CONTACT MECHANICS FOR THE CANTILEVER PROBE TIP

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PROBE TECHNOLOGY

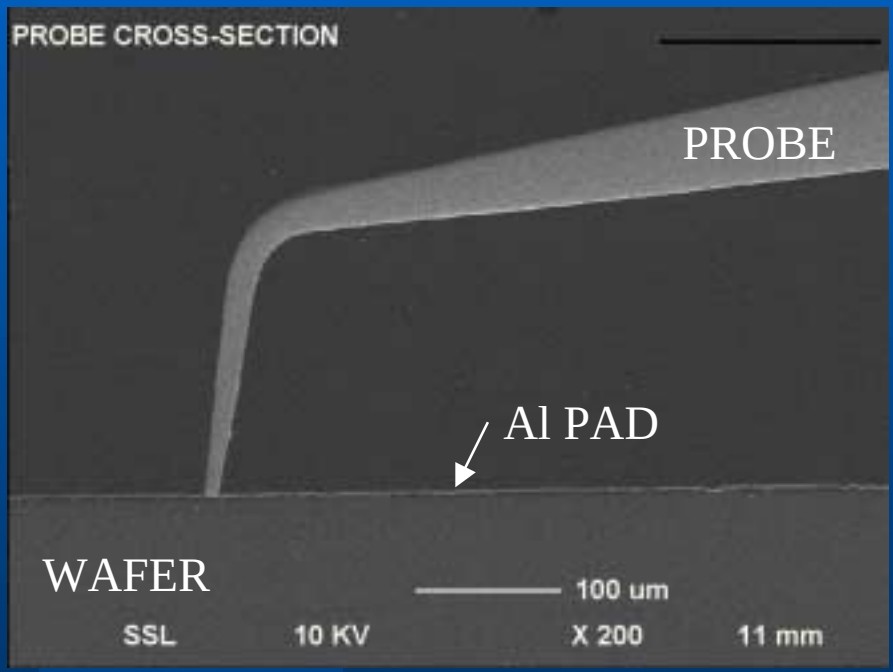
Introduction

- Studies at PTC defined relationship between probe geometry/material properties and probe force, stress/strain distribution, as well as scrub action length
- SEM provided means of analyzing probe scrub mark topography in the contact bond pads
- Identified need for understanding process of generating the scrub and the relationship between probe's parameters and the scrub mark characteristics

Objectives

- Develop understanding of micro-mechanics involved during probe tip penetration of the pad surface
- “Heel” Vs “toe” scrub, which is it?
- General FEM model of the bond pad penetration

