X-ray nanodiffraction of free-standing Ge membranes

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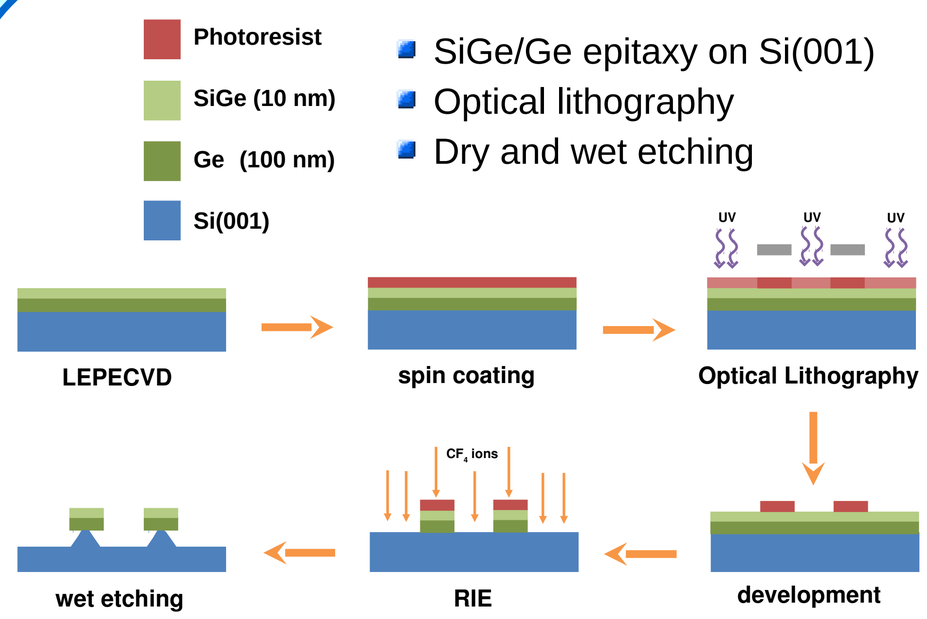
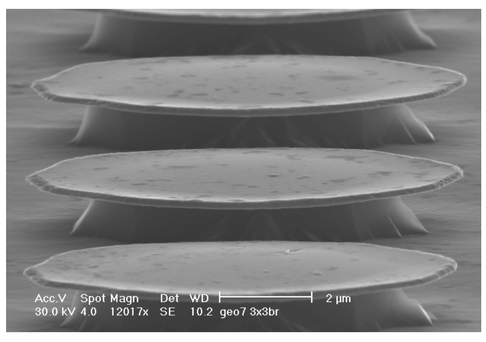
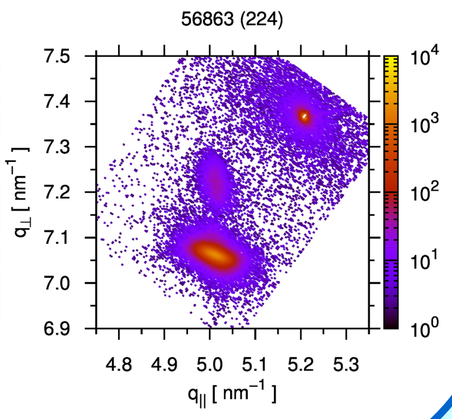
Free-standing Ge membranes are a possible route towards the goal of tensile-strained Ge, since disconnection from the Si substrate allows much greater freedom to deform the structures with suitable stressors. However, the lithographic processes required to create such membranes themselves lead to variations in the properties of the material, which need to be characterized on the sub-micron scale.

