Strain analysis of SiNWs-GQDs core-shell heterostructures

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Since the strain/structural defects strongly influence the physical properties [1], considerable work has been devoted for revealing their effects in both planar epitaxial layers and nanostructured materials [2]. Thus, the study of the strain field in nanomaterials represents a very important topic among different fields of applications. The quantitative analysis of the structural defects, as well as a deeper understanding of their source and nature became a highly desirable task associate to the further device development [3].

For this purpose, one of the common techniques used to detect the structural defects and quantify their density is X-ray diffraction (XRD). Recently, it was shown that the standard mosaic block or diffuse scattering models fail in the quantification of the structural defects in nanowires, and thus development of a new method became necessary [4]. In this paper, varying the incidence angle of the source, we get different penetration depths of the X-rays for different Si nanowire array morphologies – Figure 1.

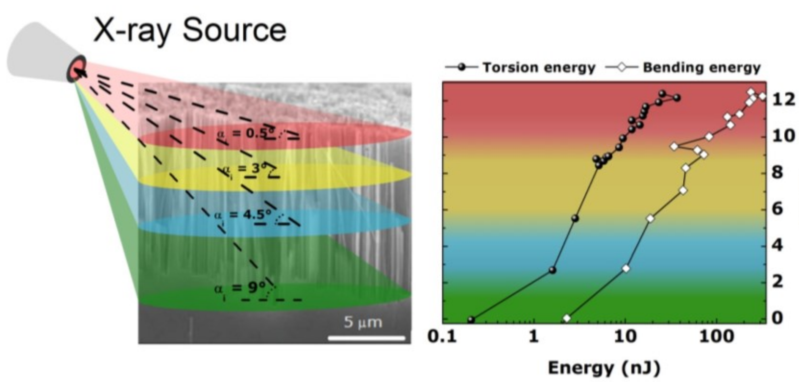

Figure 1. The incidence angle of the source was varied to get different penetration depths of the X-rays. Recording X-ray profiles along ω and φ, we obtained bending and torsion energy profiles.

Furthermore, implementing a new formalism based on these data, we obtained the bending and torsion profiles along z-direction, as well as the bending and torsion energy profiles. Attributing the entire energy lost to the dislocations' formation at the coalescence regions we were able to estimate the dislocation density in nanowire arrays. The obtained results clearly suggest the close relationship between array morphology and the density of the edge and screw threading dislocations. Moreover, the impact of graphene quantum dots (GQDs) in the strain relaxation processes will be discussed.

[1] Lewis, R. B., Corfdir, P., Küpers, H., Flissikowski, T., Brandt, O. & Geelhaar, L. (2018). Nano Lett. 18, 2343–2350.

[2] Kaganer, V. M., Jenichen, B. & Brandt, O. (2016) Phys. Rev. Appl. 6, 064023.

[3] Mihalache, I., Radoi, A., Pascu, R., Romanitan, C., Vasile, E., Kusko, M. (2017) Engineering graphene quantum dots for enhanced ultraviolet and visible light p-Si nanowire-based photodetector, ACS Appl. Mater. Interf. 9, 29234-29247.

[4] Romanitan, C., Kusko, M., Popescu, M., Varasteanu, P., Radoi, A., Pachiu, C. (2019) *J. Appl. Crystallogr.*, **52**, 1077-1086.

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