SYSE 1: Strain engineering in semiconductors

Time: Monday 14:30–15:45 Location: H1

Invited Talk SYSE 1.1 Mon 14:30 H1

Wavy and Buckled Nanoribbons and Nanotubes: Mechanics and Applications — •John Rogers — University of Illinois at Urbana/Champaign, 1304 W. Green St, Urbana, IL 61801, USA

Control over the compositions, shapes, spatial locations and/or configurations of semiconductor nanowires, nanoribbons and other nanostructures is important for nearly all applications of these materials. Although methods exist for defining some of these properties, there are relatively few approaches for controlling the two- and three-dimensional (2D and 3D) layouts of individual elements. This talk describes a mechanical strategy for creating certain classes of 3D shapes in nanoribbons that would be difficult to generate in other ways. The approach involves geometrically controlled strain coupling of these elements to elastomeric substrates. The structures that can be produced range from small amplitude, periodic one and two dimensional *wavy* geometries to periodic or aperiodic large scale buckled formations. We show that these configurations can be created in nanoribbons and nanomembranes of GaAs and Si and in individual single walled carbon nanotubes, and that these geometries can be described quantitatively with analytical and finite element models of the mechanics. As one application example, we show that certain of these structures provide a route to electronics (and optoelectronics) with extremely high levels of stretchability (up to ˜100%), compressibility (up to ˜25%) and bendability (with curvature radius down to ˜5 mm).

SYSE 1.2 Mon 15:00 H1

Wrinkled semiconductor layers: from principle to applications — •Yongfeng Mei, Dominic J. Thurmer, Francesca Cavallo, Suwit Kiravittaya, Mohamed Benyoucef, Christoph Deneke, Tim Zander, Armando Rastelli, and Oliver G. Schmidt — Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, D-70569 Stuttgart, Germany

The wrinkling of thin films on substrate surfaces is a well-known phenomenon. A few potential applications of wrinkles have been put forward such as force spectroscopy in cells and metrology methods [1,2]. In this talk, we present a deterministic layer wrinkling method to fabricate ordered nanochannel networks on semiconductor substrates. The method, termed "Release and bond-back of layers (REBOLA)", consists of the partial release, wrinkling and bond back of a compressively strained functional layer on a Si-on-insulator substrate surface, which seems compatible with main stream Si technology. The layer deformation after deterministic wrinkling and bond-back is reflected by the band-edge shifts of an embedded quantum well structure, which we can describe accurately by theory. To elucidate the usefulness of REBOLA, we demonstrate nanofluidic transport as well as femto-litre filling and emptying of individual wrinkles on a standard semiconductor substrate. Some interesting phenomena related to wrinkling (like self-similar folding and interference-enhanced emission) will also be addressed. Support: BMBF(03N8711). [1] A. K. Harris et al. Science 1980, 208, 177; [2] C. M. Stafford et al. Nat. Mater. 2004, 3, 545.

SYSE 1.3 Mon 15:15 H1

Stress in nanostructured semiconductors — •Silke Christiansen[1,2], Michael Becker[2], Andreas Berger[2], Cameliu Himcinschi[1], Vladimir Sivakov[1,3], Gudrun Andrae[3], Fritz Falk[3], Rajendra Singh[1], and Jens Schneider[4] — [1]Max-Planck Institute, Halle, Germany — [2]Martin Luther Universität Halle-Wittenberg, Halle, germany — [3]IPHT, Jena, Germany — [4]CSG Solar, Thalheim, Germany

Mechanical stress in semiconductor devices can either improve or degrade the device properties. Mechanical stress can be used to tailor the band structure of semiconductors. A higher mobility of charge carriers and higher device frequencies can be achieved. On the other hand, large mechanical stresses induce unwanted dislocations and dislocation motion. Mechanical stress fields can initiate crack formation that leads to breakage of whole wafers or devices. To detect the influence and the sources of mechanical stresses, the appropriate detection methods are needed. μ-Raman spectroscopy is a method that has gained recently increasing attention in solid-state physics to investigate mechanical stresses in semiconductor materials, structures and devices. In our talk we will show how Raman spectroscopy can be use to measure mechanical stress in nano-scale semiconductor layer stacks and stuctures and in polycrystalline silicon solar cell materials. μ-Raman spectroscopy is combined with real structure analysis by electron microscopy (EM) techniques such as high resolution transmission EM, analytical EM, and elecron-back scatter diffraction (EBSD) in a scanning EM.

SYSE 1.4 Mon 15:30 H1

Radial crystals and radial superlattices — •Christoph Deneke[1], Ute Zschieschang[1], Bärbel Krause[2], Neng Yun Jin-Phillipp[3], Cristian Mokuta[2], Till Metzger[2], Hagen Klauk[1], and Oliver Schmidt[1] — [1]Max-Planck-Institut für Festkörperforschung, Heisenbergstr. 1, 70569 Stuttgart — [2]ESRF, Boîte Postale 220, F-38043 Grenoble Cedex, France — [3]Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart

Recently, a new class of radial crystals and radial superlattices has been established by the roll-up of thin solid films on a substrate surface [1-3]. We investigate these structures by X-ray diffraction and diverse transmission electron microscopy techniques. Quite generally, the superlattices comprise alternating single crystalline and non-crystalline (or poly-crystalline) layers. For example, radial superlattices out of In(Ga)As/alkanethiolate [4] or InGaAs/metal films are created. Detailed cross-sectional TEM and (S)TEM studies reveal that neighboring windings in the superlattices are closely joined together and that in some cases the interfaces show no detectable contamination. These new types of hybrid periodically modulated heterostructures might find relevance in refined optics [4] or electronics [5] applications.

[1] Ch. Deneke et al., Appl. Phys. Lett. 84, 4475 (2004); [2] B. Krause et al., Phys. Rev. Lett. 96, 165502 (2006); [3] Ch. Deneke et al., Appl. Phys. Lett. (in press) [4] R. Songmuang et al., cond-mat/0611261 [5] O. G. Schmidt et al., IEEE J. Sel. Top. Quant. Electron. 8, 1025 (2002).