$Fe/Si/Fe$ 삼층막의 자기결합

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Magnetic coupling in $Fe/Si/Fe$ trilayer

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1 Introduction

Since the discovery of antiferromagnetic(AF) coupling between ferromagnetic layers across metallic, nonmagnetic spacer layers, there have been extensive experimental and theoretical works in this field. This oscillatory magnetic coupling has created widespread interest, due to the potential applications to magnetic and magneto-optics storage, and also to the unusual oscillation period. Many efforts have been focused on determining the spacer layer materials which show AF coupling and the structural-properties of the spacer layer that determines the periodicity of the coupling.

Toscano *et al.*[1] observed AF coupling in $Fe/Si/Fe$ trilayers grown at 40K by evaporation. Their result clearly demonstrates that for $t_{si} < 15$Å the Si layer is crystalline with either the B_2 or DO_3 structure. Extensive growth experiments suggest that crystallinity of the spacer layer is crucial for occurrence of the antiferromagnetic interlayer coupling.

2 Calculational Method and Results

Using the LMTO-ASA scheme, we have calculated self-consistently electronic structures and studied magnetic properties of $Fe/Si/Fe$ trilayer whose z-direction is (111) direction of $FeSi$ with B_2 phase. With the lattice constant of B_2 phase as reported by Kane *et al.*[2], we have obtained the electronic band structure of $FeSi$ which has $0.05eV$ band gap and a rather broad band (about $13eV$ width) with strongly mixed Fe and Si states. The ground state is paramagnetic in agreement with previous LDA results.

Next, we have investigated electronic structures $Fe/Si/Fe$ multilayers with varying the spacer layer thickness. It is found that the state with the wave vector parallel to the z-direction ($A-\Gamma$) do not disperse much , reflecting a two-dimensional nature of the $Fe/Si/Fe$ multilayer. It is also found that a pair of these localized states near the Fermi energy (E_F) move up across E_F with increasing two spacer layers. We have determined the band characters by examining the composition and the symmetry of each band.

Fe atoms on Si(111) have much reduced magnetic moment, because of the strong Fe-Si hybridization. The magnetic moment per Fe in $Fe/(Si)_3/Fe$ trilayer is $1.75\mu_B$, which is 80% of bulk. Overall amplititudes of the magnetic moment and the ferromagnetic exchange splitting are proportional to the inverse of the spacer thickness.

참고 문헌

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[2] H. von Kanel, K. A. Mader, E. Muller, N. Onda, and H. Sirringhaus, Phys. Rev. B45(1992)13807.