Abstract:
Silicon micro- and nano-structures are essential in today's integrated circuits and sensors. The functioning and performance of such devices are highly affected by thermal properties. Due to the size effect, the thermal properties of bulk silicon cannot represent those of silicon micro-structures. Furthermore, stress/strain inside the silicon structures can have a significant effect on their thermal properties. The focus of this talk is on discussing models and experiments to understand room to high temperature thermal and mechanical properties of nano- and microstructures. First part of the talk will present first ever nano and micro scale creep measurements in a material at high temperature. Analyses show an interesting coupling between deformation mechanisms that operate at nano- and micron scale at high temperatures. More importantly, analyses point out to interesting thermal and mechanical coupling that exists at such scales and at high temperatures. Based on this motivation, the next part will present first ever measurements of the thermal conductivity of a silicon micro-device under applied compressive stress at 350 °C. An atomic force microscope (AFM) cantilever made of doped single-crystal Si was used as the sample. The integrated system applied compressive load to the cantilever in the longitudinal direction while supplying heat through heating. The thermal conductivity of the cantilever was calculated using steady state heat conduction equation. The result shows that the measured thermal conductivity of the cantilever is 110 to 140 W/mK, accompanying a compressive strain of 0.1% to 0.3%. Finally, some strain dependent thermal conductivity modeling work performed in our group is presented. A most significant result is that in biomimetic materials, strain has insignificant effect on varying thermal conductivity.