Emissivity Measurements of Vitreous Silica from 4 K to 2500 K in Static and Dynamic Conditions

Ilse M. Ermini[1], Iñigo González de Arrieta[2, S, C], Franck Fayon[1], Pierrick Vespa[3] and Domingos De Sousa Meneses[1]

[1]*CNRS, CEMHTI UPR3079, Orléans, France*
[2]*University of the Basque Country UPV/EHU, Leioa, Spain*
[3]*Saint-Gobain Research Provence, Cavaillon, France*
inigo.gonzalezdearrieta@ehu.eus

Vitreous silica is a paradigmatic glassy material. Despite its chemical simplicity, it has many anomalous properties that have motivated hundreds of experimental and theoretical studies over the past century. Nevertheless, important questions remain about the structure and dynamics of this material. Many competing models have been proposed to explain the behavior of silicate glasses, particularly the role played by the medium-range order and the microscopic mechanism behind the glass transition, leading to long-lasting controversies. Therefore, experimental studies of the glass transition and adequate phenomenological models are mandatory.

In this paper, we present emissivity and reflectivity spectra of pure silica glass between 4 K and 2500 K in static conditions, as well as real-time measurements in kinetic conditions (free cooling). Infrared emission spectroscopy is an accurate and versatile experimental technique for studying glasses and liquid oxides, providing access to the temperature dependence of the dielectric function. This function provides crucial information on the structural evolution of the silica network, including changes in chemical bonding. A fitting procedure based on the analysis of five bands as a function of temperature revealed significant changes at two special temperatures, one close to the alpha-beta transition of quartz and the other corresponding to the glass transition. Our interpretation of these results is consistent with models built on molecular dynamics simulations.

Finally, in addition to the conventional emissivity spectra obtained in isothermal conditions at each temperature step, we can now follow the cooling process continuously from the molten state to about 600 K. As expected, data acquired in static and kinetic conditions are almost equivalent in silica glass, aside from a small transient effect at the glass transition. Still, this new experimental capability will allow us to perform in situ studies of crystallization phenomena for other ceramic materials.