NEW METHODS FOR NANOINDENTATION MAPPING TO ACCOUNT FOR SIZE DEPENDENCE

Andy Bushby, Queen Mary University of London
a.j.bushby@qmul.ac.uk
Alexandra Cackett, Queen Mary University of London

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The mapping of nanoindentation measurements across a surface is a powerful technique to extract the variation in materials properties of complex material systems. The information gained may be used for input to material models or for phase identification through statistical sampling. Examples include 2 and 3 phase alloys, weld and join lines, cermets and composite materials. In these methods the variation in material properties also leads to a variation in the influence of the size effect in the measure properties. Rather than a disadvantage, determining the influence of size effects allows for new methods that can extract size-independent material properties. Furthermore, the mapping method can be extended to extract estimates of internal length-scales within the material through consideration of the size-dependent response. Here we report on new methods under development as part of the Strength-ABLE programme, based on Berokovich nanoindentations at a series of pre-determined indentation depths at the same location using a multi-cycle loading protocol (Fig. 1). To investigate this method, a series of homogeneous metals are tested with varying internal length-scale through changes in grain size, work hardening and precipitate size and spacing, and hence varying the relationship between indentation size and material microstructure size.

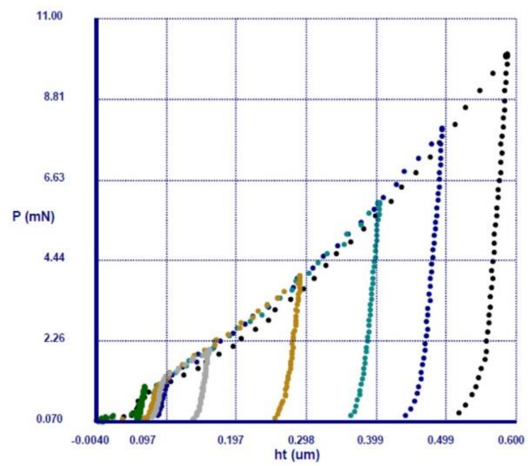

Figure 1 – multi-cycle tests at the same location in aluminum

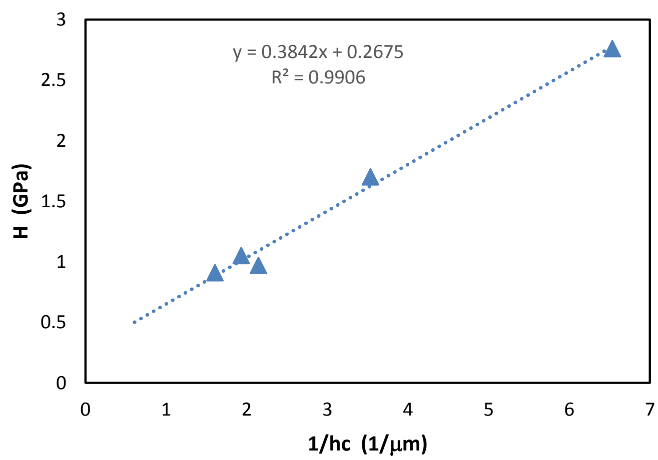

Figure 2 – data extraction from the size dependence of the measurement

The influence of pile-up or sink-in must first be identified by monitoring the elastic modulus variation (assumed to be constant with depth) and then eliminated through direct measurement of the contact area by AFM. Then by applying models of size-dependent behavior to the depth-dependent response (Fig. 2) the influence of the indentation size effect and the material microstructure length-scale can be extracted. Ultimately, understanding how to account for the indentation size effect could lead to indirect determination of internal material length-scale during mapping experiments, hence mapping both location and microstructure simultaneously.