A Novel Method for Fabricating CD Reference Materials with 100 nm Linewidths

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Project Long-Term Goal

- To provide the semiconductor industry a commercial, low-cost, reference artifact with known material and geometry properties traceable to fundamental units of length to enable calibration of metrology instruments

Metrology Challenge Addressed

- To make precise and accurate measurements of sub-100 nm patterned lines traceable to fundamental units of length

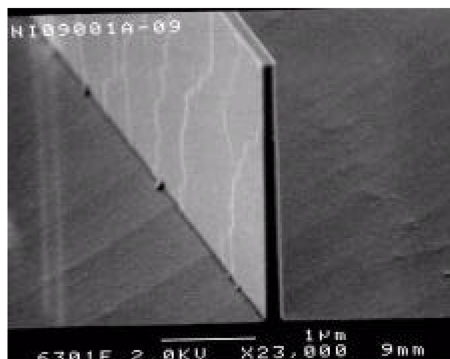
Problem Addressed in ATP Program

- To be useful for metrology tool calibration these reference artifacts must have features with:
  - Sub-minimum widths…i.e., less than 100 nm

- Conventional optical lithography and processing cannot produce such narrow, well-defined artifacts. Other lithography methods, such as e-beam, have limited applicability due to complexity, cost, and availability.

Single-Crystal Technology

Provides Known Material and Geometry



Edges of the feature align to the (111) crystal planes

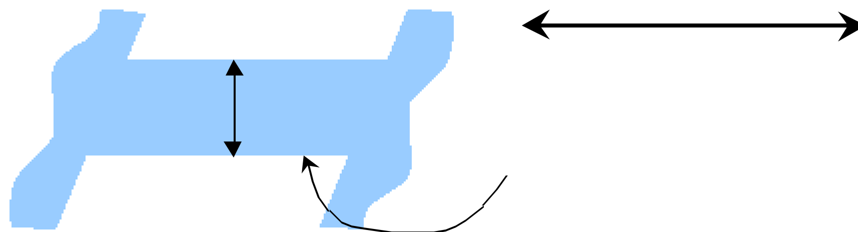
Novel Fabrication Method

Rotational Linewidth Structure

- The Rotational Linewidth Structure is designed such that the edges are not nominally aligned to the crystallographic directions…This allows for

