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Delta-Doping of Semiconductor Nanowires*

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Abstract

Recent breakthrough in growth of semiconductor nanowires [1-4] offers great opportunities to revolutionize technologies in electronics and spintronics. We believe that the key toward such potential applications is a clear understanding of the fundamental mechanism of doping in nanowires for manipulating carrier transport and signal processing. Traditional theory of electronic disorder predicts that doping in one-dimensional systems leads to carrier localization, limiting practical applications of nanowires because of poor carrier mobility. In this paper, we propose a novel concept, namely, delta-doping of nanowires, to control the carrier mobility. Different from the traditional doping, our approach features doping of a nanowire only on its surface. Our calculations based on Anderson models for a nanowire with surface disorder showed remarkably different results from the traditional doping where impurities are distributed inside the nanowire. First, carrier mobility becomes even better after dopant density exceeds a critical value. Second, there exists a transition energy level similar to the mobility edges in three-dimensional semiconductor materials. If the Fermi energy is below this energy level, the delta-doped nanowire is simply an insulator. But once the Fermi energy exceeds this energy level, the carrier mobility increases significantly. We believe this novel concept may find many important applications in future nanowire-based nanoelectronics and spintronics.

[1] A.M. Morales, and C.M. Lieber, Science **279**, 208 (1998).
[2] L.J. Lauhon, M.S. Gudlksen, D. Wang, and C.M. Lieber, Nature **420**, 57 (2002).
[3] Y.Y. Wu, R. Fan, and P.D. Yang, Nano Lett. **2**, 83 (2002).
[4] M.T. Bjork *et al*., Nano Lett. **2**, 87 (2002).

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