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Optical, Structural and Interface Characterization of Single SiO_2-SiC Core-Shell Nanowires Grown with a Low Cost Method

F. Fabbri*, F. Rossi*, G. Attolini*, G. Salviati*, S. Iannotta*, L. Aversa**, R. Verucchi**, M. Nardi**, N. Fukata***, B. Dierre****, and T. Sekiguchi****

* IMEM-CNR Institute, viale Usberti 37/A, 43124 Parma Italy
** IFN-CNR Institute, Via alla Cascata 56/C – Povo, 38123 Trento Italy
*** International Center for Materials Nanoarchitectonics, National Institute for Materials Science & PRESTO JST, 1-1 Namiki, Tsukuba, Ibaraki, 305-0044 Japan
**** Nano device characterization group, Advanced Electronic Materials Center, National Institute for Materials Science, 1-1 Namiki, Tsukuba, Ibaraki, 305-0044 Japan

Considerable efforts have been devoted in the last two decades to raise the light-emission efficiency in SiC-based systems. For instance, significant improvements have been made by using either porous or nano-sized cubic (3C) structures, where the optical emission increase is mainly attributed to either surface states or quantum confinement effects [1][2]. Such a luminescence enhancement would allow new applications in optical devices which are presently limited by the indirect SiC band gap and by its inherently low emission intensity. Due to its high biocompatibility, 3C-SiC is also a promising material for biomedical application [3]. A promising strategy to develop inorganic/organic optically active systems for biological applications is to coat the selected nanostructures with a silicon dioxide (SiO_2) shell.

In this work we report on the first solid experimental evidence of the enhancement of the 3C-SiC band edge luminescence induced by the SiO_2-shell in SiC/SiO_2 core/shell NWs. SEM-Cathodoluminescence (SEM-CL) spectroscopy is used to investigate the influence of the thickness of the amorphous SiO_2 shell on the optical emissions of the NWs. The occurrence of the shell-induced enhancement of the crystalline SiC core luminescence is experimentally demonstrated. HRTEM, Energy Filtered (EFTEM), High-Angle Annular Dark Field (HAADF) imaging, Energy Dispersive X-Ray (EDX) mapping, micro-Raman spectroscopy, and core level analysis by synchrotron radiation light are used to assess the structural and chemical properties of the NWs.

Figure 1a shows a typical plan-view SEM image of a NW bundle. The wires are several tens of microns long and have a quite narrow diameter distribution in the range of tens of nm.

Fig. 1b reports a zero-loss filtered image of a typical wire, showing the crystalline core and the coaxial amorphous shell.

Cathodoluminescence spectroscopy was performed on individual nanowires. A typical single-wire room temperature spectrum is presented in Figure 2. A broad band with a complex spectral shape due to the superposition of multiple emissions from the SiC/SiO_2 core/shell nanostructure is detected. Accurate Gaussian deconvolution is shown in order to identify and assign the different emission components.

In conclusion this work reports an accurate experimental study of the emissions from 3C-SiC/SiO_2 core/shell NWs. It demonstrates that the presence of the silicon dioxide shell enhances the silicon carbide NBE luminescence by the formation of a type I quantum well and the consequent diffusion of carriers from the larger band-gap shell to the narrower band-gap core.

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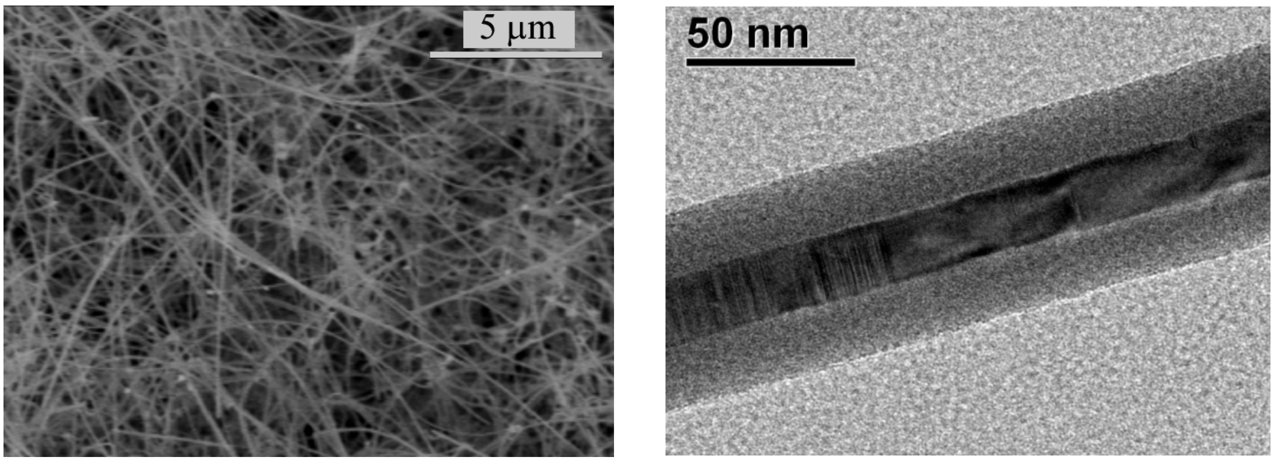

FIG. 1. (a) Secondary electron image of the typical ensemble of SiC/SiO_2 core/shell nanowires. (b)zero-loss image evidencing the SiC/SiO_2 core/shell structure

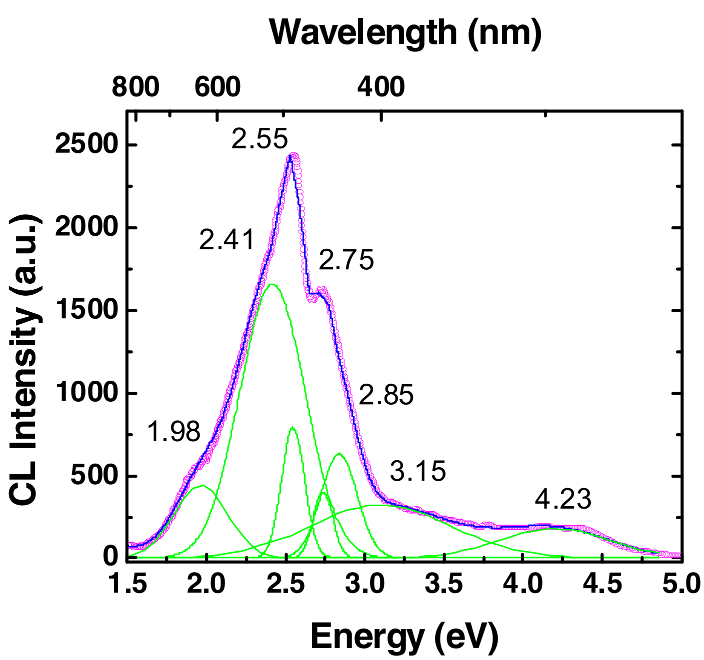

FIG 2. Typical room temperature cathodoluminescence spectrum of a single nanowire. Several sub-bands are identified by Gaussian deconvolution.

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