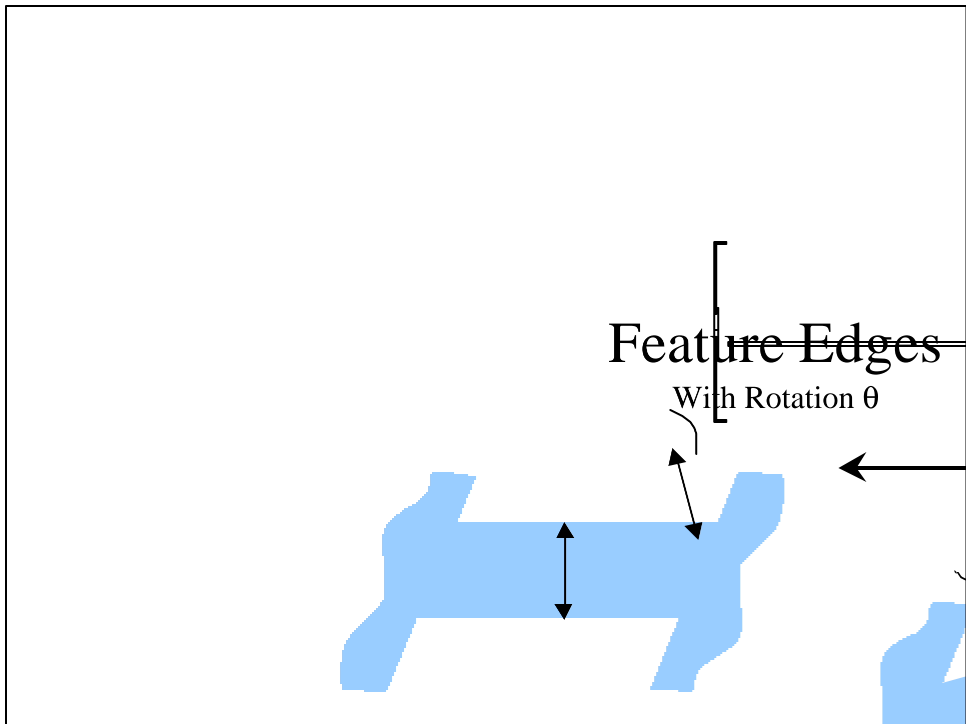
Feature Edges

No Rotation

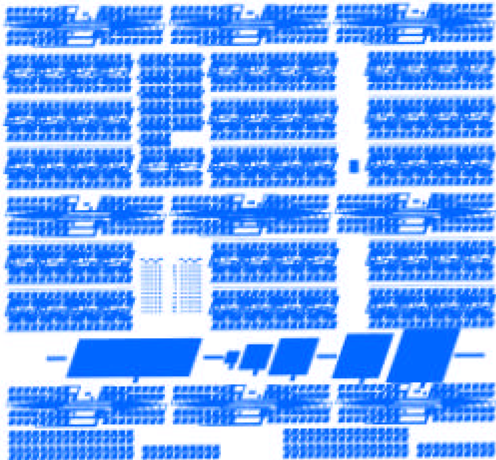


Feature Edges

With Rotation θ



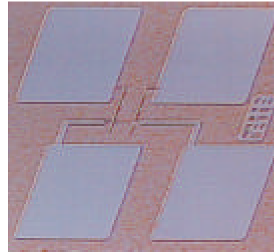
NIST35 Chip Design

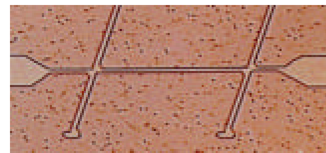


Rotation Linewidth Structure

Preliminary Fabrication

- (110) SIMOX
- Rotations up to ± 1° in 0. 1° steps
- Layout to facilitate HRTEM analysis





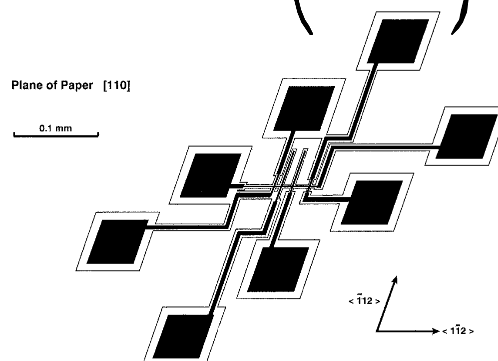
Verification

Definitions

-- the average effective conductive path width of a patterned, uniform conducting film whose length is typically much larger than its width

-- ECD determinations for sub-200 nm lines can be determined with a total measurement uncertainty of less than 10 nm and a reproducibility of less than 2 nm (3 sigma)

Single Crystal Cross-Bridge Resistor Test Structure



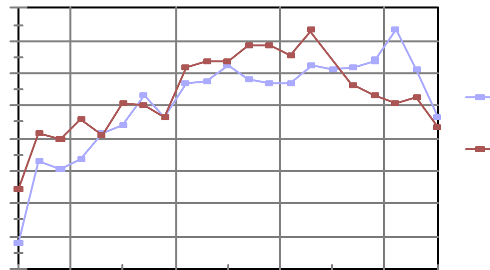
Electrical Probe Results

Rotation Linewidth Structure

- All lines designed with nominal width of 700 nm
- Each line designed with a nominal rotation relative to the crystal planes
- Initial fabrication on SIMOX wafer substrate
- Electrical measurements of lines show the final widths to range in value from 200 nm to 350 nm

Rotation Linewidth Structure

Nominal Width 700 nm



Linewidth versus alignment to crystal axis

Summary

- Scalable to <100 nm using available lithography tools
- Linewidth traceability feasible with acceptable uncertainty
- Meets projected technology requirements >2006

Future Work

- Redesign to ensure coverage of full range of widths
- Process to ensure full etch of region under mask
- Reproduce on BESOI substrate to allow HRTEM calibration
- Considerable commercialization interest

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