

Novel Experiments to Assess the Mechanical Properties of Thin Films and Nanomaterials

Horacio D. Espinosa

Yong Zhu and Bei Peng



**NORTHWESTERN
UNIVERSITY**

**NIST Workshop on “Reliability Issues in Nanomaterials,”
August 17-19, 2004; Boulder, CO**

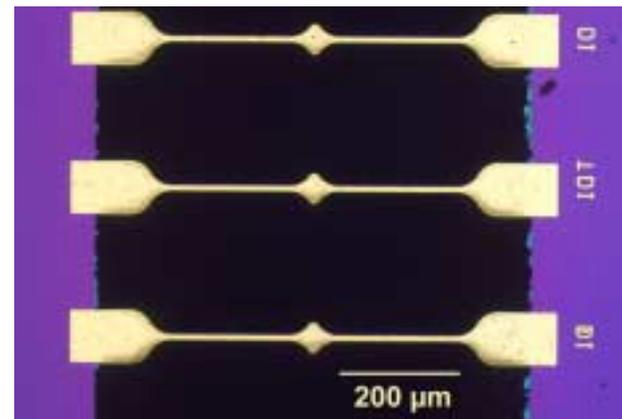
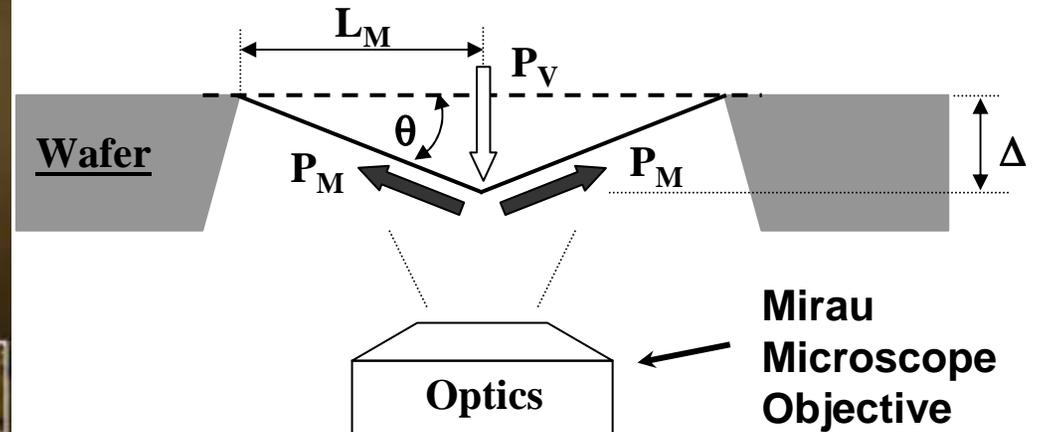
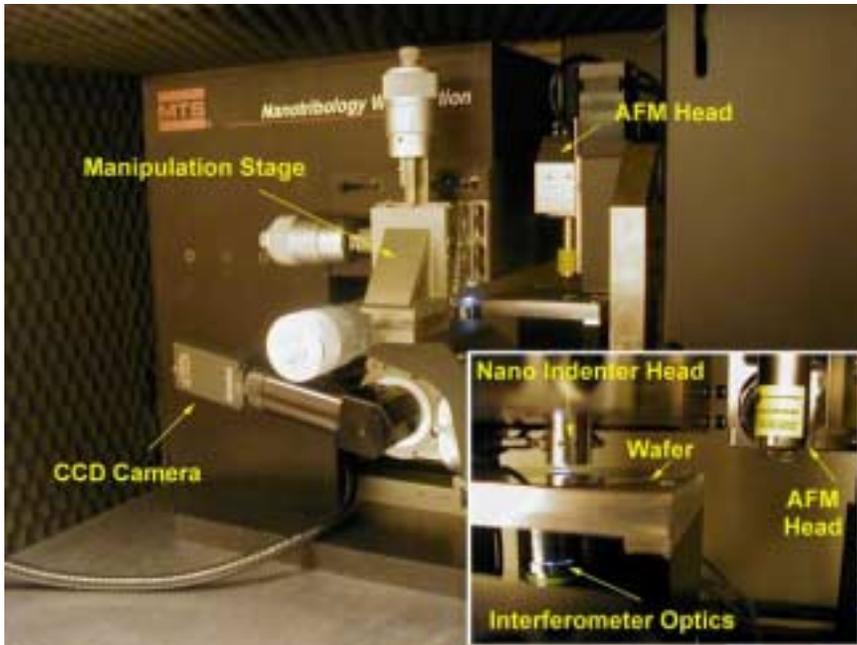


