* of the São Carlos TechParq.
ZANOTTO, E.D. - *Board of Directors of the Brazilian* Ceramic Society.
ZANOTTO, E.D. - *Brazilian representative* in the International Commission on Glass.
ZANOTTO, E.D. - *Council member* of the International Ceramic Federation.
ZANOTTO, E.D. - *Council member* of the FunGlass Institute, European Union.
ZANOTTO, E.D. - *Council member* of the Serrapilheira (Funding) Institute.
ZANOTTO, E.D. - *Council Member* of IMPA (Institute of Mathematics), Brazil.
ZANOTTO, E.D. - *Member of the Glass Crystallization / GC Committee*: ICG TC07.
ZANOTTO, E.D. - *Engineering Fellowship Selection Committee*, TWAS.
ZANOTTO, E.D. - *Gottardi Prize*, Voting Member, ICG.
ZANOTTO, E.D. - *Zachariasen and Mott Awards*, Selection Committee, JNCS.
ZANOTTO, E.D. -*Fellowship Selection Committee*, Young researchers SP session- Brazilian Academy of Sciences.

ZANOTTO, E.D- *CBMM Prize Selection Committee*, CBMM, Brazil
ZANOTTO, E.D. - *Sao Carlos Scientist of the Year Award committee*, São Carlos City, Brazil.

International visitors in 2019-2020

Dr. Alexander Abyzov – Ukraine (ZANOTTO)
Dr. Vladimir Fokin- St. Petersburg (FERREIRA & ZANOTTO)
Prof. Jincheg Du, North Texas, USA (ZANOTTO, RINO, ECKERT)
Dr. Harold Lozano - Santiago, Chile (DONOSO, DE CAMARGO)
Prof. Phil Salmon - Bath, UK (ECKERT)

Voluntary activities within the respective universities

DE CAMARGO, A. S. S. - Vice-Presidente Comissão de Pesquisa IFSC - 05/16 - atual
DE CAMARGO, A. S. S. - Membro titular da Comissão de Pós Graduação Ciência e Engenharia de Materiais, EESC/USP - 08/14 - atual
DE CAMARGO, A. S. S. - Membro titular da Comissão Coordenadora do Curso de Bacharelado em Química, IQSC/USP - 03/17 - atual
DE CAMARGO, A. S. S. - Membro titular do Conselho de Depto. Física e Ciência Interdisciplinar, IFSC/USP – Maio/16 - atual
DE CAMARGO, A. S. S. - Membro titular da Congregação do IFSC/USP, IFSC/USP – 08/16 - atual.
DE CAMARGO, A. S. S. - Membro da Comissão de Assessoramento da Chefia do Dept. de Física e Ciência Interdisciplinar e da Diretoria para distribuição de espaço físico (2019)
DE CAMARGO, A. S. S. - Membro da Comissão de Assessoramento da Chefia do Dept. de Física e Ciência Interdisciplinar para elaboração do plano institucional departamental 2018-2023.
ECKERT, H. – Membro titular de Comissão Relações Internacionais (CRINT)
ECKERT, H.- Membro titular do Conselho de Depto. Física e Ciência Interdisciplinar, IFSC/USP.
ECKERT, H. - Membro titular da congregação do Instituto de Física São Carlos (IFSC), USP.
NALIN, M – Membro da congregação do IQ-UNESP – Araraquara (2014-atual)
NALIN, M – Representante do IQ-UNESP no Conselho Universitário da UNESP- (11/2016-2018)
NALIN, M - Chefe do Departamento de Química Geral e Inorgânica, IQ - UNESP, Araraquara - (2017-2020)
NALIN, M - Vice-Chefe do Departamento de Química Analítica, Físico-Química e Inorgânica, IQ-Unesp, Araraquara (2020-2021)
FERREIRA, E.B. - Membro Titular do Conselho do Departamento de Engenharia de Materiais, EESC/USP, 2018 – atual.
FERREIRA, E. B. – Suplente da Comissão de Pesquisa, EESC/USP, 2017 - Atual
FERREIRA, E. B. – Membro suplente da Comissão Coordenadora do Curso de Engenharia de Materiais, EESC/USP, 2018 – atual.
ZANOTTO, E.D. - Member of the Research Council (CoP) of UFSCar since 2013 up to 2019.
ZANOTTO, E.D. - Member of the committee for evaluation of faculty performance, PPGCEM/ UFSCar, 2015 – Present.
ZANOTTO, E.D. - Supervisor of the LaMaV / UFSCar since 1977.
ANDREETA, M. R. B. - Coordenador da atividade de extensão: ACIEPE - "Engenheiros e Cientistas do Futuro" oferecida semestralmente (4 créditos).
ANDREETA, M. R. B. - Vice-coordenador da área de Materiais Cerâmicos- DEMa -UFSCar

