The action of the grain boundary to the narrowing rate of gold nanowires by electromigration

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Electromigration has been widely studied as a technique for nanogap formation. Nanogaps less than 10nm in metal wires can be made by the use of electromigration inducing atom diffusion if current flow is well controlled. However, controllability in the scale of a few nanometers or less is not good enough yet. To resolve this problem not only by empirical way, analysis of narrowing and breaking process should be done in nanometer or atomic scale. In this work, in-situ transmission electron microscopy (TEM) was performed on electromigration of gold nanowires.

The gold wire made by photo and EB lithography on SiN membrane was set in TEM and current was flown. A typical TEM image of the gold nanowire is shown in Fig.1(a) where the wire width is about 6 nm. During the in-situ observation, the wire width in the upstream region of electron flow, oscillated randomly by time especially around grain boundary as recognized in Figs. 1(b) to 1(d). It seems that the grain boundary blocked atom flow, which located at most constricted point of the wire. The grain boundary may induce different flowing rate between inlet and outlet of atoms. Finally, a nanogap was formed around the grain boundary. The imbalance of atom flow is thought to be a possible reason of this tendency.

Fig. 1 (a): TEM image of gold nanowire where electrons flew from the top to the bottom. (b)-(d): Time evolution of the wire width corresponding to the arrows (b) -(d) in (a), respectively.