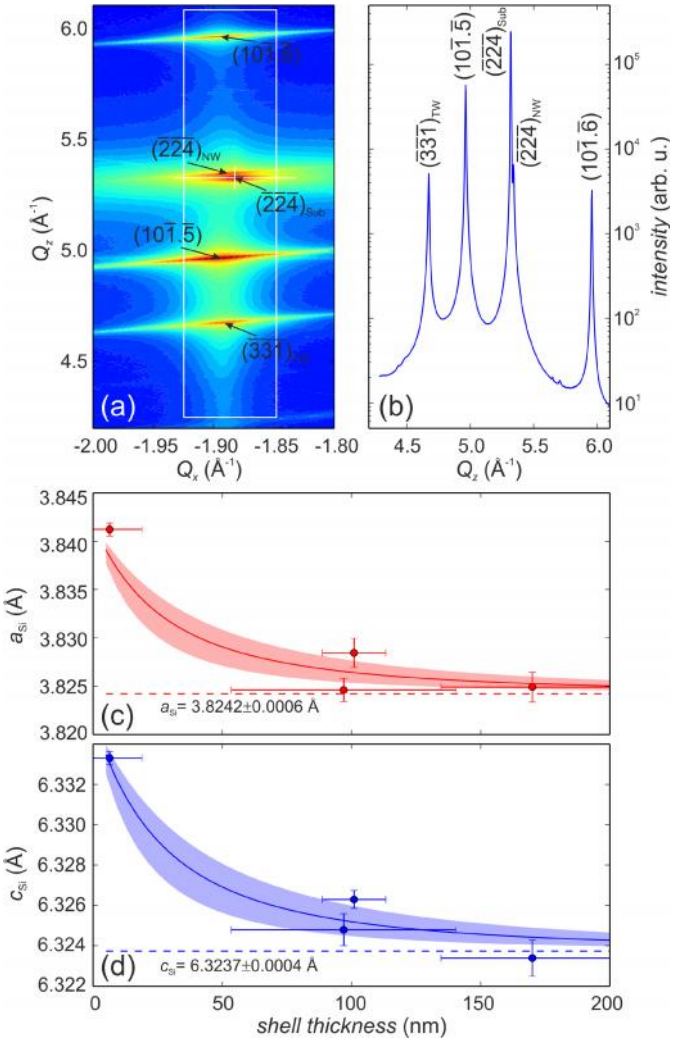
Experimental report HC-1738

Silicon, arguably the most important technological semiconductor, is predicted to exhibit a range of new and interesting properties when grown in the hexagonal crystal structure. To obtain pure hexagonal silicon is a great challenge since it naturally crystallizes in the cubic structure. Here, we demonstrate the fabrication of pure and stable hexagonal silicon. In our approach we transfer the hexagonal crystal structure from a template hexagonal gallium phosphide nanowire to an epitaxially grown Si shell, such that hexagonal Si is formed.

We apply the crystal structure transfer method in which we epitaxially grow Si shells on a template of pure gallium phosphide (GaP) NWs with the hexagonal crystal structure. First, GaP NWs are grown on (111)B oriented GaP substrates via the vapour-liquid-solid (VLS) mechanism mediated by Au catalyst islands. Si shells are then epitaxially grown at a temperature of 900°C in order to favor Vapor-Solid (VS) layer growth of Si and suppress any potential VLS growth from the Au/Ga eutectic catalyst particle. Under these conditions we achieve a high density of GaP/Si core/shell NWs.

Using synchrotron x-ray diffraction, the lattice parameters have been measured for a large ensemble of NWs to obtain a precise value of the a_{Si}- and c_{Si}-lattice constants. For this purpose, a series of samples with different shell thicknesses has been measured at beamline BM20 at the ESRF in Grenoble, France. Panel (a) shows a reciprocal space map covering several Bragg peaks as indicated in the plot; panel (b) is the corresponding line integration.



Each peak position of the different Bragg peaks yields a value of a_{Si} and c_{Si}. While for the thinnest shells a certain strain influence from the GaP core can be expected, for the thicker shells the core has virtually no influence any more, and the values converge towards the true lattice parameters of hexagonal Si. Fitting a volume-weighted model to our data, considering different core thicknesses and the statistical errors of geometrical

parameters (plotted in panels (c) and (d)), yields results of a_{Si}=3.8242±0.0006 Å and c_{Si}= 6.3237±0.0004 Å (dashed lines).

The results obtained from this beamtime have been published in:

H.I.T. Hauge, M.A. Verheijen, S. Conesa-Boj, T. Etzelstorfer, M. Watzinger, D. Kriegner, I. Zardo, C. Fasolato, F. Capitani, P. Postorino, S. Kölling, A. Li, S. Assali, J. Stangl, E.P.A.M. Bakkers, "*Hexagonal Silicon Realized*", Nano Lett. 15, 5855–5860 (2015).
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