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Understanding role of length scale and temperature in indentation induced creep and thermal behavior of Si based materials

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This investigation presents nanoscale and micron scale creep and thermal analyses on single crystal Si and Si based materials at temperatures ranging from room temperature to 500 degree-C. The properties of focus include elastic modulus, hardness, thermal conductivity, creep exponent, and creep strain rate. Analyses show that at the nanoscopic length scale the deformation mechanism is dominated by dislocation climb and diffusion. With increase in length scale to microscale the thermal activation volume increases by approximately 10 times. The increase in free volume leads to the deformation mechanism switching to volumetric densification and dislocation pile up. An important physical effect analyzed is the effect of increase in temperature on the observed deformation mechanism. At the nanoscale, with increase in temperature, both hardness and elastic moduli show an increase. At the microscale, however, hardness reduces with increase in temperature. The indentation size effect is observed at both scales. However, at the nanoscale the indentation size is linked with strain hardening. At the microscale, a strain softening behavior is observed. Last portion of the talk focuses on how coupling between mechanical and thermal properties could be used to further deduce high temperature properties of such materials.

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