Nano-Scale Strain Mapping in Complete Nanowire Based Electronic Devices by Bragg Coherent X-Ray Diffraction

D. Dzhigaev[1], R. Zhe[1], S. Hammarberg[1], Y. Liu[1], R. Timm[1], A. Krishnaraja[2], Z. I. Balogh[3], F. Lenrick[4], J. Svensson[2], L.-E. Wernersson[2], A. Mikkelsen[1]

[1]Division of Synchrotron Radiation Research, Department of Physics, Lund University, Lund, Sweden,
[2]Electrical and Information Technology, LTH, Lund University, Lund, Sweden
[3]Center for Electron Nanoscopy. Technical University of Denmark, Copenhagen, Denmark
[4]NanoLund, Lund University, Lund Sweden
dmitry.dzhigaev@sljus.lu.se

The progress achieved in a growth of heterostructured nanowires led to design of nano-electronic devices with record-breaking parameters in transistors, quantum computations, solar cells and light emitting technologies. The strain plays significant role in the performance of these nano-electronic devices. In multi-segment nanowires the strain induced at the interfaces significantly change a charge carrier mobility, thus alternating the speed and power consumption during operation [1]. The only way to image the strain in real functional device with many functional layers and over extended field of view is to employ scanning techniques with the use of nano-focused X-ray beams. We made a deeper look at nanoscale features within single heterostructured nanowires, which are embedded in realistic nano-electronic devices. These are InAs/GaSb segments of Tunnel Field Effect Transistors (TFETs) [2] which are covered by processing layers of the metal gate, organic space and top metal contact.

Exploiting extraordinary brilliance of 4th generation synchrotron MAX IV (Lund, Sweden) and dedicated nano-focusing end-station NanoMax we could obtain the information which was not accessible before at resolution of 60 nm and below. Development of Bragg diffraction mapping and Bragg ptychography techniques in recent years opened exciting possibilities for 3D imaging of strain and tilt in extended structures [3,4]. These techniques were employed during our studies. Particularly the influence of the metal gate deposition process on the strain within a single nanowire transistor was revealed. The experimental challenges will be discussed in more detail. Interpreting of the results plays a significant role in obtaining quantitative information, which includes developing of proper models for strain engineering in nano-electronics. In our case, we support the experimental findings by Finite Element Method simulations which take into account material properties, boundary conditions and allow precise simulation of the diffraction experiment.

References

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