3D printing of sol-gel and melt-derived glass-ceramics for bone regeneration

The American Ceramic Society

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ABSTRACT BOOK

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How to Use the Abstract Book

Refer to the Table of Contents to determine page numbers on which specific session abstracts begin. At the beginning of each session are headings that list session title, location and session chair. Starting times for presentations and paper numbers precede each paper title. The Author Index lists each author and the page number on which their abstract can be found.

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11:20 AM

(ICACC-S15-035-2020) 3D printing of sol-gel and melt-derived glass-ceramics for bone regeneration

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Scaffolds for bone grafting procedures have to satisfy a series of minimum requirements to provide mechanical support while allowing cell migration and fluid exchange. However, traditional manufacturing techniques suffer from poor repeatability and low control on porosity, which may preclude a safe therapeutic use of the device. In this sense, additive manufacturing technologies represent a powerful platform to easily tailor all these parameters by simply acting on the design and process parameters. In this work, a glass-ceramic based on the system SiO_2-CaO–P_2O_5–Na_2O–MgO-K_2O was successfully synthetized for the first time by sol-gel route and compared to the correspondent melt-derived material. Thermal properties, crystallization and surface area were object of study for comparison. In a second part of the study, both the systems were used as basic materials for the production of highly controlled grid-like 3D scaffolds by robocasting technology. Bioactivity and ion release were assessed by soaking the scaffolds in Simulated Body Fluid (SBF), in both static and dynamic conditions. In the latter case, a customized perfusion system designed for continuous SBF recirculation through the scaffolds was used to mimic physiological conditions. Up to now, results are promising and future studies deserve to be carried out to investigate cellular response and mechanical properties of the developed scaffolds.

Direct Writing and Ink Jet Printing III

Room: Coquina Salon B
Session Chair: Michael Halbig, NASA Glenn Research Center

1:30 PM

(ICACC-S15-036-2020) Sol-Gel Derived Inks for 3d Printed Glass Optics (Invited)

R. J. Dylla-Spears*[1]; K. Sasan[1]; T. Fears[1]; N. Dudukovic[1]; M. Johnson[1]; D. Nguyen[1]; T. Yee[1]; O. Herrera[1]; C. Mah[1]; A. Lange[1]

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Techniques for three-dimensional (3d) printing of glass have opened the door to novel glass optics with both unconventional structures and tailored compositions. In the direct ink writing (DIW) approach, rheologically tuned silica-containing pastes are first extruded through a nozzle at room temperature and deposited in the geometry of interest, forming low density green bodies. The green bodies are then converted to full density, optically homogeneous glass by a series of heat treatments. The 3d-printed glass components have material and optical properties that rival conventionally prepared optical grade fused silica. However, to fully realize the potential of this technique for preparing novel optics requires the development of a library of ink formulations that lead to glasses with different properties. Several sol-gel approaches to ink preparation leading to refractive index control in 3d printed silicate glasses will be presented. In addition, efforts to blend and thermally process these inks into gradient composition optics will be described. This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344 within the LDRD program 16-SI-003 and 19-ERD-020. LLNL-ABS-765937

2:00 PM

(ICACC-S15-037-2020) Quantifying the Link between Rheology and Printability for Ceramic On-Demand Extrusion

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This study will continue research to link feedstock rheology to the 'printability' of ceramic components fabricated by Ceramic On-Demand Extrusion (CODE), a direct-write extrusion process which utilizes a rising oil bath to prevent excessive and non-uniform drying. Relevant background work assessing extrudability and printability will be discussed. Next, a comprehensive approach to couple rheology to object printing parameters will be described, and a wide range of zirconia pastes will be explored to establish process-property relationships. Paste microstructure will also be explored. From these investigations the constraints on ideal paste design will be discussed.

2:20 PM

(ICACC-S15-039-2020) Robocasting of reaction bonded silicon carbide structures

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Additive manufacturing of ceramics shows great potential to overcome the shape limitations of traditional fabrication methods due to the layerwise deposition of material. In this work, a novel shaping method for the manufacturing of reaction bonded silicon carbide (RBSC) structures was investigated. RBSC is attractive for high temperatures and extreme condition applications, such as turbines and bearings, due to its outstanding thermal and mechanical properties. To produce RBSC, a highly filled paste consisting of silicon carbide and carbon powder was developed and printed by robocasting technology using nozzles with diameter of 0.5 and 1.5 mm. To enable printing, the paste has to show suitable rheology, which means the presence of a yield point and a shear-thinning behavior. After heat treatment, the samples were further processed using the liquid silicon infiltration technique to obtain dense near-net shape RBSC. Different structures such as lattices, hollow cylinders, bending bars and gyroids were printed to show the variability of robocasting. The mechanical and physical properties of the robocasted samples were measured and are comparable with those of traditionally fabricated RBSC. These results open the field for a wide variety of materials, which can be processed in similar manner.

Fused Deposition Modeling

Room: Coquina Salon B
Session Chair: Rebecca Dylla-Spears, Lawrence Livermore National Laboratory

3:20 PM

(ICACC-S15-040-2020) Ceramic matrix composites fabricated by Fused Filament Fabrication (FFF)

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Ceramic matrix composites with SiC short fibers have been fabricated by Additive Manufacturing (AM) using a thermoplastic approach. By means of Fused Filament Fabrication (FFF) or Fused Deposition Modelling (FDM) a ceramic part is shaped layer by layer using a thermoplastic filament which is extruded through a heated nozzle.