On growth technique of electromigration-based free-standing Al micro/nanowires

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Electromigration (EM) is a physical phenomenon of atomic transportation by electron wind force due to high density electron flow. EM causes the short and open circuit with forming hillocks and voids due to the accumulation and depletion of atoms in a metallic interconnect, deteriorating the reliability of metallic interconnects in electronic packaging. Various ways to propose countermeasure against EM have been reported.[1] Conversely, EM has been utilized as the next-generation growth technique of micro/nanowires.[2]

Micro/nanowire is a promising micro/nano-scale material for increasing device performance. For example, the sophisticated gas-sensor, nano-scale probe system, thermal device, and plasmonic device have been developed by micro/nanowires. However, the control method to generate micro/nanowires with desired shape is required. The EM-based growth technique (hereafter EM technique) for fabricating micro/nanowires has unique characteristics. The properties of wires grown by the EM technique are in single crystal, pure material and high-aspect ratio. In addition, the cross-sectional shape of wires can be controlled by changing the shape of a hole through which atoms are extruded. Recently, Kimura (2018)[3] reported the irregular bending of Al microwires, showing several shape types of wires of kinking, curve, and straight. The kinking can be prevented by higher growth rate and smaller wire diameter, but the fundamental mechanism of bending wire has to be required to obtain precise control method. In addition, it is necessary to pay attention to the structure of the thin film, which is the source of growing the wire, and this will determine the quality of the wire.

In this work, we introduce the growth technique of EM-based free-standing Al microwire, and examine the structure analysis of wire and films to sophisticate the EM technique. Specifically, scanning electron microscope, transmission electron microscope and energy dispersive X-ray were utilized to analyze the structure of thin films and fabricated microwires. A part of this work was supported by JSPS KAKENHI Grant-in-Aid for Scientific Research (B) No. 20H02026.

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