Edge Effects in Nanoindentation Measurements of Biological Materials

Nanoindentation is commonly used in materials research to characterize material properties (e.g., elastic modulus, hardness, creep) of sub-micron-size volumes of material. The most widely used nanoindentation data analysis is the Oliver-Pharr method, which implicitly assumes the material being tested is homogeneous, fills a half-space, and has rigid support. However, many specimens tested these days violate these assumptions and artifacts arise in the results when the Oliver-Pharr method is applied, often unbeknownst to the researcher performing the experiments. At the USDA Forest Service, we are interested in assessing the material properties of the micron-size domains in wood (i.e. the compound corner middle lamellae (CCML) and S2 cell wall laminae (SCWL) seen in figure 1 below). However, indents placed in the CCML and SCWL are in close proximity to heterogeneities (i.e. the heterophase interfaces between the CCML and SCWL and the free edge between the SCWL and lumen) and further complicating the test, wood is an open cellular structure and the entire specimen may flex during testing. To account for these types of heterogeneities and specimen-scale flexing, Forest Service researchers in collaboration with the University of Wisconsin-Madison developed simple experimental methods to account for edge effects and specimen-scale flexing in nanoindentation experiments. Model systems were used to demonstrate the efficacy of our methods. Using our methods, we can now assess the material properties of CCML and SCWL in wood without artifacts arising from heterogeneities or specimen-scale flexing. The methods can also be applied to material system with heterogeneities and specimen-scale flexing.

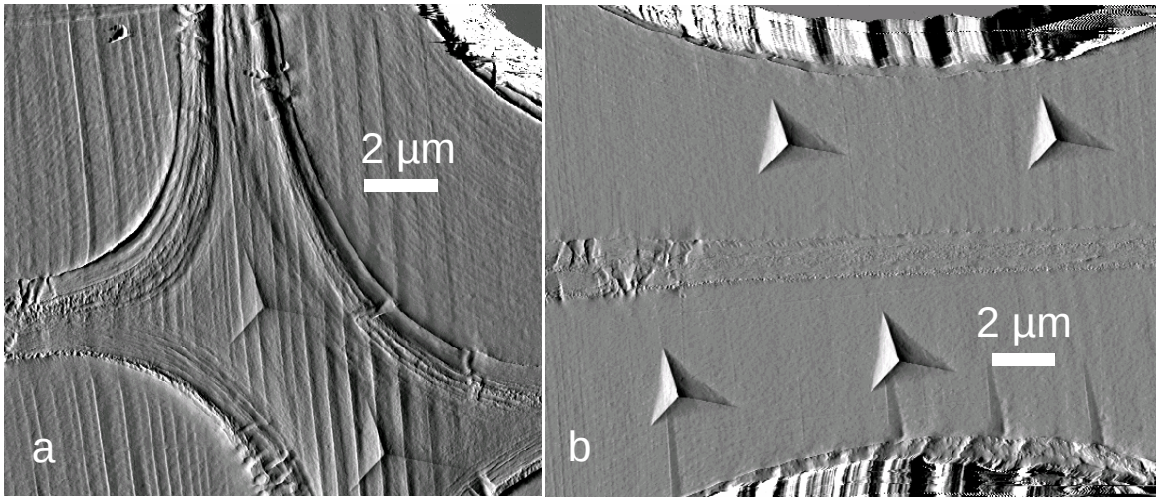

Figure 1. Indents placed in (a) compound corner middle lamella and (b) S2 cell wall lamina in the transverse plane of Loblolly pine.

Jakes, J. E.; Frihart, C. R.; Beecher, J. F.; Moon, R.J.; and Stone, D. S.; Experimental method to account for structural compliance in nanoindentation measurements, Journal of Materials Research, 23 (4): 1113-1127, 2008

Jakes, J. E.; Frihart, C. R.; Beecher, J. F.; Moon, R. J.; Resto, P. J.; Melgarejo, Z. H.; Suarez, O. M.; Baumgart, H.; Elmustafa, A. A.; Stone, D. S.; Nanoindentation near the edge, Journal of Material Research, 24 (3): 1016-1031, 2009

Patents or other steps toward commercialization:

***Contributing Agency*: USDA**