X-ray nanodiffraction in lithographically-defined semiconductor structures

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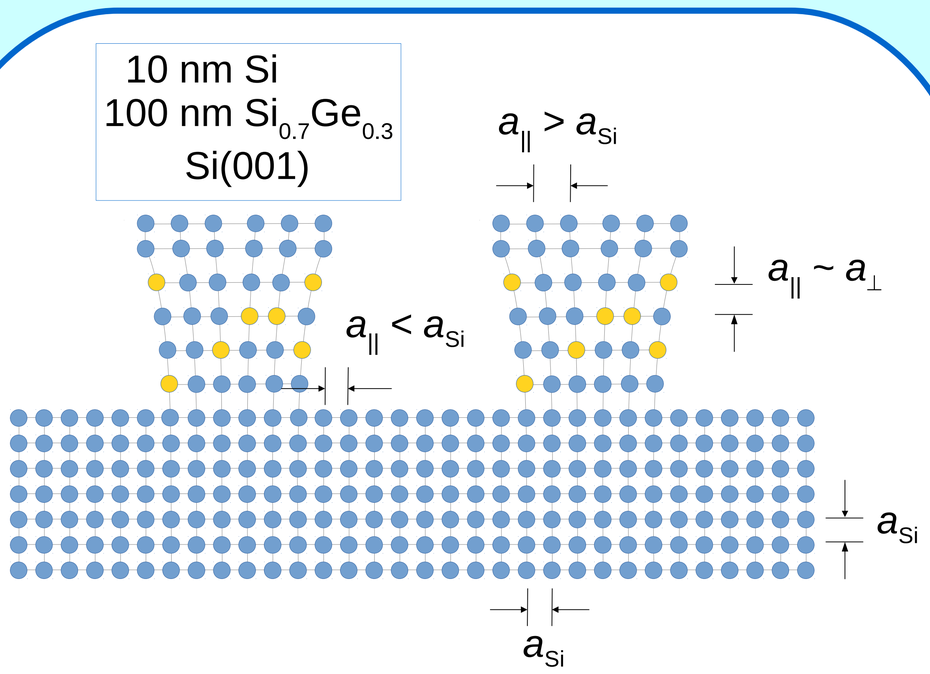
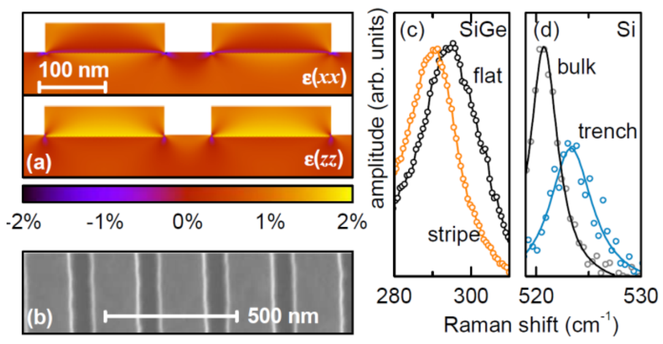
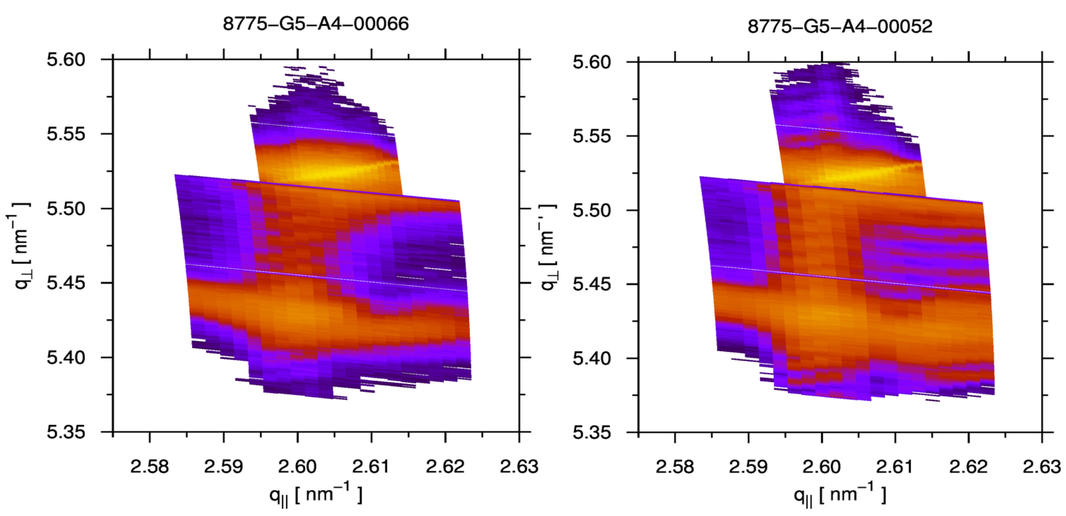
The continued progress of computing technologies continually requires new concepts which improve the performance, efficiency, and scalability of Si-based devices. Uniaxial strain obtained using local stressors has become part of mainstream Si-based technology over the past few years, since uniaxial strain in Si improves its figures of merit in terms of microelectronic applications.
In this work, top-down structures obtained by nanolithography are used as stressors for the creation of high deformation fields. Exploiting the fact that the Ge lattice parameter is 4.17% larger than that of Si, carefully shaped SiGe nanostructures can be used to locally induce uniaxial strain in Si.
Nanofocused x-ray beams based on refractive or diffractive optics have recently become available at synchrotron light sources, allowing the distribution of strain within individual nanostructures to be measured directly.



