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Electrode-induced In-plane Strain Variation in Si Quantum Well

JOONKYU PARK, YOUNGJUN AHN, DONALD SAVAGE, University of Wisconsin Madison, JONATHAN PRANCE, Lancaster University, CHRISTINE SIMMONS, MAX LAGALLY, SUSAN COPPERSMITH, University of Wisconsin Madison, MARTIN HOLT, Argonne National Laboratory, MARK ERIKSSON, PAUL EVANS, University of Wisconsin Madison — Silicon quantum devices are often formed in electrostatically defined quantum dots within Si/SiGe heterostructures incorporating a strained silicon quantum well. Structural variations within the quantum well arise from several sources, including the plastic relaxation of the SiGe substrate and stresses arising from electrodes. The residual stress in the electrode causes an elastic bending distortion of the quantum well that modifies the energy by which the two split-off conduction minima in the silicon quantum well are shifted by biaxial strain. We report a synchrotron hard x-ray nanobeam diffraction study of the quantum well distortion (i) near isolated Pd electrodes and (ii) within a complex quantum dot pattern. The strain difference between the two interfaces of the 10-nm-thick silicon quantum well has a magnitude of up to 10^{-5} in (i) while it is as large as 10^{-4} in (ii) which is far larger than the strain difference arising from the plastic relaxation of the SiGe substrate. Mechanical analysis using the edge-force model, shows that the residual stress in the Pd electrode was 350 MPa. We expect that similar effects will arise in all quantum electronic systems with metal-electrode-defined devices.

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