# In-Situ Raman Spectroscopy During Indentation to Study Plastic Deformation in Silicate Glasses

Shefford Baker*[1], Nicole Wiles[1], Zachary Rouse , Thomas Wyrobek[2], Praveena Manimunda[2], and S. Syed Asif[2]

[1]Cornell University – Ithaca, New York 14853, United States
[2]Bruker Nano Inc. (formerly Hysitron) – 9625 West 76th Street Minneapolis, MN 55344, United States

**Abstract**

Understanding plastic deformation in silicate glasses is extremely important in the development of glasses with improved resistance to mechanical failure. Plastic deformation under a point contact determines the stress state, which determines whether a surface flaw forms, which in turn determines the strength of the glass. Unfortunately, relatively little is known about the atomic scale mechanisms that control plasticity in silicate glasses. To date, most effort has focused on the continuum concepts of shear and densification. Raman spectroscopy is a powerful tool for investigating structure of glass. This method has been used to study glasses deformed by indentation ex-situ, however this approach can only interrogate the unloaded glass after deformation. To investigate the structure of plastically deformed glass under load, we have developed an instrument in which the deformed material under the indenter can be investigated in-situ, while the load is being applied. We show that we are able to track changes in spectra which can be correlated to ring size, bond angles, and other structural motifs with load. By tracking these changes, we could identify transient structural changes which no longer exist after load is removed. We are also able to investigate these quantities with position under the indenter using simple mapping and to comment on the relative amounts of shear and densification modes. Additional experiments to study the effect of composition, water content and strain rate, as well as applications to other nanomechanical tests are described.

**Keywords:** Raman spectroscopy, indentation, plastic deformation, hardness

*Speaker