(6/2019 - 6/2021)
ANDREETA, M. R. B. - Membro suplente da Coordenadoria de Iniciação Científica e Tecnológica (CCET Tecnológicas - Campus São Carlos) - 2018/2020.
SCHNEIDER, J.F. – Coordenador do Curso de Bacharelado em Física, Instituto de Física de São Carlos/USP, 2016 – atual.
SCHNEIDER, J.F. – Membro da Comissão de Graduação, Instituto de Física de São Carlos/USP, 2016 – atual.
RINO, J.P. – Membro titular representante do CCET para avaliação e desempenho acadêmico dos docentes. 2015-2019.
MASTELARO VR- Membro Titular junto ao Conselho Departamental FCM desde 04.02.2010.
MASTELARO VR- Vice-chefe do Departamento de Física e Ciências dos Materiais desde 2016-2020.
MASTELARO VR- Membro Titular junto a congregação do IFSC desde 05/.2018.
DONOSO, G.J. - Membro da Comissão de Cultura e Extensão, IFSC - USP (desde 2018)

Current Research Students and Post-docs working on glasses and vitreous materials July 2019 – June 2020

Current internship (IC) students working on vitreous materials			
Edgar Dutra Zanotto			
Enzo Miguel	IC	2019 - 2020	FAPESP
José Herculis Dantas de Araújo (TCC)	IC	2018-2020	PIBIT – CNPq
Mayara Cerruti	IC	2018-2020	IVOCLAR
Julio Cesar Ferreira Faria	IC	2019-2020	No grant
Anelise S. Sampaio (TCC)	IC	2020	Industry
Eduardo Bellini Ferreira			
Icaro Marino Bittencourt (with C. Magon)	IC	2020-2021	FAPESP (cota CeRTEV)
Letícia Cursini	IC	2019-2020	FAPESP (cota CeRTEV)
		2017-2019	PUB-USP
Marcelo Nalin			
Victoria Luisa Mameli	IC	2019-2020	PIBIC
Amanda Rodrigues Rossi	IC	2019-2020	PIBIC
Marcello R. B. Andreeta			

Marcelo Watanabe Machado	IC	2019-2020	PIBIC
Andrea S. S. de Camargo			
Gabriel Brambilla	IC	2019-2020	PIBIC
José Pedro Donoso Gonzalez			
Flavio Alves Conti	TCC	2020	w/o fellowship
Hellmut Eckert			
Victor Reis	IC	2020	w/o fellowship

Current MSc and PhD students working on vitreous materials			
Edgar Dutra Zanotto			
Maurício Lima	MSc	2020-2022	CNPq
Ricardo F. Lancelotti	MSc	2019-2021	FAPESP
Andreia de Menezes	MSc	2020-2021	CBMM
Rodrigo C. Passos	MSc	2019-2021	FAPESP
Maria H. Acosta (Colombia)	PhD	2017-2020	CNPq
Débora Mendes	PhD	2017-2020	CAPES
Bruna Valerini (w/ Odonto-UNESP)	PhD	2019-2021	Submitted
Lorena Rodrigues	PhD	2018-2021	CNPq
Andrea de Camargo			
Raquel Riciatti do Couto Vilela	PhD	2017-2021	CAPES
Thiago Augusto Lodi	PhD	2018-2022	CNPq
Walter Justi Faria	PhD	2019-2023	CNPq
Marylyn Setsuko Arai	PhD	2019-2023	CNPq
Iago Carvalho	MSc	2018-2020	CNPq
Eduardo Bellini Ferreira			
Katherine Santos Oliveira	MSc	2019-2021	CAPES
João Matheus Rugeri Murdiga	MSc	2019-2021	CAPES
Mariana Cristina Haleplian Pinto	MSc	2018-2021	Glass company

			employee
Flávio Vilas Boas	MSc	2019-2022	-
Ana Caroline Batista Pires	MSc	2020-2022	CAPES
Guilherme Silva Macena	PhD	2019-2023	CAPES
Johnata Cavalcanti Fonseca	PhD	2019-2023	CAPES
Karem Janeth Rimachi Hidalgo (Peru), (coorientação Odonto UNESP)	PhD	2018-2022	CAPES Institucional (até Dez/2019)
Marcello R. B. Andreeta			
Maíra Dombroski Neme	MSc	2019-2021	Bolsa CNPq
Natã Pereira de Almeida	PhD	2019- 2023	Bolsa CNPq
Ana Candida M. Rodrigues			
Vinicius Martins Zallocco	MSc	2019-2021	CNPq
Lucas Hidalgo Pitaluga	MSc	2020-2022	SCHOTT Brasil
Paulo Sergio Pizani			
Rafaella Bartz Pena	PhD	2017-2021	FAPESP
José F. Schneider			
Gabriel Felipe Morguetto	MSc	2018-2020	CAPES
Gabriel Felipe Morguetto	PhD	2020-2024	CAPES
Hellmut Eckert			
Hugo Damasceno	MSc	2017-2021	Nippon Glass
Millena Logrado	PhD	201 -2021	Nippon Glass
Marcelo Nalin			
Leonardo V. Albino	PhD	2019-2022	CAPES
Samira N. Stain	PhD	2019-2022	CAPES
Juliana Moreno Paiva	PhD	2018-2021	CAPES
Valmor R. Mastelaro			
Vinicius Duarte Jesus	MSc	2019-2021	CAPES

