DOI: 10.1017/S1431927605500126
Microsc Microanal 11(Suppl 2), 2005

A Nanowire Produced by Electron Beam-Induced Deposition and Its Electric Properties

M. Shimojo*,**, M. Takeguchi*, R. C. Che*, W. Zhang* and K. Furuya*

* High Voltage Electron Microscopy Station, National Institute for Materials Science, 3-13 Sakura, Tsukuba, 305-0003, Japan.
** Precision and Intelligence Laboratory, Tokyo Institute of Technology, 4259 Nagatsuta-cho, Midori-ku, Yokohama, 226-8503, Japan.

Resistivity and related electronic properties of nanowires are of great importance, not only for the understanding of nano-physics but also for the application to novel electronic devices. It is necessary to place nano-wires at desired positions for the production of such devices. However, the fabrication of such nanometer-sized wires at desired position has been a major challenge. Several techniques have been proposed to produce nanometer-sized structures, such as mask deposition [1] and lithography [2]. Electron beam induced deposition (EBID) is one of the promising techniques to produce position-controlled nanometer-sized structures with high flexibility in their shape. It has been shown that free-standing nano-wires of less than 10 nm in thickness can be fabricated using an EBID technique [3, 4]. In this paper, we report the resistivity measurements of one individual nanowire produced by EBID.

A straight free-standing nanowire was fabricated at the apex of a tungsten needle tip by EBID with a metal-organic precursor, iron pentacarbonyl ($Fe(CO)_5$). The tungsten needle tip was prepared by standard electro-chemical etching. Electron-beam-induced deposition was carried out in the chamber of a field-emission-gun scanning electron microscope (JEOL JSM-7800UHV) operated at an accelerating voltage of 30 kV and a beam current of 8×10^{-10} A under a base pressure of 2×10^{-6} Pa. The precursor gas was introduced into the chamber through a nozzle with a 0.2 mm inner diameter. The tungsten tip with the nanowire and a copper substrate were placed on a piezo-driven specimen holder for a transmission electron microscope (TEM, JEOL JEM-3000F). The nanowire was approached and finally made contact with the substrate using the piezo-driven device inside the TEM under in-situ observation. AC voltages of 20 Hz were applied to the nanowire through a resistance of 1M-ohm, and the voltage between the tungsten tip and substrate was measured using a lock-in-amplifier to calculate the resistivity of the nanowire. A schematic illustration is shown in Fig. 1.

Figure 2 shows the nanowire with tungsten tip, contacting the copper substrate, observed in-situ in the TEM. Figure 3 shows the applied voltage, calculated current flown through the nano-wire, and resistivity of the nanowire vs. number of measurement. The resistivity was in a range between 0.1 and 1 when measuring with current below 10 nA. A decrease in resistivity was observed after flowing more than 100 nA, which is may be due to microstructural change caused by ohmic heating. These results indicate the potential of an EBID technique for producing conducting nanowires.

References
[1] K. Liu, et al., Appl. Phys. Lett. 81 (2002) 4434.
[2] K. Mibu, et al., Phys. Stat. Sol. (a) 189 (2002) 567.
[3] M. Shimojo, et al., J. Vac. Sci. Technol. B 22 (2004) 742.
[4] M. Shimojo, et al., Appl. Phys. A 79 (2004) 1869.

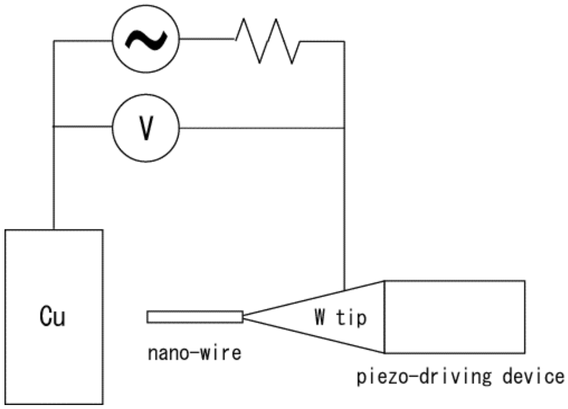

Fig. 1 Schematic illustration of resistivity measurements

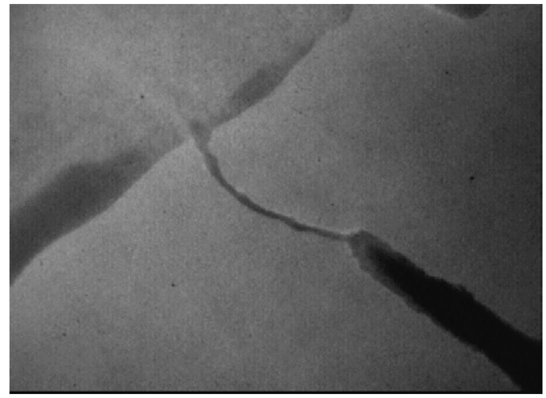

Fig. 2 In-situ observation of a nano-wire contacting a copper substrate

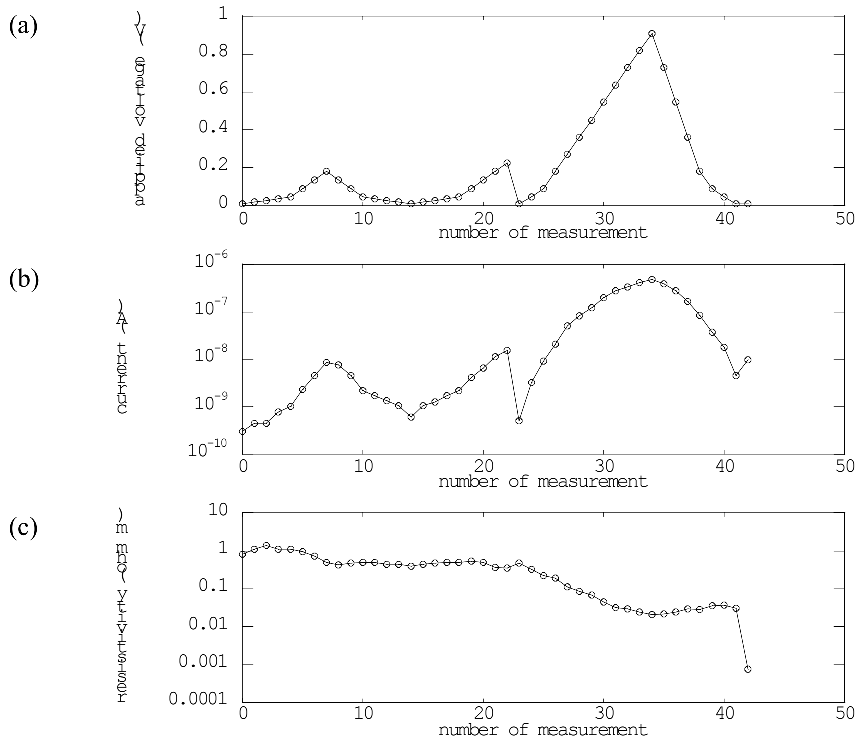

Fig. 3 Applied voltage (a), calculated current (b) and resistivity (c) of the nanowire

https://doi.org/10.1017/S1431927605500126 Published online by Cambridge University Press