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Correcting time dependent displacements effects in nanoindentation analysis

Norbert Schwarzer[1], Michael Davies[2], Nicola Everitt[2], Ben Beake[3]

[1]Saxonian Institute of Surface Mechanics, Ummanz / Rügen, Germany [2]University of Nottingham, Nottingham, United Kingdom [3]Micro Materials Ltd., Wrexham, United Kingdom

n.schwarzer@siomec.de

Instrumented nanoindentation is now a commonly used tool in assessing the properties of materials for a wide range of applications. Analysis of nanoindentation data is typically carried out using the methods popularised by Oliver and Pharr, with Young's modulus determined by a power law fit to the unloading data of the load displacement plot. One of the key limitations of this analysis technique is that it does not allow consideration of time dependent deformation mechanisms such as creep or visco-elastic behavior exhibited by some materials. Hence if testing such materials experimentalists find Young's modulus values which are dependent on the experimental unloading rate.

Conventional nanoindentation techniques use a fast unloading rate in order to minimise the influence of time dependent deformation on calculated Young's modulus. Such techniques have been used on two representative samples - a visco-elastic polymer and gold, at room temperature and higher (creep) temperatures respectively. Oliver and Pharr analysis of this data returns acceptable Young's moduli but there is still an unloading rate dependence in the results. Additionally, failure to account for time dependent depth change can lead to physically unrealistic fitting constants in the power law.

Results using a new analysis method which allows determination of the time dependent contributions to the Nanoindentation depth will be presented. This enables calculation of a Young's modulus independent of the unloading rate and with physically meaningful fitting constants in the power law. As well as extracting true material properties, such analysis conveys the advantage that testing procedures can become more standardised since no special experimental treatment is needed for materials which have time dependent deformation mechanisms.

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