Valdinei Liber	MSc	2020-2022	CNPq

Current Post-Docs working on vitreous materials (grant good up to)		
Edgar Dutra Zanotto		
Leila Separdar (Iran) w/ Rino	FAPESP	Aug. 2019 - 2021
Azat Tipeev (Russia) w/Rino	FAPESP	2021
Gisele Guimarães	AGC, Japan	May 2019 - Oct. 2020
Daniel Roberto Cassar	FAPESP	2017- Oct. 2021
Henrik Bradtmueller (Alemanha) w/ H. Eckert	FAPESP, approved	Nov. 2020- 2022
Marina T. Souza	Vetra, Brazil	Dec. 2020
Laís Dantas	IVOCLAR AG, Liechteinstein	2019-Oct. 2020
Viviane Oliveira Soares	CNPq	2019 - 2020
Hellmut Eckert		
Bianca Cerrutti	Sem bolsa	2021
Igor Danciaes	FAPESP	2021
Henrik Bradtmüller	WWU Münster	2020
Andrea S.S. de Camargo		
Gustavo Galleani	FAPESP (BEPE)	2020
José Pedro Rino		
Azat Tipeev (Russia) (w/ Zanotto)	FAPESP	2020
Leila Separdar (Iran) (w/Zanotto)	FAPESP	August 2019 - 2022
Ana Candida Martins Rodrigues		

Nilanjana Shasmal (Índia)	FAPESP	Renewal submitted
Karina Omuro Lupetti	FAPESP/Jornalismo	2019-2020
Jéssica Fabiana Mariano dos Santos	CNPq	Submitted
Paulo Sérgio Pizani		
Benjamin Moulton (Canadá)	FAPESP	Nov. 2020
Thiago Rodrigues da Cunha	FAPESP	Cota FAPESP
Marcelo Nalin		
Douglas Faza Franco	FAPESP	2018-2021
Lia Mara Marcondes	CNPQ	2019-2020
Juliane Resges Orives	FAPESP	2019-2022- Cota FAPESP
Eduardo Bellini Ferreira		
Maria Costa (w/ *Eckert*)	FAPESP	2019 - cota FAPESP
Marcello R. B. Andreeta		
Rafael Bonacin de Oliveira	Submitted to CBMM	2019-2020

IC, MSc, PhD and Post Doc students that graduated in 2019 -2020 / current work			
Edgar Dutra Zanotto			
Caroline Vidal	MSc	2018-2020	Internship Ireland
Geovana Lira	MSc	2018-2020	PhD student CNPq
Graziela Pentean Bessa	MSc	2017-2020	Ibar Refratários
Jeanini Jiusti	PhD	2016- 2020	PD France
Laís Dantas	PhD	2016-2019	PD, Ivoclar grant

Claudia Abadia (Colombia)	PhD	2016-2019	Applying for PD
Hellmut Eckert			
Henrik Bradtmüller	PhD	2017-2019	Postdoc, WWU Münster
Lena Marie Funke	PhD	2015-2019	Postdoc, UC Berkeley
Maria Costa (w/Ferreira)	Post Doc	2019	FAPESP
Marcelo Nalin			
Ana Carolina Silva Sampaio	IC	2018-2019	
Nicole Gouveia Roque	IC	2018-2019	
Antônio Eduardo de Souza	PhD	2015-2019	Coordenador Cursinho Pandora
Roger Fernandes	Post Doc	2019	Pós-doc - Germany
Hssen Fares	Post Doc	2017-2019	FAPESP
Ana Candida Martins Rodrigues			
Manoel da Cruz Barbosa Neto	MSc	2017-2019	Consultant
Adriana M. Nieto Muñoz (Colombia)	PhD	2016 - 2020	Searching for a job
Jairo Felipe Ortiz Mosquera (Colombia)	PhD	2016-2020	To defend in two months
Andrea de Camargo			
Walter José Gomes Juste Faria	MSc	2016-2019	
Leandro Piaggi Ravaro	Post Doc	2019	
Kassio Papi Zanoni	Post Doc	2019	
Eduardo Bellini Ferreira			
André Balogh de Carvalho	IC	2018-2019	
Lucas Miguel Cândido (coorientação Odonto UNESP)	PhD	2016-2020	
Marcello R. B. Andreeta			
Angela Santana Nunes	MSc	2017-2019	

José Pedro Rino			
José Vitor Michelin	PhD	2017-2019	
Ary Rodrigues Ferreira Junior	Post Doc	2019	
Oscar Peitl			
Tathiane Ferroeni Passos (com Clóvis Buzzato)	MSc	2017-2019	
José Fabián Schneider			
Lucas Ely Bins Tsunaki	IC	2018-2019	
Cláudio José Magon			
Carsten Doerenkamp (Alemanha)	Post Doc	2019	