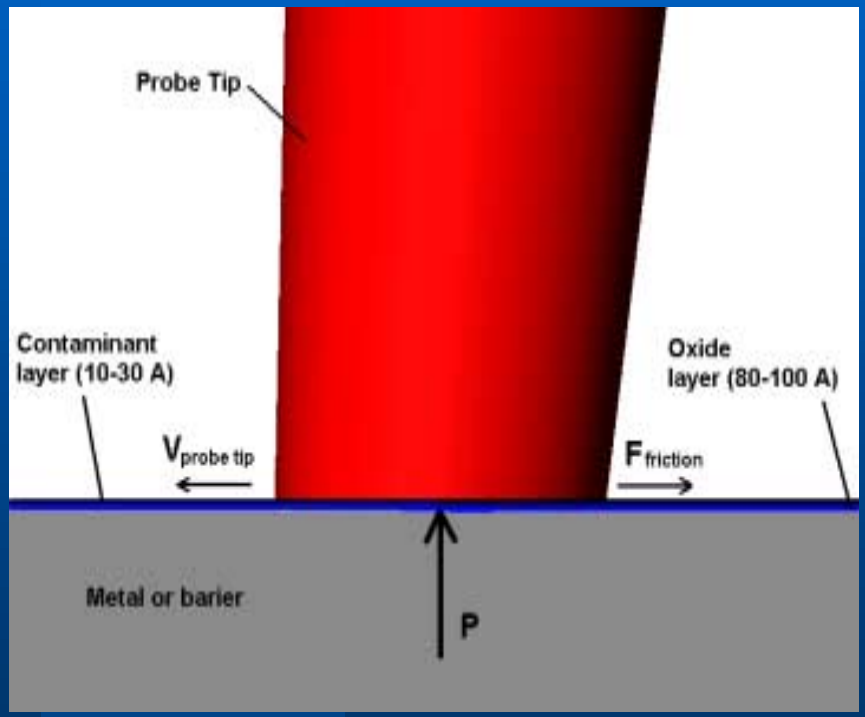
Challenges in Probe Design



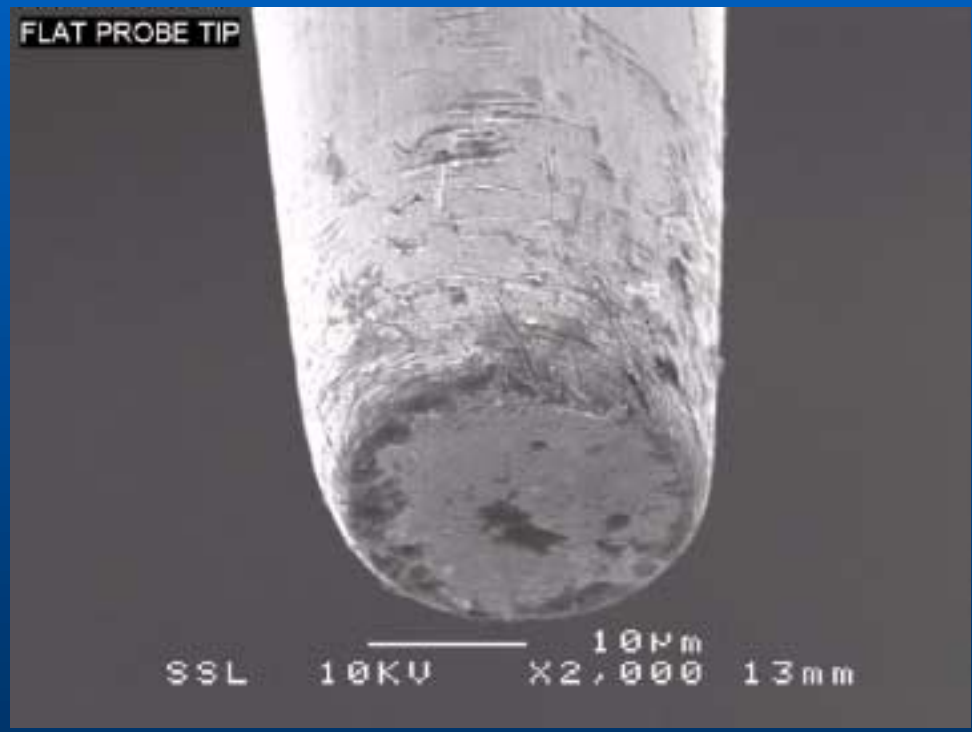
SEM photo of Probe in contact with Al wafer. View of cross-section.

- Penetrate electrically insulating films between tip & pad
- Small Pad size - must minimize scrub length & width
- Pads are placed over circuitry - must minimize scrub depth
- Long life - high mechanical fatigue strength
- Long life - wear resistance
- AC performance - “small” geometry

