ELECTRIC FIELD INDUCED SOFTENING OF GLASS: WHAT CAN IT TELL ABOUT THE MECHANISM OF FLASH SINTERING?

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Electric field induced softening (EFIS) of glass is a recently discovered phenomenon, which was inspired by dramatic effects of electric field on sintering of ceramic powders. It represents the effect of DC or AC electric field on the softening of glass that is heated at a constant rate under fixed compressive load. As shown in Fig. 1(a), the application of applied voltage reduces the softening temperature, and the softening transition becomes significantly sharper when voltage is above a critical value.[1] Remarkably, this behavior is similar to that reported for flash sintering, as seen in Fig. 1(b).[2] In both types of experiments, emission of white light is observed when the sample is in the vicinity of sharp transition. The power density at the onset of EFIS and flash sintering is comparable at ~1W/cm^2. Neither phenomena can be explained as Joule heating of a homogeneous solid. Notwithstanding these empirical similarities, we note that flash sintering of powders of varying properties is a far more complex phenomenon than heating of a clear, homogeneous, ion conducting silicate glass. As a result, EFIS is relatively well understood, while there are several diverging explanations of flash sintering that has been investigated much more extensively. The EFIS is understood to result from the following sequence of events: polarization of the sample from ion displacement under the application of electric field as in electro-thermal poling, formation of an alkali ion depletion layer, development of large internal electric fields across this layer, electrolysis and charge injection followed by dielectric breakdown, and very high localized heating near the anode, ultimately leading to thermal runaway and softening throughout the sample. Building on this understanding, in this presentation we will explore the question: how can EFIS help discern the various mechanisms of flash sintering, and compare their validity?

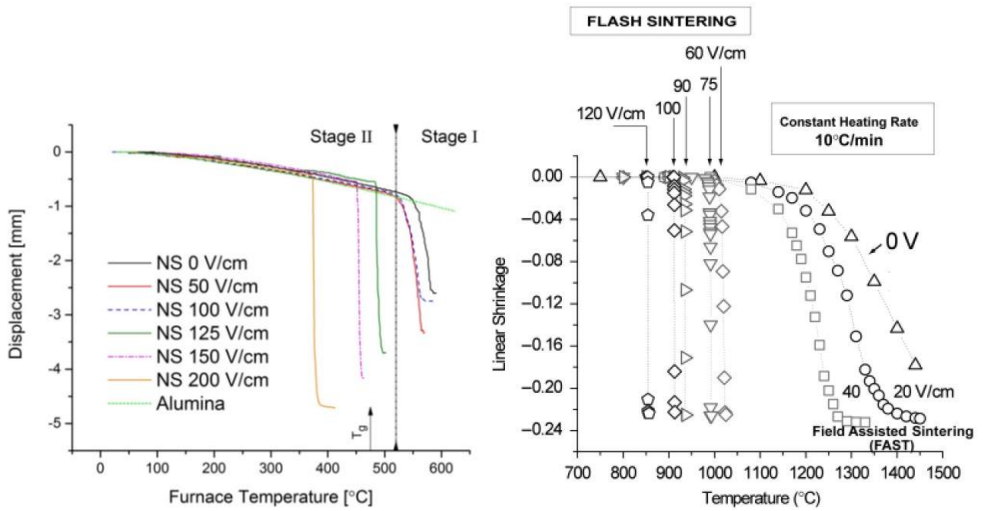

Fig. 1(a) (Left). Displacement vs. furnace temperature of sodium silicate (NS) glass at various applied electric fields with a constant heating rate of 10°C/min. The lines from right to left correspond to 0 V/cm to 200 V/cm. The monotonic dashed line is for reference alumina. Fig. 1(b) (Right). Sintering of yttria-stabilized zirconia (3YSZ) under varying dc electrical fields. Flash sintering occurs for fields > 40 V/cm.

References

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