구두발표 II-1

Growth and Magnetism of virtually pristine Fe film on GaAs(100)

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Introduction

Fe film on GaAs(100) has been extensively studied as a representative system for ferromagnetic metal-semiconductor heterostructure. Because epitaxial growth of Fe film on GaAs(100) is achieved, due to the small lattice mismatch (~ 1.3%) between the double of the lattice constant of Fe and that of GaAs. Recently, the report of spin injection from the Fe film to GaAs substrate at room temperature have ignited renewed interest in this system as a superb candidate as a spin injection system for spintronic applications. However, the injection efficiency is still too low around several percentage range. The origin of such poor injection efficiency is attributed to the low spin polarization of the film and the interface, and high spin flip scattering cross-section. This is mainly caused by the notorious, historic problem of As and Ga out-diffusion from the substrate and their non-magnetic alloy formation.

In this talk, we will report the growth of kinetic stabilization of the pure Fe film on GaAs (100) at low temperature, ~120 K, and salient magnetic features of the pristine Fe film such as 1)magnetically alive Fe adjacent to the GaAs substrate, 2) unprecedentedly early onset of ferromagnetic order of the Fe film, and 3) perpendicular magnetic anisotropy of the Fe film that has never been observed before.

Experiment

Celan GaAs(100) sample is obtained via cycles of sputtering and annealing of the substrate. Clean GaAs(100) showed well defined 4x2 LEED pattern and no contaminants in photo-electron spectra. Fe film is deposited by an e-beam evaporator, and the thickness is monitored by a flux meter that is calibrated by both a quartz microbalance and surface x-ray reflectivity measurement.

The chemical structure of the Fe film and the interface is determined by high resolution photoelectron spectroscopy (PES) using synchrotron radiation. The morphological evolution and chemical structure of the Fe film is monitored by *in situ* real-time x-ray reflectivity study (XRR). Magnetic properties of the Fe film investigated by x-ray magnetic circular dichroism (XMCD).

Results and Discussion

PES finds exponential decay of As 3d intensity with the increasing thickness of the Fe film, indicating the suppression of the As segregation. The Ga 3d spectra also show the compound formation by Ga with Fe film of limited thickness less than 3 A. XRR also observes pristine Fe film on GaAs(100). The surface is however rough due to limited diffusion of Fe at the low growth temperature.

XMCD measurement finds that a 0.7 ML (monolayer) Fe film shows XMCD signal, which means that the Fe film is magnetically alive. For 1.2 ML Fe film, MCD signal is observed even at remanence, suggesting the inception of ferromagnetic order. But, the hysteresis curve is largely indicative of paramagnetic Fe film. For 1.7ML Fe film, however, clear MCD signal is observed at remanence. Hysteresis curve is of well-defined square shape, and shows perpendicular magnetic anisotropy (PMA). At 2.3 ML, spin reorientation transition from PMA to the in-plane anisotropy is observed.

PMA is widely observed in the early stage of magnetic thin film growth, due to the contribution of the surface anisotropy. However, the present report is the first that presents PMA for the Fe film on GaA surfaces. This is because the almost pure Fe film can be grown at low substrate temperature. It definitely tells that the compound formation by the out-diffused Ga and As plays a critical role for the magnetic properties of the film. Even for the present system, however, the SRT thickness is too low, and the orbital moment is not much enhanced for the Fe film showing PMA. The alloying with Ga, although minor, may still affect the magnetic properties of the Fe film, reducing the spin and orbital moment of the Fe film.