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Structural analysis of Co/h-BN/Ni(111) using low-energy electron diffraction

Shen Zili [a] and Masahiro Sawada [b]

[a] *Graduate School of Advanced Science and Engineering, Hiroshima University*
[b] *Research Institute for Synchrotron Radiation Science, Hiroshima University*

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TMR devices used in magnetic read heads, magnetic memory (MRAM), magnetic field sensors, etc. have a ferromagnetic tunnel junction (MTJ) structure (ferromagnet/insulator/ferromagnet layers) whose interfacial structure and magnetic state are crucial for performance of the TMR effect. In this study, we focus on a junction structure using a single layer of hexagonal boron nitride (h-BN) as an insulator layer in the MTJ structures. Hexagonal boron nitride is chemically inert and can be used as a monoatomic barrier layer because of its insulating band gap of about 6eV, and its elastic chemical bond network of honeycomb structure has an advantage to uniform formation of monatomic films with few defects and pinholes. Furthermore, magnetic transition metals such as Ni, Co, and Fe are expected to form ideal epitaxial interfaces because of their good lattice matching with the h-BN honeycomb [1]. In order to utilize MTJ structures consisting of a single h-BN burrier layer as high-performance TMR devices, it is necessary to establish monatomic control of film fabrication and investigate their interfacial magnetism and interface structure. In a previous study [2], it has been shown that ultrathin Co layers two-dimensionally grown on h-BN/Ni(111) exhibit antiferromagnetic interlayer magnetic interactions between Co layer and Ni substrate, but their interface structures have not sufficiently been investigated.

In this study, we fabricated ultrathin films of Co grown on h-BN/Ni(111) and analyzed the interface structure in atomic-scale. Quantitative analysis of low energy electron diffraction (LEED) allows the atomic arrangement in the near-surface region to be determined with sub-angstrom accuracy, where the diffraction spot intensities are carefully measured as a function of the electron beam energy (LEED I-V). A numerical package [3] is used to determine the bast structural model reproduces the experimental LEED I-V, whose numerical calculation can simulate realistic LEED diffraction intensities by means of a multiple scattering model. The calculations for 1ML and 2ML-Co/h-BN/Ni(111) have provided best-fit structural models as shown in Figure 1. Parameters of interlayer distance are optimized for Co-BN and Co-Co layers. In both cases of overlayer thickness of 1ML and 2ML, the Co-BN distance (1.85Å and 1.88Å) are similar, indicating the stable atomic distances in the interface of Co/BN and no modification in the interfacial magnetic interaction between Co and Ni thorough a h-BN layer.

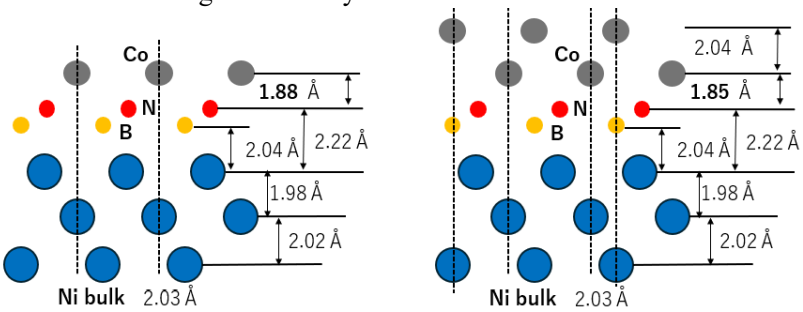

FIGURE1 Structure models for (a) 1ML and (b) 2ML-Co/h-BN/Ni(111) optimized by LEED I-V calculation.

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3. Barbieri/Van Hove STALEED and Phase Shift package