AFM based mechanical property mapping for glass corrosion studies

JULIANE HOPF AND ERIC M. PIERCE[1]

[1]Environmental Science Division, Oak Ridge National Laboratory, Oak Ridge, TN 37774
(hopfj@ornl.gov, pierceem@ornl.gov)

Quantitative Nanomechanical Peak Force® (PF-QNM) measurements by means of atomic force microscopy was used first-time to study polished glass surfaces. The PF-QNM technique allows for topography and mechanical property information to be measured simultaneously at each pixel. Young's modulus, adhesion force, energy dissipation, and deformation of the international simple glass (ISG, representing a simplified version SON68 glass) were mapped in combination with a detailed roughness characterization.

The ISG's topography ranges from 0 to 84 nm (RMS = 11.2 nm), adhesion ranges from 0 to 17 nN, and deformation ranges from 0 to 3 nm. Young's modulus values with a frequency $\geq$ 30 counts represent 95% of all the measurements collected and range from 21.8 to 84.3 GPa; with the average modulus being 53.2 ±15.8 GPa. Those preliminary results for the ISG suggest an average Young's modulus that is within the experimental error of the modulus measured for SON68 glass (63-65.5 GPa) with conventional approaches [1,2].

Although the average modulus values are consistent with values generally reported for glass (~50 to 90 GPa), the wide distribution of measured values (standard deviation) suggests that surface roughness and technique error are impacting the measurements. Therefore, future PF-QNM measurements on glass will focus on reducing the distribution of measured modulus values by systematically quantifying the effect surface roughness has on force distance curves and by increasing the both the scan size and number of scan locations on the sample.

Application of the PF-QNM technique will be extended to in situ glass corrosion experiments with the goal of gaining atomic-scale insights into altered layer development by exploiting the mechanical property differences that exist between silica gel (e.g., altered layer) and pristine glass surface.

[1] Ougier-Simonin *et al* (2011). *Int J Eng Sci* **49(1)**, 105-121.
[2] Chorfa *et al* (2010). *Ceramic-Silikaty* **54(3)**, 225-234.