TORSIONAL SUBSURFACE IMAGING USING ATOMIC PROBE MICROSCOPY

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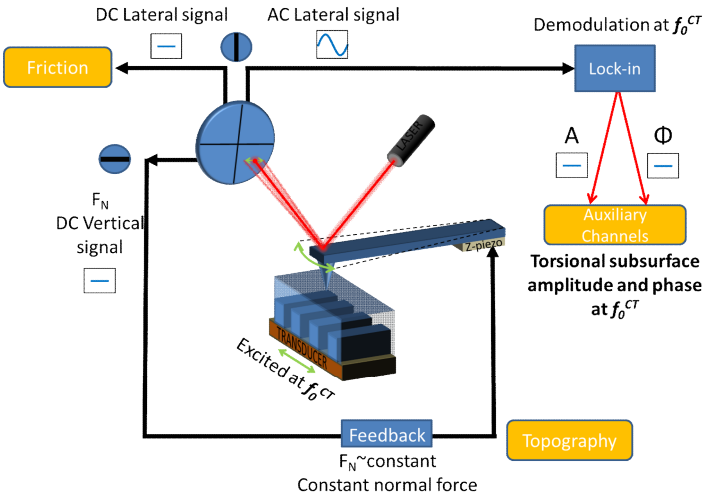
INTRODUCTION

- Torsional subsurface probe microscopy (TSPM) is a non invasive technique that allows the detection of features below the surface of a sample, enhancing the contrast at the edges.
- Excitation of a sample parallel to its surface, at the cantilever's *contact torsional resonant frequency*, f_0^{CT}, induces the torsional oscillation of the cantilever in contact with the sample.
- Example of **application**, torsional APM allows the detection of in-plane defects such as delamination, edge dislocations or stacking faults, essential to detect in the semicon industry where high epitaxial surface quality is essential in order to prevent adverse effects on device characteristics.

TECHNIQUE

- Amplitude and phase (demodulated at f_0^{CT}) contain information of subsurface features with enhancement of boundaries between different phases of the material or defects below the surface.



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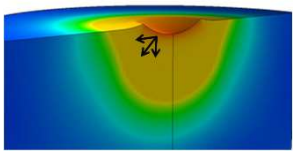
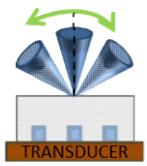
RESULTS

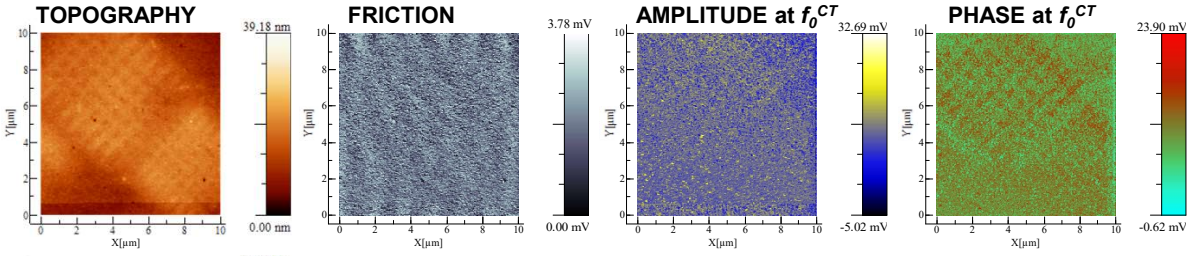
- A stress field below the surface is induced due to the force applied by the tip.



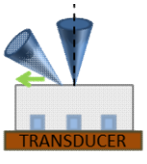
- The Physical contributions to lateral signal come from:
  1) *Subsurface shear elasticity* → Conservative
  2) *Friction* → Dissipation of energy

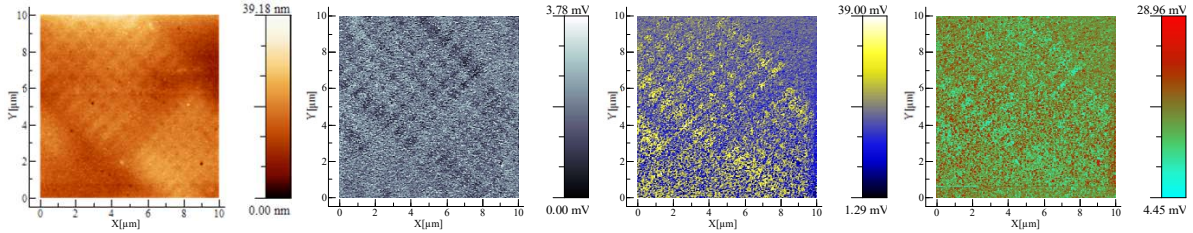
Subsurface, no friction:
→ Tip pivots



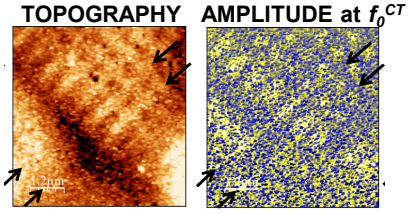


Subsurface and friction:
→ Tip slides





Subsurface torsional amplitude shows buried features not visible in topography



SUMMARY

- TSPM is a promising non-invasive technique to obtain enhancement of boundaries or in plane-defects buried below a surface.
- Torsional signal gives information of dissipation at the surface (*friction*) and the shear elastic properties below the surface (*torsional subsurface*).