ABSTRACT - ORAL

In Situ Monitoring and Modelling of Densification and Young's Modulus Evolutions during Viscous Sintering of Slip-Cast Borosilicate Glass Parts

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This work was carried out within the framework of the Interreg VerAdMa project, which aims to develop innovative routes for the manufacturing of glass components using both direct and indirect additive manufacturing technologies. The present study focuses on the indirect process, in which a suspension of borosilicate glass particles is slip-cast into a porous mold produced by additive manufacturing. Achieving the desired density and mechanical performance requires a precise understanding and control of the sintering process. The objective of this work is to investigate the relationship between densification and elastic stiffness development during the sintering of slip-cast glass parts.

Sintering was monitored *in situ* using optical dilatometry, allowing continuous measurement of shrinkage and relative density evolution throughout the thermal cycle. In parallel, the evolution of Young's modulus was continuously followed by the Impulse Excitation Technique (IET), providing direct insight into the progressive mechanical consolidation of the material.

To interpret the experimental results, a viscous-flow sintering model was implemented. The temperature dependence of the glass viscosity was described using the Vogel-Fulcher-Tammann (VFT) equation, enabling prediction of densification kinetics under non-isothermal heating conditions. Model predictions were compared with the density evolution derived from optical dilatometry measurements, showing good agreement over the investigated temperature range.

A percolation-based approach was further employed to establish a quantitative relationship between relative density and Young's modulus. The model describes the emergence of a mechanically continuous network as interparticle neck growth progresses and porosity decreases during sintering. The results reveal a strong correlation between densification and elastic stiffening, highlighting a transition from a weakly connected particulate assembly to a rigid load-bearing structure. The percolation model successfully captures the rapid increase in Young's modulus associated with the formation of an interconnected solid skeleton and subsequent pore elimination.

The combination of *in situ* optical dilatometry, impulse excitation measurements, viscous-flow sintering modelling and percolation theory provides a comprehensive framework for understanding the coupling between microstructural evolution, densification kinetics and mechanical property development in glass-based materials. This approach offers valuable tools for optimizing sintering schedules and predicting the final properties of additively manufactured glass components.

Keywords: borosilicate glass, slip casting, viscous-flow sintering, optical dilatometry, impulse excitation technique, Young's modulus, percolation model, densification, VFT equation, additive manufacturing