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Measurement of Power Law Creep Parameters by Nanoindentation

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ABSTRACT:

Great progress has been made over the past decade in making mechanical property measurements by nanoindentation at elevated temperatures. In addition to allowing one to measure the temperature dependence of those properties commonly investigated by nanoindentation such as hardness and elastic modulus, these advances have also paved the way for making small-scale measurements (micron and sub-micron) of the material parameters used to describe power law creep behavior such as the activation energy for creep, , and the stress exponent for creep, . The ability to make such measurements by nanoindentation allows for high point-to-point spatial mapping of properties as well as the characterization of thin films, thin surface layers, and even small particles or the individual phases in complex multiphase microstructures. Despite this progress, significant experimental difficulties are still often encountered, and how one converts the data obtained in nanoindentation tests to the parameters normally used to characterize uniaxial creep is not at all straightforward because of the complex, non-uniform stress states produced during indentation contact. In this presentation, we report on progress in making meaningful measurements of power law creep by nanoindentation based on recent experience with a new high temperature nanoindentation system capable of testing at temperatures up to 1100°C. Special attention is given to the models and data analysis procedures needed to convert nanoindentation load-displacement-time data, usually obtained with pyramidal indenters, into the creep parameters normally measured in uniaxial tension or compression testing. The models and procedures are evaluated by comparison to several sets of creep data in which the material behavior has been probed both by nanoindentation and by uniaxial testing methods.

BIOGRAPHY:

George M. Pharr is TEES Distinguished Research Professor in the Department of Materials Science and at Texas A&M University, College Station, TX. He received his BS in Mechanical Engineering at Rice University in 1975 and Ph.D. in Materials Science and Engineering from Stanford in 1979. Dr. Pharr received ASM International's Bradley Stoughton Award for Young Teachers of Metallurgy in 1985. His honors also include the Amoco Award for Superior Teaching at Rice University (1994), a Humboldt Senior Scientist Award (2007), the Materials Research Society's inaugural Innovation in Materials Characterization Award (2010), and the University of Tennessee Macebearer Award (2015). He is a member of the National Academy of Engineering (2014) and a Fellow of ASM International (1995), the Materials Research Society (2012), and TMS (2016). Dr. Pharr has been an Associate Editor of the Journal of the American Ceramic Society since 1990 and Principal Editor of the Journal of Materials Research since 2012. He is an author or co-author of more than 200 scientific publications, including 4 book chapters. His research focuses on mechanisms of plasticity and fracture in solids, especially at small scales.