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ELECTROMAGNETIC PERFORMANCE OF SPIRALLY DEFORMED COATED NANOWIRES

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ABSTRACT

In this study, we demonstrated the spiral formation of the metal coated nanowires (NWs). The spiral formation is a self-deformation technique based on the residual stress of the thin film. The NW works as a conductive coil at a nanoscale. The fabricated coil has a diameter of approximately 1-5 μm and a high conductivity (~2.18×10^{6} /Ω·m). The conductive coil could be used for electromagnetic sensing according to the principle of electromagnetic induction. Specifically, it could be used for magnetic state observation and control at a nanoscale.

Keywords: core-shell structure, residual stress, stress relaxation, micro/nanocoil.

INTRODUCTION

Magnetic recording has become high-density and miniaturization. According to this, the local detection technique of electromagnetic properties at nanoscale becomes extremely high demand. Researchers have spent much effort to detect the magnetic properties at nanoscale, which resulted in the development of several devices (Haberle, 2010 and Vasyukov, 2013). For example, magnetic force microscope is a kind of scanning probe microscope, which detects the magnetic field of the sample surface using a magnetized probe. However, a quantitative measurement is sometimes difficult because the atomic force affects the detection results.

In this study, we demonstrated the spiral formation of the coated NW by self-deformation technique (Toku, 2010) based on the residual stress of the thin film. The metal coated NW spirally formed with high conductivity. The electrical and magnetic properties of the coil were investigated. The coil is possible to be used as an electromagnet to detect the electromagnetic properties of nanomaterials.

RESULTS AND CONCLUSIONS

Figure 1 shows an experimental procedure. Firstly, CuO or Al NW (Mingji, 2012) was placed on a micro cantilever using a manipulator (Fig. 1(a)). The NW was coated Cr or Pt thin film by sputtering device (Figure 1(b)). Finally, the sample was heated in Ar gas to induce creep deformation of the NW, which resulted in stress relaxation of thin film. This is possible because the melting temperature of the NW is lower than that of the coated material. As a result, the coated NW deformed spirally (Figure 1(c)). Figure 2 shows the scanning electron microscope (SEM) image of an example of the coil placed in Au electrodes. Fabricated coil diameter was found to be about 1-5 μm. Additionally, the current test was conducted. The best conductivity of the coil was estimated to be approximately 2.18×10^{6} /Ω·m, which was achieved using spirally deformed Cr/Al NW.

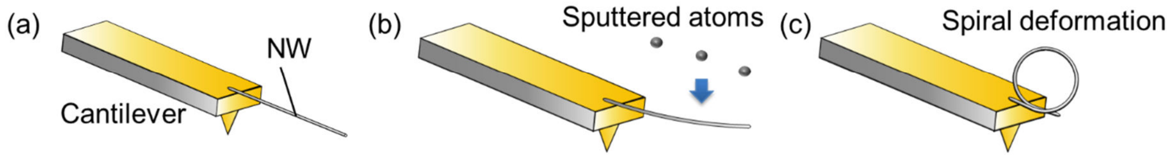

Fig. 1 - Schematic illustration of the experimental procedure: (a) The NW was placed on the micro cantilever; (b) Sputtering; (c) After heating.

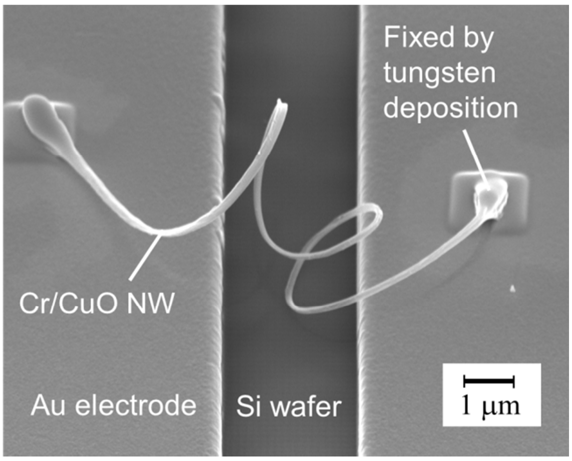

Fig. 2 - One of the coils in Au electrodes.

This value is extremely higher than the carbon microcoil which is reported as a conductive microcoil (Motojima, 2003). The conductive coil is expected to be an electromagnetic sensing device with high spatial resolution.

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