

Abstract

Structural and mechanical reliability of brittle solids for both conventional and advanced applications is determined by the rate at which it can deform and sustain externally applied static or dynamic strain at the microstructural length scale. Hence, the effect of loading rate on nanomechanical properties of brittle solids like soda-lime silica glass (SLS), MgAl_2O_4 Spinel glass ceramics and polycrystalline alumina ceramics have been investigated at different microstructural as well as measurement length scales. The nanohardness of brittle solids was found to increase with the loading rate. Further, signatures of serrations were observed in the P-h plots. These serrations were linked to the formation of shear bands inside and around the indentation cavities. A new concept of inelastic deformation (IED) parameter was found out to describe well the observed trend of loading rate dependencies of the nanohardness data. Further, it is predicted from the present work that the shear stresses developed at various loading rates just beneath the tip of the nanoindenter were sufficient enough to cause shear induced plastic flow and / or deformation band formation inside the nanoindentation cavities. Time-dependent deformation behavior was also investigated for commercially available SLS glass with the help of a sharp Vicker's diamond pyramidal indenter at a given peak load of 10 N by varying contact duration from 1- 90 sec. The results showed that the deformation behavior may be represented in terms of a simple mechanical model analogous to a viscoelastic system.

Further, an attempt was also made to understand how the high strain rate flyer plate impact affects the nanohardness of alumina ceramics. The load controlled nanoindentation experiments were conducted with a Berkovich indenter on an as received coarse grain ($\sim 10 \mu\text{m}$) alumina and shock recovered tiny fragments of the same alumina obtained from gas gun experiments conducted at 6.5 GPa and 12 GPa shock pressure. The nanohardness of the as received alumina (ARA) was much higher than that of the 6.5 GPa and 12 GPa shock recovered (SA) alumina. The indentation size effect (ISE) was strongest in 12 GPa SA sample, relatively stronger in 6.5 GPa SA sample but mild in the ARA sample. These results were rationalized by analysis of the experimental load depth data and evidences obtained from field emission scanning electron microscopy.