Surface-controlled Transport Properties in 1D and 2D Nanocrystals

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We give an overview to the surface effects on electronic transport properties in the low-dimensional material systems. For one-dimensional (1D) systems, photoconduction (PC) properties are dominantly controlled by the surface depletion regions in group-III nitrides (e.g. GaN, InN, and AlN) and metal-oxide (e.g. ZnO, SnO_2, TiO_2, WO_3, etc.) nanowires. Electron-hole spatial separation and oxygen sensitization PC mechanisms are two major causes resulting in the several orders of magnitude higher PC gains and carrier lifetimes in the nanowires in comparison to their bulk counterparts. In addition, a remarkable thickness-dependent conductivity was generally observed in quasi-2D layer semiconductors such as MoS_2, $MoSe_2$, and WS_2. A probable higher surface conductivity and electron surface accumulation are proposed to explain the anomalous dimension effect.

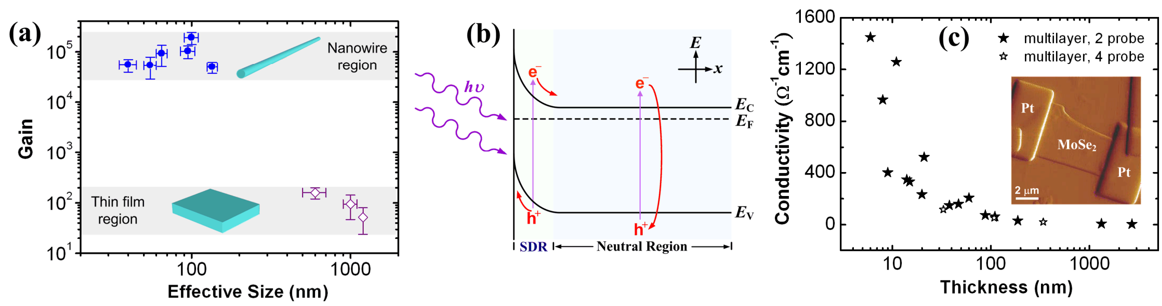

Fig. 1 (a) The photoconductive gain as a function of size for the GaN NWs (solid circles) and thin films (open diamonds) at 400 V/cm applied field and 4.0 eV excitation with 10–12 W/m^2 power density. The "effective size" is defined by the values of the NW diameter and the film thickness.[1,2] (b) The schematic band diagram shows the spatial separation and direct recombination of *ehp* in the SDR and neutral region, respectively.[3] (c) The electrical conductivities for the $MoSe_2$ multilayers with different thicknesses ranged from 6 to 2700 nm measured by two-probe (black solid star) and four-probe (black open star) methods. Inset: The AFM image of a $MoSe_2$ multilayer device with a thickness at ~60 nm fabricated by focused-ion beam (FIB) approach.

References

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