Magnetotransport Properties of Single InAs Nanowires

°R. Kodaia[1]*, R. Horiguchi[1], P. Uredat[2, 3], M. T. Elm[2, 3, 4], P. J. Klar[2, 3], and S. Hara[1]

[1]Reseach Center for Integrated Quantum Electronics, Hokkaido University, Sapporo, Japan

[2]Center for Materials Research, Justus Liebig University, Giessen, Germany

[3]Institute of Experimental Physics I, Justus Liebig University, Giessen, Germany

[4]Institute of Physical Chemistry, Justus Liebig University, Giessen, Germany

*E-mail: kodaira@rciqe.hokudai.ac.jp

Vertical semiconducting nanowires (NWs) are of great interest for next-generation electronic, photonic, and spintronic devices. We have been demonstrating the synthesis of vertical ferromagnetic MnAs nanoclusters (NCs)/semiconducting InAs heterojunction NWs with atomically abrupt heterointerfaces between MnAs and InAs [1, 2]. Our heterojunction NWs can provide new possibilities and versatility in the creation of novel nanospintronic devices, e.g., spin-NW-transistors. To realize such novel nanospintronic devices, it is crucial to analyze fundamental magnetotransport characteristics of single MnAs/InAs heterojunction NWs and host InAs NWs without any MnAs NCs. In this paper, we report on magnetotransport and magnetoresistance (MR) characteristics of host InAs NWs on the basis of lateral device structures. We grew vertical InAs NW arrays by selective-area metal-organic vapor phase epitaxy on SiO_2-masked GaAs (111)B substrates. For the magnetotransport measurements, the single InAs NWs were separated from the GaAs substrates mechanically by ultrasonic vibration in isopropanol solution and deposited again on SiO_2/Si substrates. Electrical contacts were prepared using electron-beam (EB) lithography followed by thermal evaporation of Ti/Au (20 nm/200 nm) thin layers.

Figure 1 shows top views of scanning electron microscope (SEM) images of lateral single InAs NW devices. The electrical contact areas of NWs in Fig. 1 were treated by argon milling and Semico Crean 23 solution to etch off the native oxide on the NW surfaces. The length *L* and the diameter *d* of the NW in Fig. 1(a) are estimated to be approximately 1.7 μm and 120 nm, and those in Fig. 1(b) are approximately 8.3 μm and 200 nm, respectively. The InAs NW in Fig. 1(a) showed a positive MR effect reaching up to 30% at 20 K when the external magnetic field ***B*** was applied from 0 to 5 T perpendicular to the NW. The NW in Fig. 1(b), on the other hand, showed not only a positive but also negative MR effect and, in addition, universal conductance fluctuations in the range of ***B*** between 0 and 3 T. The observed different MR behaviors are possibly due to the differences in *L* and *d* and/or due to different native oxide conditions on the InAs NW surfaces. It is possible that the InAs NW surface is affected by the etching processes of the native oxide during electrical contact preparation, while the InAs NW surface areas beside the electrical contacts were covered with EB resists during the etching processes.

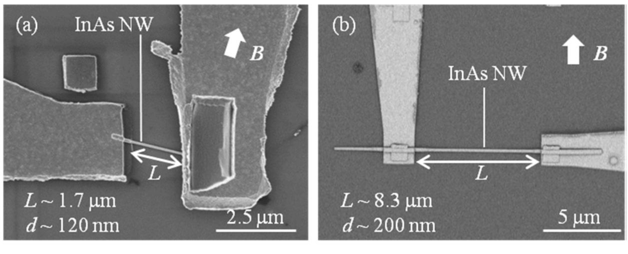

Figure 1. Top views of SEM images of the lateral single InAs NW device structures for magnetotransport measurements. The direction of the external magnetic field ***B*** and the length of the NWs *L* are indicated by thick and thin white arrows, respectively.

References: [1] R. Kodaira, *et al.*, JJAP, **55**, 075503 (2016); JJAP, **56**, 06GH03 (2017), [2] K. Kabamoto *et al.*, JCG, **464**, 80 (2017).