Applications of Automated High Resolution Strain Mapping in TEM on the Study of Strain Distribution in MOSFETs

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Introduction

• Strain measurement is critical to monitor designed and unintended strain distributions
  Desired: Strain introduced in Si to enhance electron mobility in the channel
  Unintended: Stress concentration in devices leads to failure

Conventional Nano-Beam Diffraction

• Acquire spot diffraction patterns from strained and unstrained regions using a quasi-parallel nanoprobe
• Use measured shift in spot positions to calculate strain
• Experiment is relatively straightforward
• High spatial resolution (better than 5 nm)

Disadvantage

• Strong dynamical effects lead to rapid changes in spot intensities with small thickness and orientation changes
• Strong dependence of spot intensities on changes in local thickness and orientation makes automated analysis challenging
– Requires manual intervention in identifying spot positions
– Inadequate sampling of higher order reflections limits the accuracy

Precession Electron Diffraction (PED)

Conventional PED

• Diffraction patterns with and without precession from single crystal Si
• FIB prepared sample

Experiment

• Microscopy was performed on a JEOL ARM 200F operating at 200kV
• Automated acquisition of PED patterns and their analysis for strain mapping was performed using Topspin.
• Precession angle: 0.7°
• Diffraction pattern acquisition time: 0.02 s

Topspin Strain Measurement Analysis

• Diffraction patterns from strained region are matched against a reference pattern
• All pixels utilized, not just selected spot centers

Precession angle: 0.7°
Step size: 2 nm
Scan size: 200x65 steps
Acquisition time – 4 mins

nMOS Strain Mapping with Topspin

pMOS Strain Mapping with Topspin

We gratefully acknowledge the use of facilities within the LeRoy Eyring Center for Solid State Science at Arizona State University.