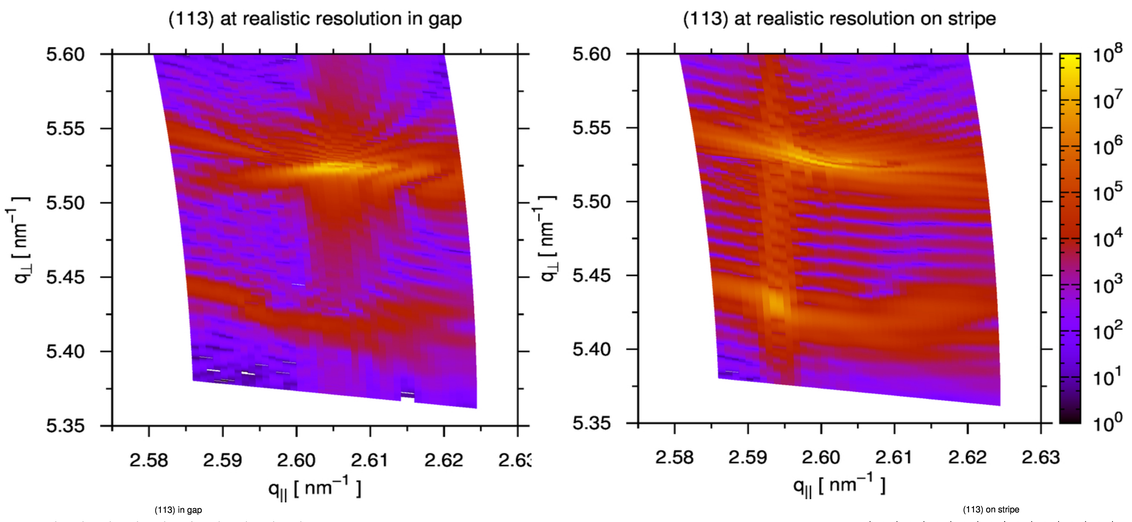
- Patterning allows elastic strain relief
- Tensile strain induced in Si cap
- Compressive strain induced in Si substrate



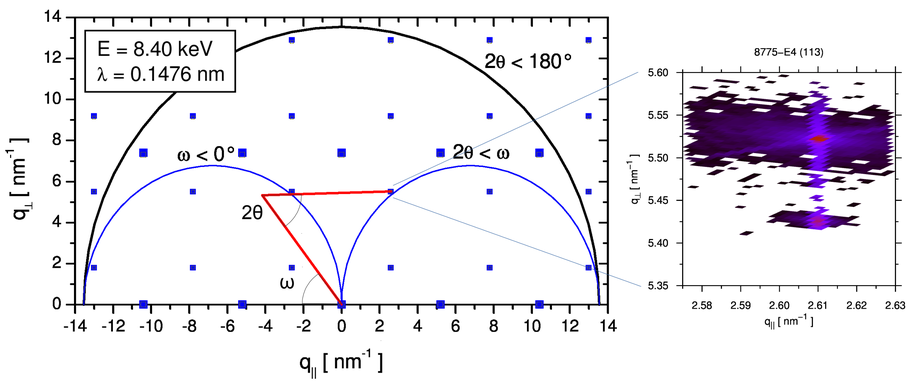


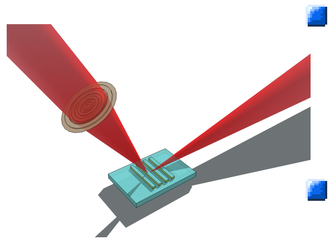
- Reciprocal Space Maps reconstructed from scanning of focused beam over structure
- Simulated RSMs calculated by kinematical diffraction over FEM displacement field.

OpenFOAM



- Simulated “beam” scans over structures
- Comparison of RSMs allows strained SiGe and Si to be identified





- ω ~ 90° would give smallest beam footprint, limited to < 55° by optical microscope
- 2θ ~ ω: “grazing exit” concentrates scattering near the surface of the sample

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