Cantilever Probe Tip Over Wafer



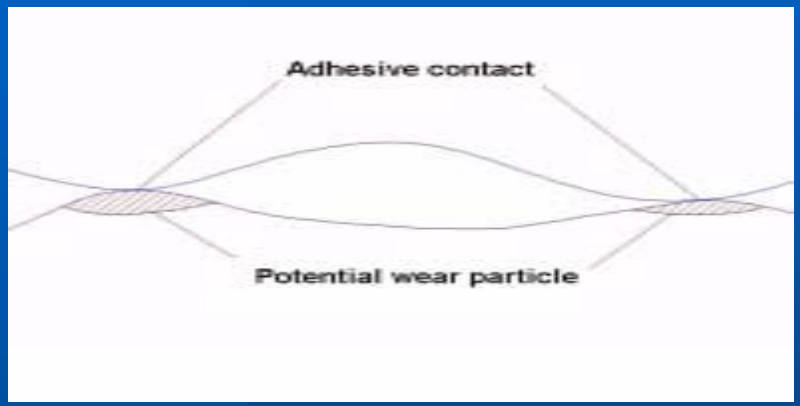
Probe in contact with metal surface. Oxide layer and films indicated



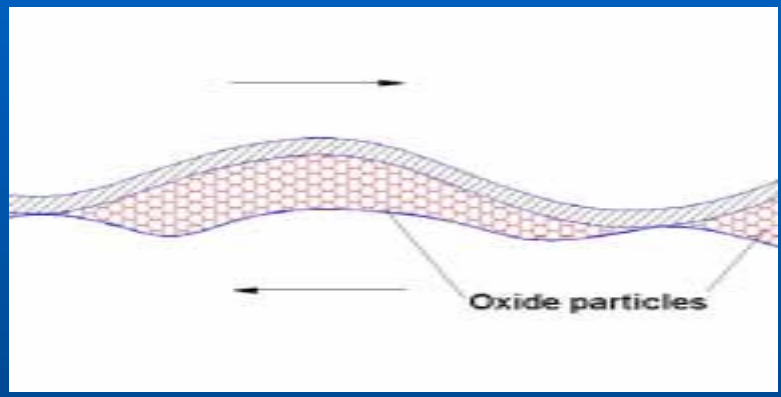
SEM photo of Rhenium-Tungsten probe tip

PROBE TECHNOLOGY

