Transport properties of Au nanoparticle-VO_2 nanowire assembly

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We present electrical transport analysis for Au nanoparticle (NPs)-VO_2 nanowire (NW) assembly fabricated using ac dielectrophoresis (DEP) experiments. [1] Gold NPs of 10 nm radius are placed on the surface of VO_2 [100] NW of 210 nm x 120 nm rectangular cross section and 4 μm length. (See Fig. 1.) The number of Au NPs on the VO_2 NW surface is manipulated by varying duration, frequency, and bias voltage of the DEP processes.

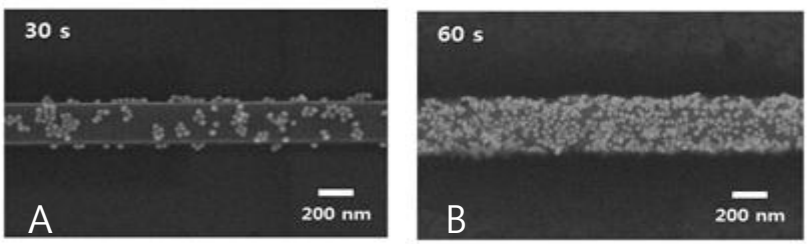

Figure 1 SEM images of DEP processed Au NP-VO_2 NW assemblies manipulated at 1 MHz and 2.5 V. DEP duration t = 30 s and surface density of Au NPs of 3.51 × 10^{10} cm^{-2} (panel A), and t = 60 s and Au NPs of 1.68 × 10^{11} cm^{-2} (panel B).

Under an external electrical bias, the nonlinear symmetric I-V characteristic, a signature of space-charge-limited transport, is observed and conductance oscillations prevail at 150 K. The current-voltage characteristic and channel conductance of an assembly with Ti/Au electrodes are illustrated in Fig. 2, respectively. We understand that the attached Au NPs act as dopant material providing mobile carriers to the semiconducting VO_2 NW forming a thin electron accumulation layer around the NW and that the carrier conduction occurs through the nanobelt around the insulating core of the VO_2 NW. The cross sectional area of the NW contributing to charge conduction is much reduced from the physical cross section of the NW. Observed plateau structures in the I-V curve and the oscillations in the corresponding channel conductance are analyzed with respect to quantum confinement-induced 2D subband structure of the nanobelt. [2] KSY acknowledges a partial support by a two-year grant from the PNU Research Foundation.

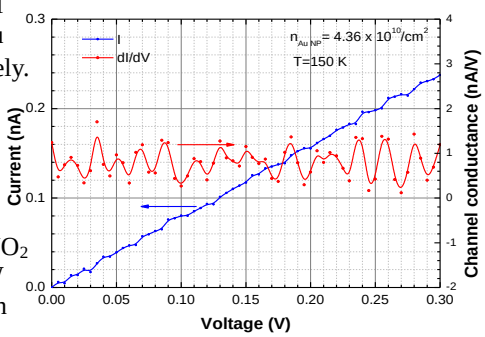

Figure 2 I-V characteristic and the corresponding channel conductance behavior as a function of source-drain voltage for the VO_2 NW at 150 K. The surface concentration of Au NPs was 4.36 x 10^{10} /cm^2.

[1] D. Cheon, S. Kumar, Gil-Ho Kim, Appl. Phys. Lett. **96**, 013101 (2010).
[2] K. S. Yi, K. Trivedi, H.C. Floresca, H. Yuk, W. Hu, M. Kim, Nano Lett. **11**, 5465 (2011).

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