**NORTHWESTERN
UNIVERSITY**

Micro and Nanomechanics Lab
Department of Mechanical Engineering

Wafer Level Tension Experiments

Combined AFM/Nanoindenter with Integrated Mirau Microscope-Interferometer

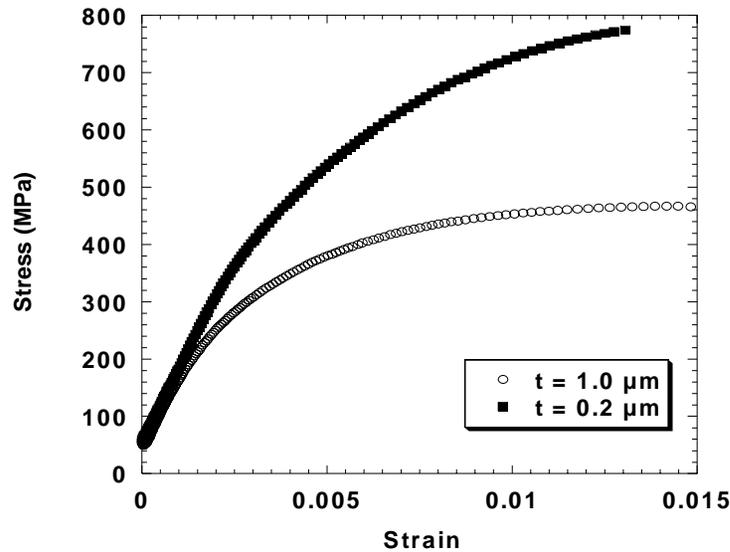


Espinosa et al., *JMPS*, 51, (2003) 47-67

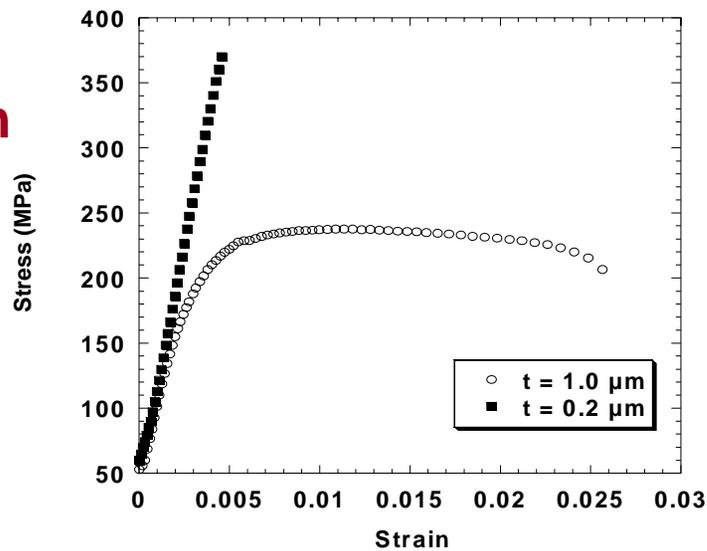
Acknowledgements: Warren Oliver
Erik Herbert