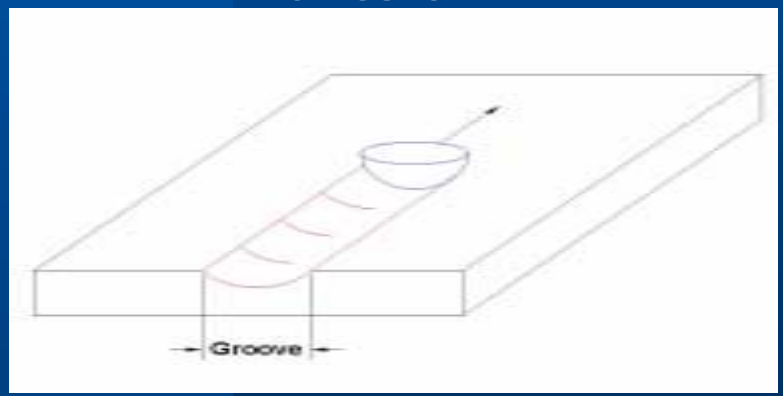
Friction Mechanisms



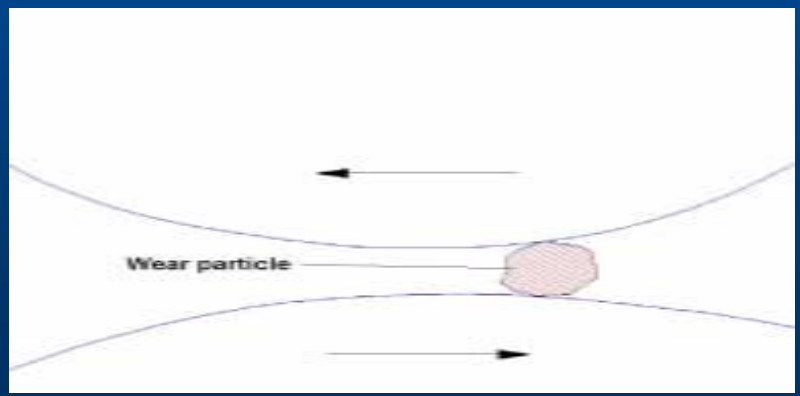
Adhesion



Deformation & fracture of oxides

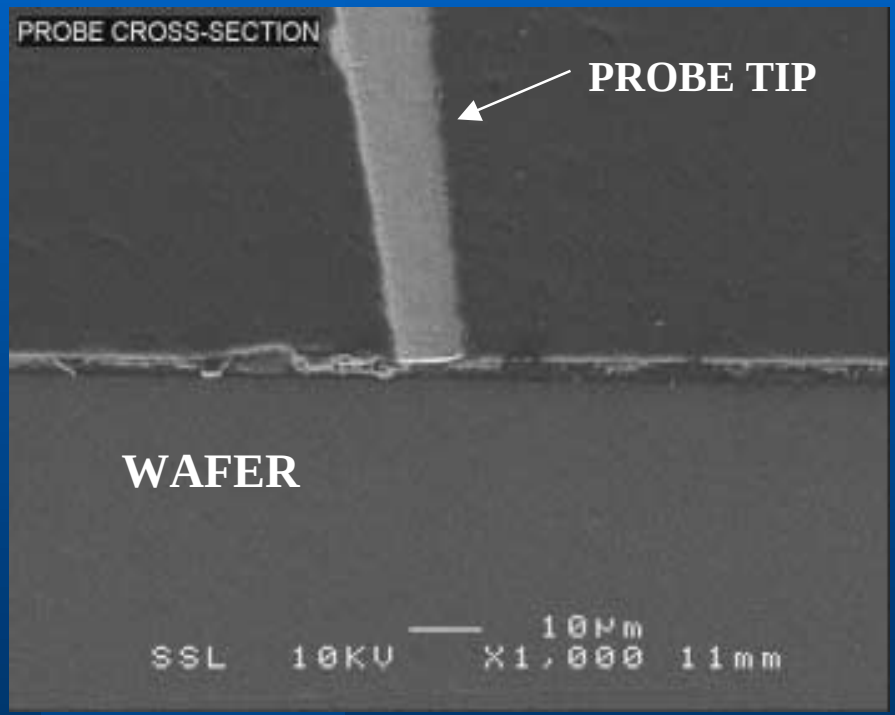


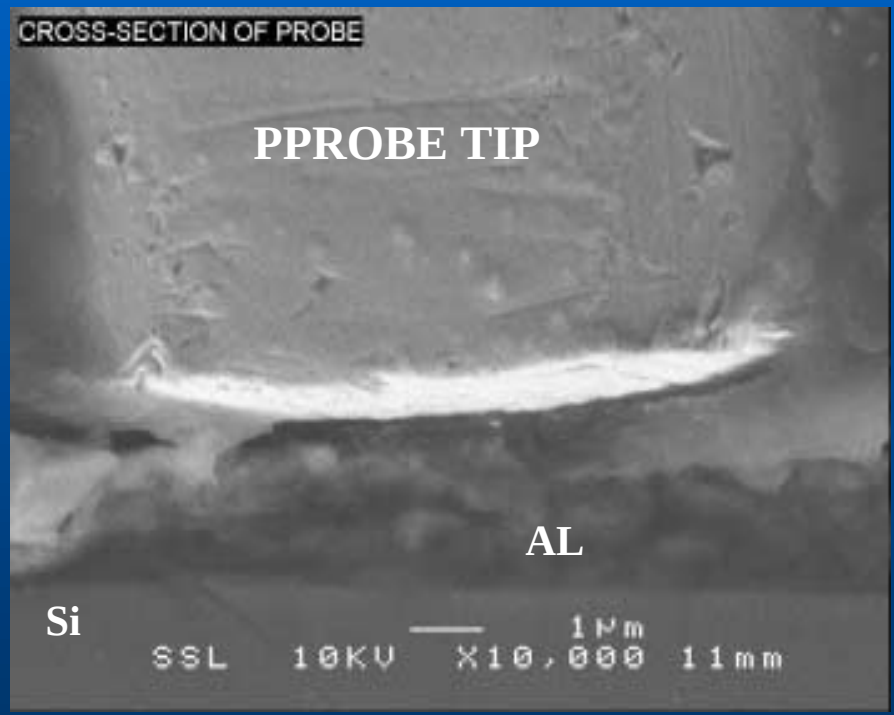
