PA16

Electrical Properties of Planar-type Magnetic Tunnel Junction Covered with Insulating Layer

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Well-defined nanostructures of oxide can be fabricated on metal thin films by applying a negative bias on a conductive atomic force microscopy (AFM) cantilever. With using this technique, planar-type magnetic tunnel junctions have been fabricated [1]. Recently, magnetoresistance ratio above 100% at 16.3 K which strongly depended the bias voltage was observed in planar-type Ni/Ni-oxide/Ni magnetic tunnel junction [2]. Fig. 1 shows a Ni/Ni-oxide double tunnel junction based on a Ni strip thin film of 8 nm. A Ni strip of 50-200 nm width was patterned by electron beam lithography. Nanowires of Ni-oxide were fabricated by the AFM nano-oxidation. A diode characteristic was observed in current-voltage measurement at the temperature range of 17-300K. Fig. 2 shows a different structure of the double tunnel junction based on a 2-4 um NiFe strip patterned by photo lithography. In order to reduce the size of the junction, the AFM nano-oxidation was used for fabricating certain areas of NiFe-oxide. As a results a small NiFe electrode of "island" smaller than 100 nm*100nm was fabricated between the double junction. The diode was also observed in this structure, which suggested that the nanostructures of oxide exhibited insulating property. Both device structures of their size of 100 nm or less indicated in Fig. 1 and 2 were promising structures for ferromagnetic single electron transistors.

Surfaces of these planar device structures suffer exposure to air and humidity. In order protect the surfaces, we have developed a AFM nano-oxidation process for metal thin films covered with insulating cap layers. After patterning a stripe shape of NiFe thin film of 10 nm, Al layer was deposited on the surface, resulting in a formation of capped Al-oxide in air. The planar-type magnetic tunnel junction covered with the insulating layer was successfully fabricated.

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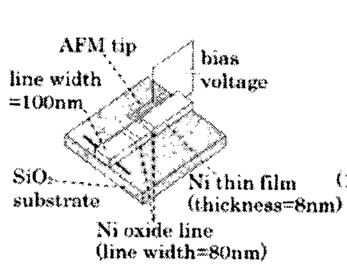

Fig. 1. Planar-type magnetic tunnel junction.

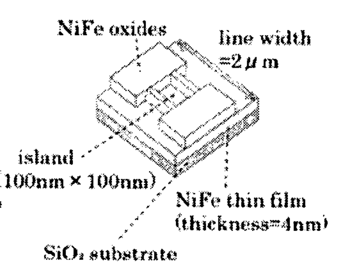

Fig. 2. Planar-type magnetic tunnel junction with a small iskand.

PB01

Optical Studies of Multiferroic Oxides

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The results of Raman-scattering and infrared reflectivity measurements of single-crystalline $(Tb_{1-x}Na_x)MnO_3$ (x = 0.0, 0.03, and 0.05) and $DyMnO_3$ are presented. At room temperature, several Raman-active phonons are observed, and their symmetries identified. The variations of lattice distortions due to Na doping or different rare earth Tb and Dy affect significantly both the phonon frequencies and linewidths. Moreover, the room-temperature optical conductivity spectra of all samples are typical of an insulator, showing only phonons in the far-infrared. With increasing Na concentrations of $TbMnO_3$, the linewidths of all infrared-active modes broaden, while the high-frequency optical absorption bands are robust. The temperature dependence of the lattice dynamics of these multiferroic oxides will be discussed.

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