Single-electron Transport in Ultra-thin Gold Nanowires

Satoshi Moriyama[1*], Masanori Yoshihira[2], Yoshifumi Morita[3], Hoël Guerin[4], Yusuke Ochi[2], Hiroaki Kura[5], Tomoyuki Ogawa[5], Tetsuya Sato[2] and Hideyuki Maki[2]

[1] International Center for Materials Nanoarchitectonics (WPI-MANA), National Institute for Materials Science (NIMS), Tsukuba, Ibaraki 305-0044, Japan
[2] Department of Applied Physics and Physico-Infomatics, Faculty of Science and Technology, Keio University, Hiyoshi, Yokohama 223-8522, Japan
[3] Faculty of Engineering, Gunma University, Kiryu, Gunma 376-8515, Japan
[4] École Polytechnique Fédérale de Lausanne (EPFL), Nanoelectronic Devices Laboratory (NANOLAB), CH-1015 Lausanne, Switzerland
[5] Department of Electronic Engineering, Graduate School of Engineering, Tohoku University, Sendai, Miyagi 980-8579, Japan

* MORIYAMA.Satoshi@nims.go.jp

Abstract

Ultra-thin gold nanowires (AuNWs) with a diameter of a few nanometers have been produced by wet chemical synthesis. These AuNWs, which are difficult to realize with conventional lithography techniques, could be promising candidates for nanowire-based single-electron devices following carbon nanotubes and semiconductor nanowires. In this paper, we present the electron-transport data of an individual ultra-thin AuNW, which exhibits Coulomb blockade effects and spin splitting of single-particle states in magnetic fields.

Several techniques have been used to synthesize AuNWs in the last decade, and we employed wet chemical synthesis [1]. AuNWs with uniform diameters of 2 nm and lengths of up to 100 μm are synthesized via the reduction of gold (III) chloride in an oleylamine matrix and they are coating with oleylamine as a surfactant. The AuNW devices were fabricated on a highly doped silicon substrate with a SiO_2 top layer that was used as a back-gate insulator. Source and drain electrodes were patterned on the substrate. Then, a few droplets of the solution containing the AuNWs were drop-cast onto the substrate to connect the AuNWs to the electrodes. The electrical contact between an AuNW and an electrode was formed through a layer of oleylamine, which functioned as a tunnel barrier [2]. Low temperature transport measurements were carried out at ^{3}He cryostat. The experimental results reveal that the device acts as single-electron transistors in which the electrons though the quantum dots flow one by one. **Figure 1** shows the color scale plot of the differential conductance (dI/dV_{sd}) as a function of source-drain voltage (V_{sd}) and gate voltage (V_g) at 230 mK. Regular Coulomb diamonds such as triangle-shaped were observed. At the Conference, we will provide a detailed report of the transport characteristics of the AuNWs as QDs.

References

[1] H. Guerin, et al., Journal of Applied Physics **111** (2012) 054304.
[2] M. Yoshihira, et al., Applied Physics Letters **102** (2013), 203117.

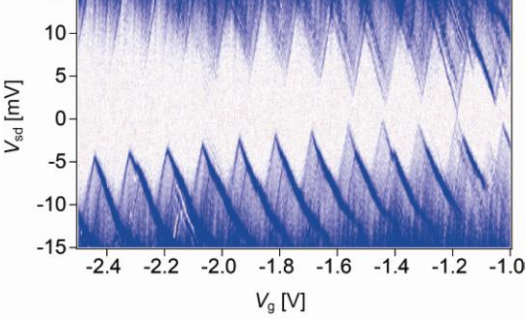

Fig. 1. A color scale plot of the differential conductance (dI/dV_{sd}) as a function of source-drain voltage (V_{sd}) and back gate voltage (V_g), measured at 230 mK.