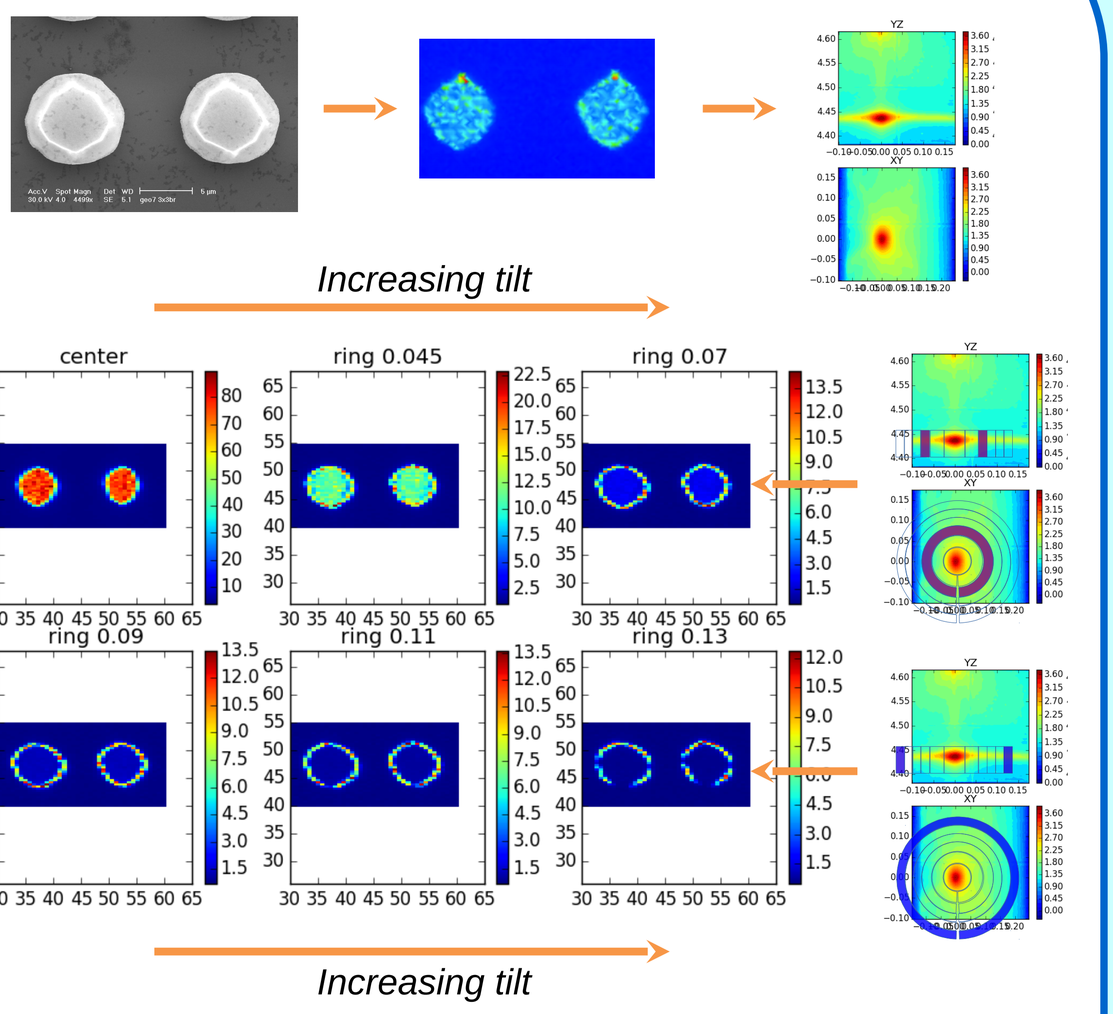
Nanodiffraction experiments were performed using a nano-focused X-ray beam at the ID01 beamline of the European Synchrotron Radiation Facility in Grenoble. Fast-scanning X-ray nanodiffraction microscopy [4] was used in order to map the structural quality, strain state, and deformation of the Ge membranes. Nanodiffraction results were compared with finite-element method simulations, micro-Raman measurements, and large-area laboratory X-ray diffraction results.



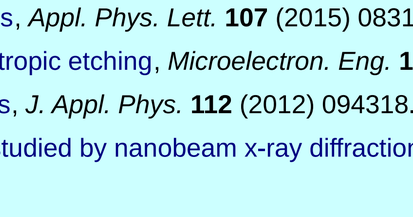
- SiGe/Ge epitaxy on Si(001)
- Optical lithography
- Dry and wet etching
- Free-standing SiGe/Ge film – strained SiGe on Ge
- Patterning allows elastic strain relief
- Bending of Ge layer at edges

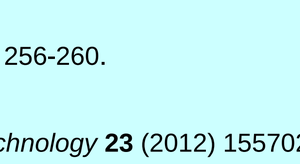




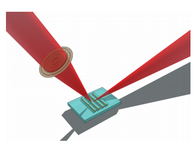


- FEM simulation of free-standing edge of layer
  - Shown in cross-section:

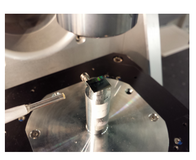




- Reciprocal Space Maps reconstructed from scanning of focused beam over structure
- SiGe preserved after etching
- Ge tilted around edge
- FEM: slightly compressed Ge



- Beam energy: 8.005 keV
  - λ = 0.1549 nm
- Fresnel zone plate
  - ~100 nm spot
- Sample mounted on piezo-stage
- Piezo-stage mounted on goniometer



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