S-2

GROWTH STRUCTURE AND STRESS-EVOLUTION STUDY OF EPITAXIALLY GROWN $Co_{35}Pd_{65}$ FILMS ON Cu/Si(001)

KAIST J.-R. Jeong*, S.-K. Kim, J.-W. Lee, and S.-C. Shin

$Co_{35}Pd_{65}$ 합금박막의 성장구조 및 응력변화에 관한 연구

한국과학기술원 물리학과 정종률, 김상국, 이정원, 신성철

I. INTRODUCTION

In this study, we have investigated growth stress and growth structure of CoPd alloy films using a submonolayer resolution stress measurement system in an ultrahigh-vacuum (UHV) chamber equipped with surface magneto-optical Kerr effects (SMOKE) system, reflection high energy electron diffraction (RHEED) facility, and scanning tunneling microscope (STM).

II. EXPERIMENT

All the experiments were carried out in an UHV chamber with the base pressure of 7×10^{-11} Torr. The pressure remained at better than 1.0×10^{-10} Torr during the deposition. $Co_{35}Pd_{65}$ films were prepared onto a 25 μm-thick Si(001) substrate fort stress and magnetoelastic coupling measurement. Co and Pd were co-evaporated from e-beam evaporator sources at ambient temperature. Si(001) substrates were cleaned chemically prior to their introduction in the chamber. The magnetoelastic coupling and growth stress of CoPd films were measured by high-sensitive laser deflection system using 1-dimensional position sensitive detector (PSD) in UHV chamber. Stress was determined from the change of the curvature(R) of substrate using the following equations :[1,2,3]

$$\sigma = \frac{Y_s t_s^2}{6(1-\nu_s^2)t_f}\frac{1}{R}$$

III. RESULTS AND DISCUSSION

Fig. 1 shows a stress evolution of $Co_{35}Pd_{65}$ /Cu(001)/Si(001) films. The negative slope indicates the compressive stress. A very large compressive stress in $Co_{35}Pd_{65}$ alloy layer could be observed at the beginning of alloy deposition. This compressive stress of 5.4 GPa can be simply understood from lattice mismatch argument, since the lattice constant of $Co_{35}Pd_{65}$ is larger than that of Cu(001). Lattice misfit stress of 6.3 GPa is expected from ideal coherent growth of $Co_{35}Pd_{65}$ on Cu(001), due to the misfit of 5.3% in the (001) matching planes of Cu and $Co_{35}Pd_{65}$ alloy. About 10% discrepancy between the experimental stress and the estimated misfit stress might be assigned to the effect of Cu(001) surface morphology. It is worthwhile to note that the film stress shows discontinuous stress relaxation at about 3 ML. In general, there are two possible mechanisms that cause stress relaxation in thin film growth, i.e., formation of misfit dislocations and 3D islands. In our samples, the observed stress relaxation at 3 ML CoPd alloy could be understood to be from partial relief of the misfit strain by the formation of 3D islands from the STM and RHEED results. Fig. 2 shows the STM image and RHEED pattern obtained after (a) 1.7 ML and (b) 5 ML alloy deposition, respectively. Fig. 2(a) clearly shows an overall flat second layer on top of first layer. This layer-by-layer growth mode proceeds up to a thickness of 3 ML. As the alloy coverage increases over 3 ML, the surface becomes rougher with higher island as shown in Fig. 2(b). The RHEED results also show a transition from layer-by-layer growth to island growth. The RHEED pattern obtained from 1.7 ML-thick alloy film as shown in Fig. 2(a). No large qualitative changes in the RHEED pattern are observed compare to the 1000-Å Cu/Si(001). However, as the alloy coverage increases over 3 ML, the RHEED pattern becomes into an elongated streaks as shown in Fig. 2(b) indicating that the growth of CoPd alloy was dominated by 3D island growth. Thus, it could be conjectured that the observed stress relaxation at 3 ML could be understood to be from partial relief of the misfit strain by the formation of 3D islands.

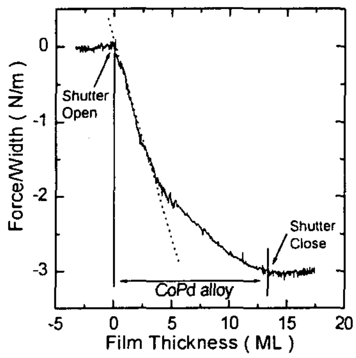

Fig. 1. Stress evolution during the growth of $Co_{35}Pd_{65}$ film on Cu/Si(001).

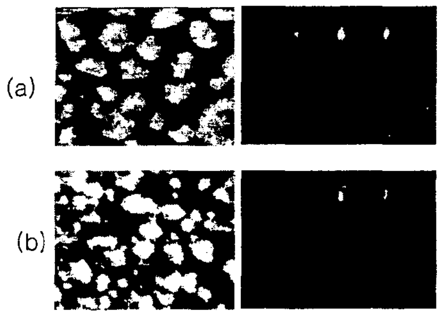

Fig. 2. STM image(10nm×10nm) and RHEED pattern obtained from (a) 1.7-ML $Co_{35}Pd_{65}$/1000-Å Cu/Si(001) and (b) 5-ML $Co_{35}Pd_{65}$/1000-Å Cu(001)/Si(001).

IV.ACKNOWLEDGEMENT

This work is supported by Korean Ministry of Science and Technology through Creative Research Initiatives Project.

V. REFERENCES

[1] B. Schulz and K. Baberschke, Phys. Rev. B, **50**, 13467 (1994).

[2] J.-R. Jeong and S.-C. Shin, Appl. Phy. Lett., **75**, 3174(1999).

[3] D Sander, Rep. Prog. Phys., **62**, 809 (1999).