C-15

Effects of interdiffusion in interface on magnetic property of Co/InP system

Yong-Sung Park[1]*, Jong-Ryul Jeong[1,2], and Sung-Chul Shin[1]
[1]Department of Physics and Center for Nanospinics of Spintronic Materials, Korea Advanced Institute of Science and Technology, Daejeon, 305-701, Korea
[2]Cavendish Laboratory, University of Cambridge, JJ Thomson Avenue, Cambridge CB3 0HE, UK

The ferromagnetic metal/semiconductor (FM/SC) hybrid system has attracted great interest because their novel structural and magnetic properties provide fundamental studies in magnetism and offer possibilities for spintronic applications[1-3]. So far most investigations on FM/SC systems have been devoted to FM/GaAs, while a little study on FM/InP have been performed. III-V semiconductor InP has a direct bandgap energyand a high carrier mobility, and is used in optoelectronic devices for realizing low rectifying contacts[4]. In addition, InP has better properties in thermal conductivity, breakdown voltage, electron mobility and so on, compared with GaAs. Therefore, study on FM/InP system might provide possibility to new device applications.

In FM/SC systems it is significant to understand physical and chemical properties of interface regions between ferromagnetic metal and semiconductor, because these properties play critical roles in characteristics of spintronic devices. It was reported from some publications that interdiffusion between FM and SC has influence on their magnetic properties of FM in FM/SC hybrid systems such as Fe/GaAs and Co/GaAs[5,6]. As for InP, it is well known that Ion bombardment and Annealing (IBA) method makes InP surface clean and such an InP surface becomes indium-rich surface. In addition high annealing temperature induces to indium-droplets on InP surfaces. That is, IBA process of InP might inevitably lead to Indium-rich InP surface or InP surface with In droplets. Therefore, it might provide meaningful information to study how such indiums on InP has influence on magnetism of FM/InP.

In the present work, we observed surface morphology of InP, which were annealed at different temperature of 400 °C, 425 °C, and 450 °C in IBA processes, by scanning tunneling microscope (STM). Magnetic properties of Co films on theses InP surface were studied by Surface Magneto-Optical Kerr Effects (SMOKE) and Auger electron spectroscopy (AES) depth profile were performed to know how magnetic properties of Co/InP samples are affected by interdiffusion between Co and InP.

We compared STM images of surface of InP, which was annealed at 400 °C, 425 °C, and 450 °C in IBA processes. STM image of InP, which was annealed at 400 °C in IBA processes, shows that this InP surface is clean and has well-ordered InP (2×4) reconstructed surface. From STM results of InP surface which were annealed at 425 °C and 450 in IBA processes, we observed that higher annealing temperature induces indium droplets on InP surfaces due to preferential desorption of phosphorus. As temperature becomes higher, more indium-droplets are visible and size of indium-droplets become larger.

Co films were deposited on InP surfaces which were treated with such IBA processes. Longitudinal SMOKE measurements of Co/InP samples were performed at specific Co thickness. SMOKE results show that when InP was annealed at 400 °C, ferromagnetic hysteresis loop of Co/InP start to appear at Co thickness of 2 nm. However, when InP surface wes annealed at 425 °C in IBA processes, ferromagnetic signal is observed at Co coverage of 16 nm and as for InP which was annealed at 450 °C in IBA processes, ferromagnetic signal is not observed at Co thickness of 16 nm.

From AES depth profile results of these three samples, we observed that interdiffusion between Co and In is very active and is related to weakened magnetism of Co. Especially as for AES result of Co on InP, which was annealed at 450 °C in IBA processes, quantity of In is more than that of Co near surface of the sample and this means serious interdiffusion between Co and In.

In conclusion, we studied effect on magnetism of Co/InP systems which InP was annealed at different temperature in sputtering-and-annealing processes. It is observed from STM resultsthat more In droplets are produced, higher annealing temperature is in sputtering-and-annealing processes. These In dropletsstrongly interact with Co films and such an interdiffusion makes the magnetism of Co weak. AES depth profile results show serious interdiffusion between In and Co

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