Interfacial Creep in Multi-Component Materials Systems

DMR Award 0075281

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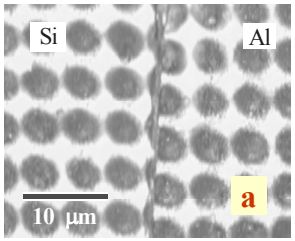
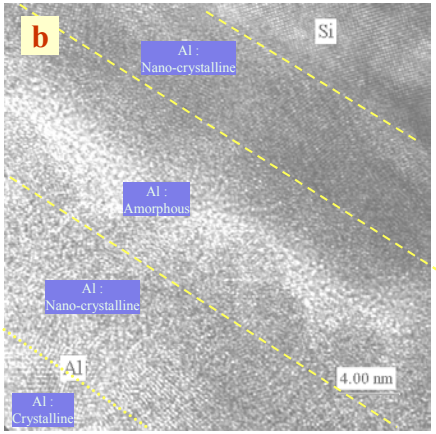
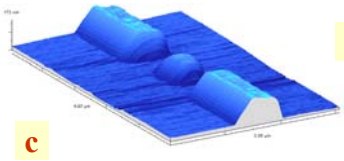
- Most modern engineering systems contain numerous interfaces between dissimilar materials. Examples are: (1) microelectronic devices; (2) composite materials
- Materials may slide at mating surfaces, even when bonded to each other = *Interfacial Creep*
- Important for reliability problems, particularly as component/feature sizes become smaller
- Goal : understand mechanism, develop models, and study impact of interfacial creep

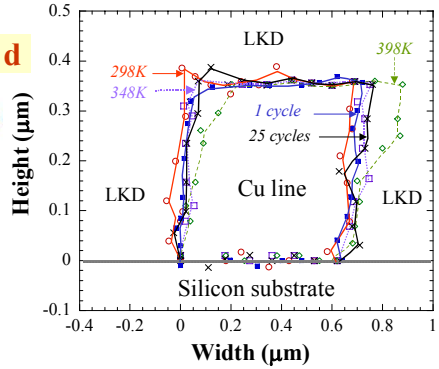




(a) Sliding at Al-Si interface, evidenced by relative displacement of carbon grids across the interface under shear; (b) High resolution transmission electron microscope image of interface, showing the role of amorphous interfacial layer



(c) AFM image of cross section of an electronic device, showing Cu lines embedded in a dielectric;



(d) Contours of the perimeter of the small Cu line in the center at different temperatures, showing evidence of shear deformation

1. I. Dutta, M.W. Chen, K. Peterson and T. Shultz, "Plastic Deformation and Interfacial Sliding in Al and Cu Thin Film: Si Substrate Systems Due to Thermal Cycling", *J. Electronic Mater.*, 30, 2001, p.1537.
2. K. A. Peterson, I. Dutta and M.W. Chen, "Measurement of Creep Kinetics at Al-Si Interfaces", *Scripta Mater.*, 47 (2002) p. 649.
3. K. A. Peterson, I. Dutta and M.W. Chen, "Diffusionally Accommodated Interfacial Sliding in Metal-Silicon Systems", *Acta Mater.*, 51 (2003), pp. 2831-2846.
4. C. Park, I. Dutta and J. Vella "Interfacial Sliding and Deformation in Back-End Interconnect Structures in Microelectronic Devices", *J. Electronic Mater.*, 32 (2003), pp. 1059-1071.

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TRAINING

- 4 graduate students (Tom Shultz, Keith Peterson, Mark Thornell, Carl Parks) have participated
- 3 post-doctoral associates (Dr. M.W. Chen, Dr. S. Choi, Dr. R. Marks) have participated
- Materials engineer (Dr. Chanman Park) has developed expertise in hot-stage atomic force microscopy
- Organized a series of 5 overview articles in JOM (Jan 2003) to educate the materials community on the role of on Creep in Multi-component Material Systems

MS student Carl Parks and NRC Postdoctoral associate Dr. Robert Marks depositing thin films on Si for making test samples for interfacial creep

OUTREACH

- Prof. Dutta served as a mentor for an internship program administered by the Monterey Academy for Oceanography and Sciences (MAOS), through which a high school senior, Aric Kwon, participated in the project during June-Aug 2002 . He started undergraduate study in Materials Engineering at UCLA in Fall 2003. Jesse Sherburn, a college junior in Physics, worked on this project part-time during June-Aug 2002 and 2003. He helped MS student Carl Parks make Si/Al thin film/Si samples for interfacial creep tests via diffusion bonding. Jesse is currently thinking about pursuing graduate work in Materials Science.