Plowing



Trapped wear particle

Probe Tip in Contact with Pad at 3mil Deflection

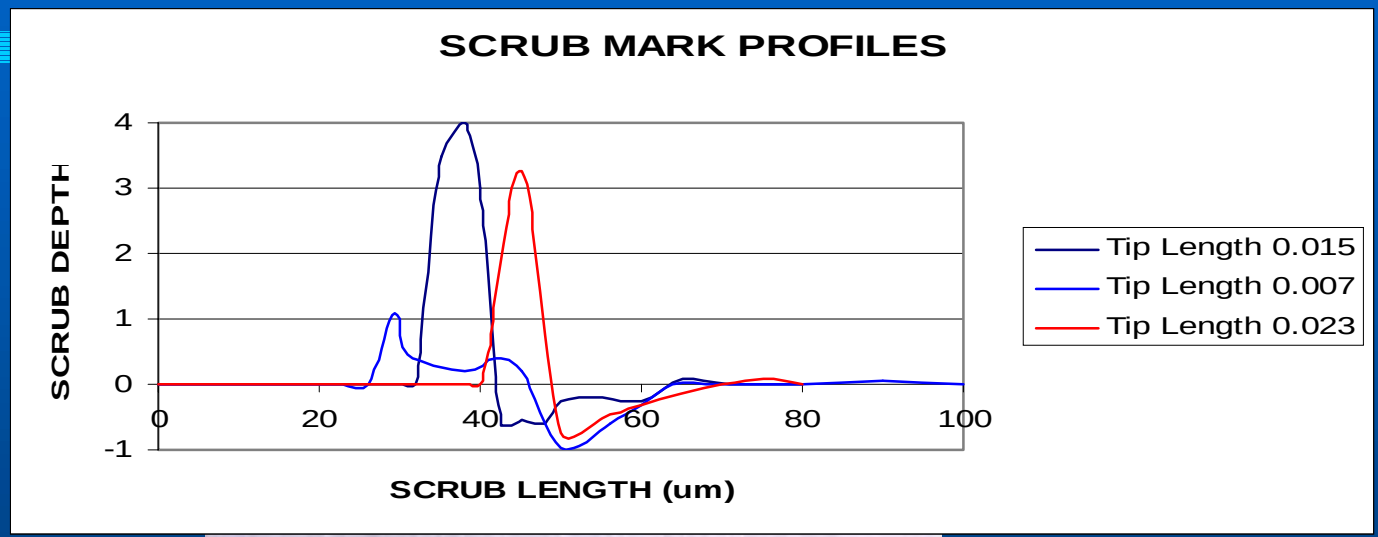




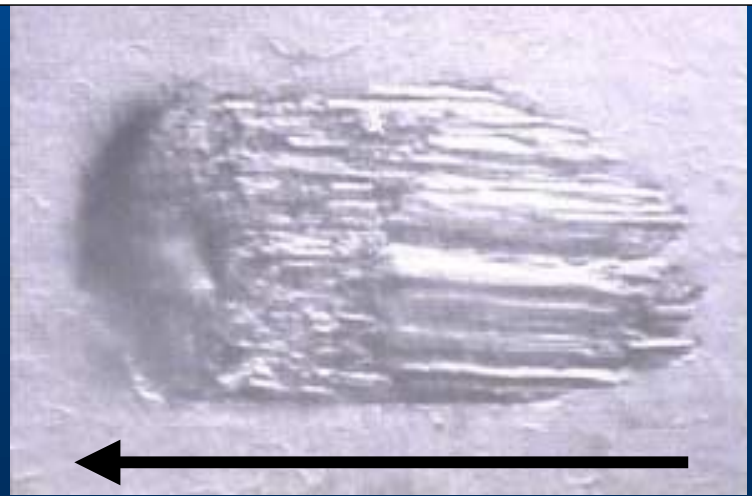
SEM photograph of probe tip in contact with Al pad.
View of x-section

