X-Ray Diffraction and Strain Studies on a Single SiGe Quantum Dot Integrated in a Field Effect Transistor

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We report on the analysis of a single island in a 2D periodic array of SiGe dots. The sample was grown by MBE on e-beam pitpatterned Si (001) substrates and capped with Si for the realization of an n-channel DotFET device. These devices employ epitaxially grown SiGe dots for as stressor for a Si channel to achieve higher tensile strain values compared to conventional Si based MOS devices [1]. We successfully recorded reciprocal space maps of the (004) and (224) Bragg peak of a single SiGe dot with a diameter of 220 nm integrated in a fully processed device with a TiN + Al(1%Si) gate stack and source, gate and drain contacts in place, employing a 400 nm focused X-ray beam at the ID01 beamline of the ESRF in Grenoble [2]. Strain fields in the dot and the Si channel were determined using FEM and X-ray simulations, with the experimental data serving as reference. A maximum in-plane tensile strain of 1% in the Si channel was found, substantially higher than achievable for dislocation-free tensile strained Si on planar substrates.

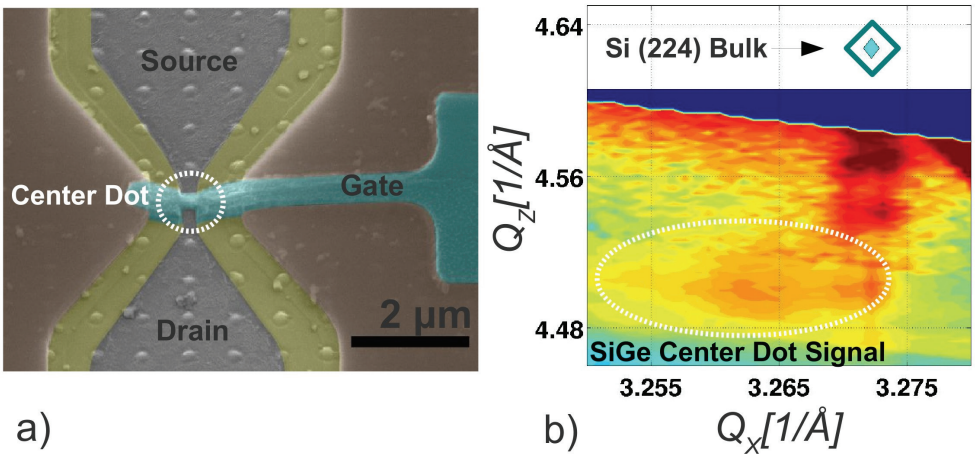

Fig. 1: (a) SEM image of the transistor structure with source and drain contacts not yet in place, the gate finger is perfectly aligned to a single dot. The region labeled 'center dot' was probed in the X-ray experiments, panel (b) shows the corresponding reciprocal space map.

The electrical evaluation of this transistor was performed by comparing to non-strained reference devices processed on the same wafers but without dots: the DotFET showed an increase of drain current between 20 and 60 % [3].

This work was supported by the EC d-DOTFET project (012150-2) and the FWF Vienna (SFB025 IR-On).

References

[1] R. A. Donaton *et al.*, IEDM'06, 346813 (2006).

[2] Mocuta *et al.*, PRB 77, 245425 (2008)

[3] Jovanović *et al.*, IEEE Electron Device Letters, 31, 1083-1085 (2010)