Since the 1950’s there has been experimental evidence that structures on the sub-micron scale can exhibit strengths approaching the theoretical strength of the material. The general hypothesis taken is that if dislocation sources are missing, then the nucleation, rather than propagation, of these defects must control deformation. In small samples it is possible to create nominally dislocation free solids, which provides a possible platform for both fundamental measurements of materials properties as well as insight into designing strong structures. Two common ways these extraordinary strengths are being examined experimentally are with nanoindentation and micro-machined structures such as tensile and compression samples, both in ambient conditions as well as during in situ electron microscopy. However, defects other than existing dislocations are either unavoidable (vacancies) or often introduced during the sample preparation process (FIB machining can add self interstitials). This presentation will examine the effects of point defects, surface defects, and other impurities on the onset of plastic deformation in metals and molecular organic crystals. In the case of metallic systems, it will be demonstrated experimentally that defects such as vacancies can lower the yield strength; simulations of these structures using molecular dynamics suggest that decreases in strength of up to 50% are possible in the presence of a variety of “hard to observe” defects. The simulations, when compared with positron studies of free volume of indented samples, match the trends observed experimentally. Impurities, such as solute hydrogen, also alter the onset of deformation, albeit in a different manner, retarding the multiplication of dislocations at high stresses. From this a methodology of demonstrating the sensitivity of the distribution of yield behavior in nanoindentation to defects will be shown. (cont.)

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If Smaller is Stronger, is Nothing Weaker?

Prof. David Bahr is currently the Head of Materials Engineering at Purdue University. Prior to this position he was Director and Professor of Mechanical and Materials Engineering at Washington State University. He received his BS and MS in MSE at Purdue University, and a PhD in Materials Science at the University of Minnesota in 1997. He worked for a short time at Sandia National Laboratories during his PhD before starting as a faculty member in the School of MME at WSU in 1997. He has supervised 2 Post-docs, 17 PhD students, 27 MS students, and over 50 undergraduate researchers in the general area of mechanical behavior. In 2000 he won the Presidential Early Career Award for Scientists and Engineers for his work with Sandia on DOE stockpile stewardship, in 2003 he received the Bradley Stoughton Award from ASM International, and in 2007 received the Robert Lansing Hardy award from TMS (where he currently serves as a member of the board of directors). He has published over 125 papers in the literature and given over 40 invited talks and seminars world wide.