Contact area between probe tip and aluminum pad

Scrub Mark Profile Measurements



- Profile measured with stylus-based profilometer
- Arrow indicates scrub direction

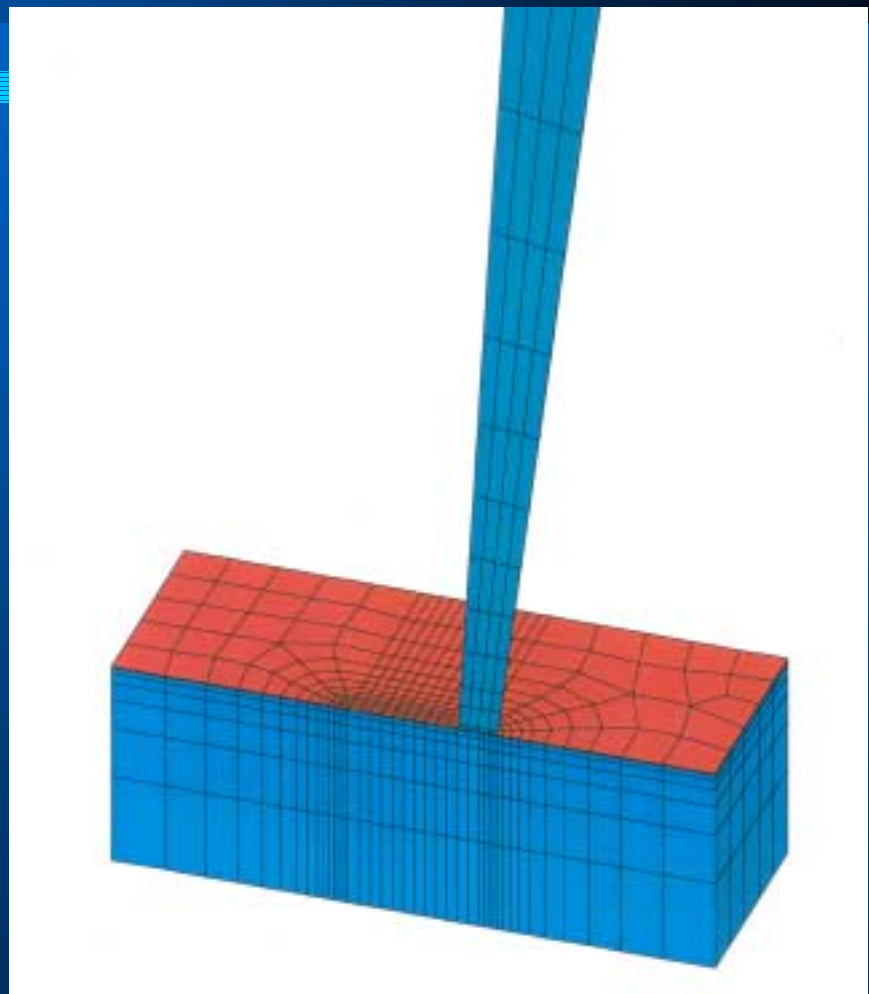


- Scrub mark profiles shown for 3 probe geometries
- Tip lengths indicated in inch

PROBE TECHNOLOGY

FEA Model

- Simulated Contact between probe tip and Aluminum layer on top of Silicon
- Contact modeled using nonlinear elements
- Includes friction effects
- No mechanical fraction