Size Scale Effects in FCC metals

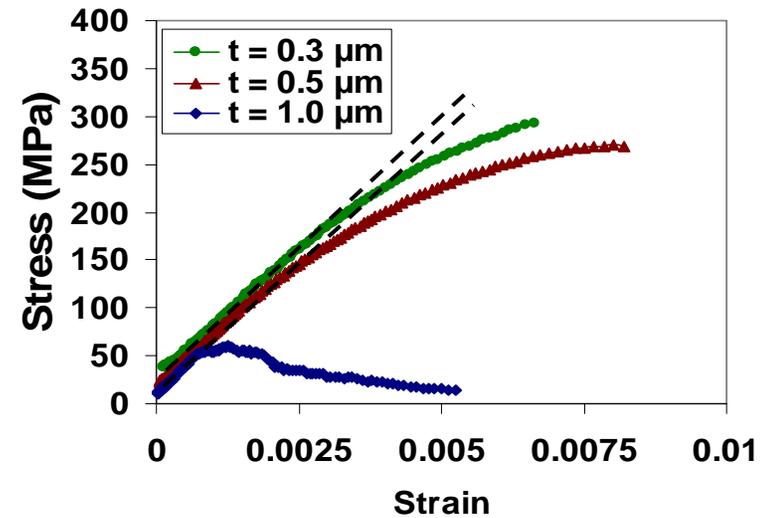
Copper



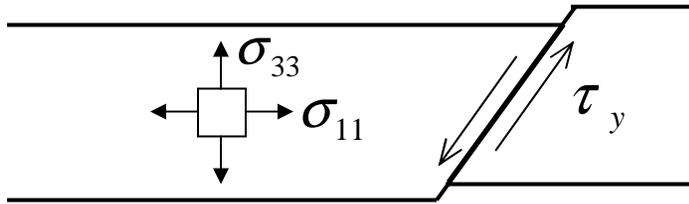
Aluminum



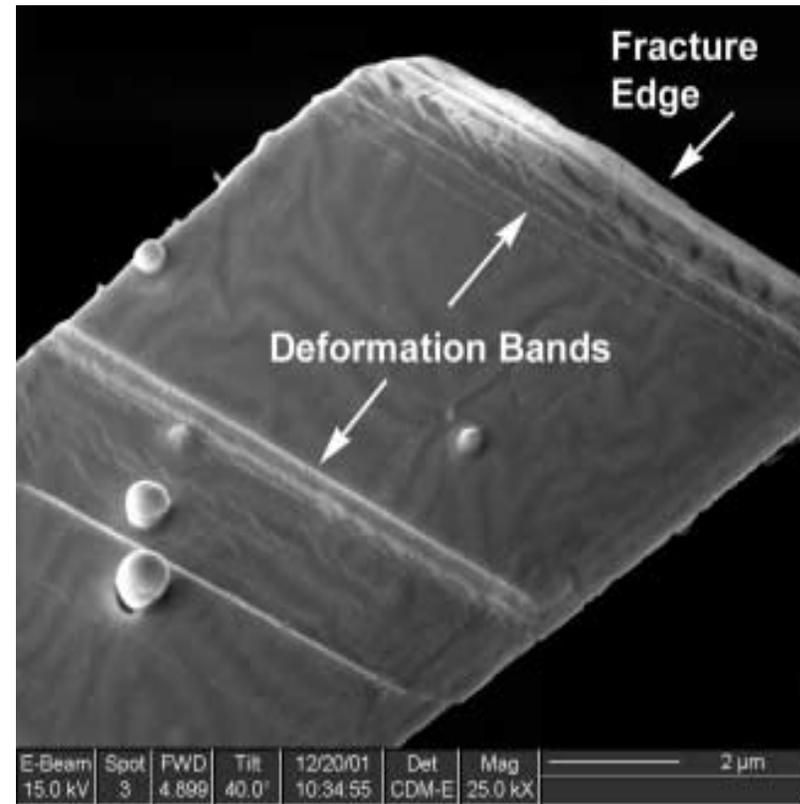
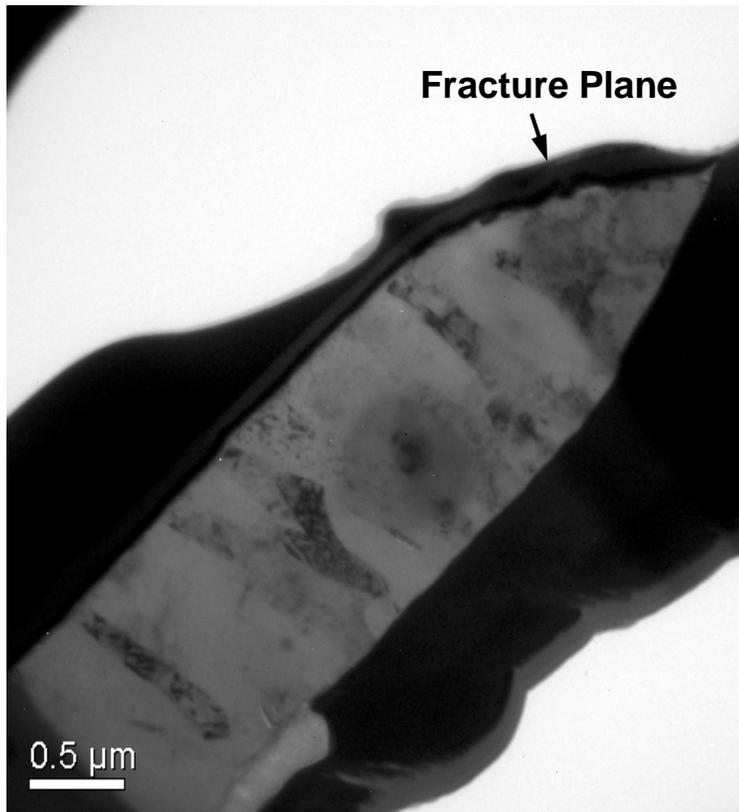
Gold



SEM/TEM Observed Fracture Features



$$\sigma_{11} - \sigma_{33} = 2\tau_y$$



Conclusions

- **The Membrane Deflection Experiment is an effective *on-chip* test for investigating elasticity, plasticity and fracture of freestanding thin films.**
- **Strong plasticity size effects were observed in FCC freestanding films possessing an approximately constant grain size. The size effect is not related to deformation gradients**