PROBE TECHNOLOGY

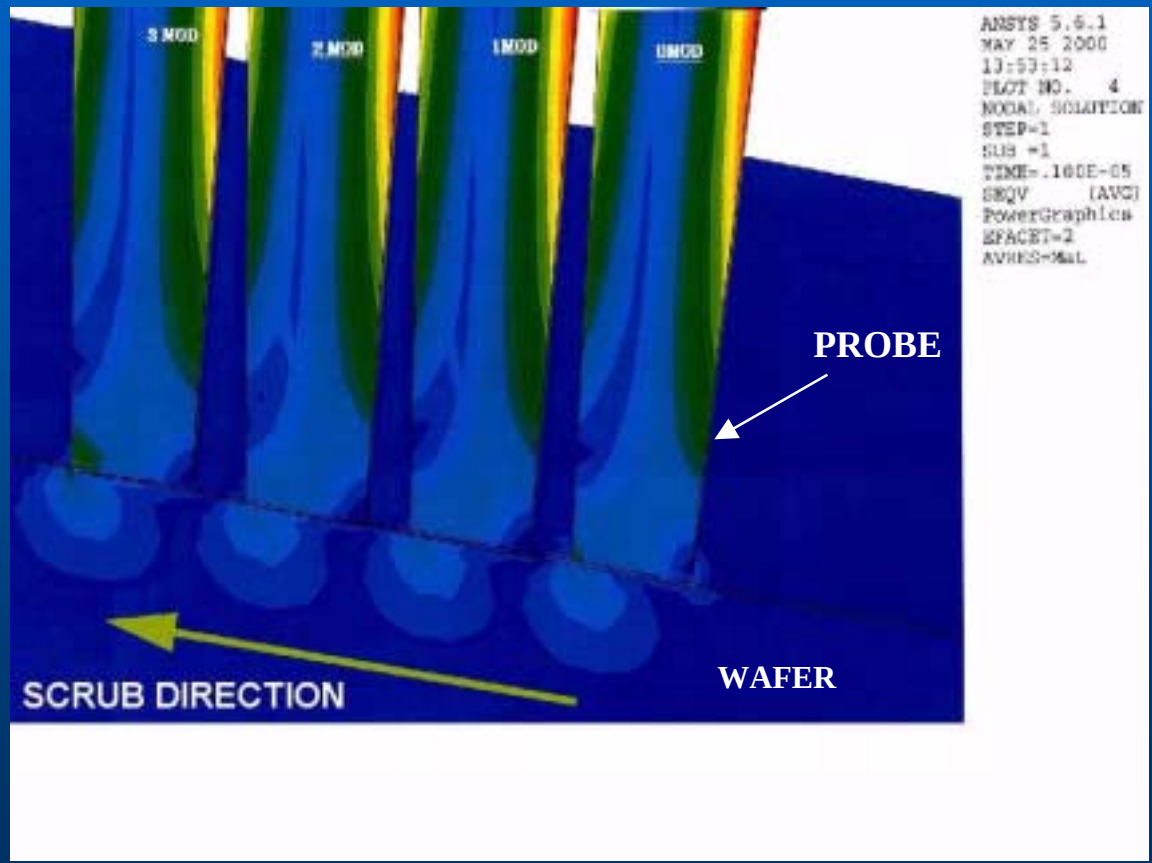
Long Probe Tip Scrub Mechanism

The following two composite plots simulate animation of 5mil diameter probe with 0.9mil tip and 25mil tip length:

- Mechanical stresses in Al pad and probe tip as the tip travels from near 0.0 mil deflection position to 1.0, 2.0 and 3.0 mils
- Mechanical stresses in Al pad and probe tip as the tip retracts form 3.0 mil-deflection to 2.0, 1.0 and near 0.0 mils deflection

Mechanical Contact Stresses

- Snapshot of stress fields for deflections @ 0, 1, 2 & 3 mils
- Mechanical Stresses in tip, Al pad & underlying silicon
- "Toe" scrubbing action



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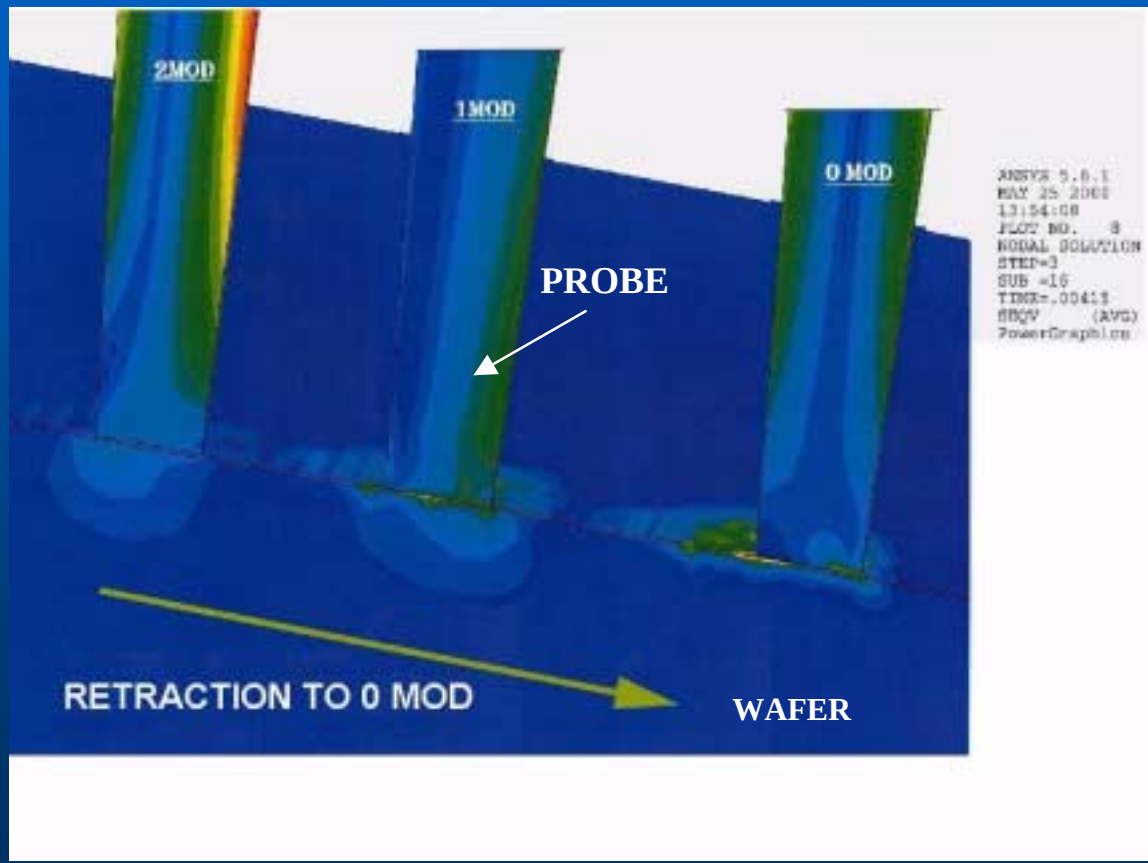
Mechanical Contact Stresses

- Snapshot of stress fields during <u>deflection decrease</u> @ 2, 1, & 0 mils
- Mechanical Stresses in tip, Al pad & underlying silicon
- Deformed aluminum remains seen as highly stressed in front of tip



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Long Probe Tip Scrub Analysis

- Animation shows that toe digs into the pad early in the deflection. Heel traces the pad scrub during retraction
- For a “long” or slender tip the friction suppresses sliding movement
- Large mechanical stresses occur in location between the flat tip and the probe knee
- In extreme case mechanical stresses can exceed probe tip material strength causing plastic deformation and tip “fish-hooking”