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Spontaneous morphological change from thin film to nanodots in metallic alloy films examined by GISAXS

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Introduction

Controlling microstructure / nanostructure during heat treatment is an important method to provide functional composite materials cost-effectively in large scale. Among them, preparation of metallic nanodots without lothographic techniques has potential importance for magnetic nanodots. It was found that codeposition of multicomponent metallic sources may lead to a well-defined nanodot microstructures, either by a morphological change from an initially uniform thin film into spatially separated nanodot structures, or in-situ phase separation during deposition. In the present report, we examined temporal evolution of Fe-based ternary thin alloy films during annealing in an intermediate level of vacuum. In-situ examination of such morphological evolution is important to know the key factors that control the size and morphology during the process.

Experimental

Thin alloy films were deposited onto Si substrates with an insulation layer. The nominal thickness of the alloy layer was about 2 to 3 nm. Since the alloy composition is an important factor that determines the transformation path during heat treatment, the composition of the alloy film was measured by Rutherford Backscattering yeild of He2+ operated at 2MeV. In-situ GISAXS measurements were performed at beam-line 15A of Photon Factory, with an in-situ grazing-incidence hearing stage evacuated by a turbomolecular pump. After adjusting the grazing incidence angle, the sample was heated upto the annealing temperature, and the change in the GISAXS intensity was recorded by a II-CCD detector.

Table 1: Composition of the alloy film determined by Rutherford Backscattering yield.

Elements	Fe	Pd	Cu
Composition (%)	26	29	45

Results and Discussions

The alloy composition of as-deposited ternary film is shown in Table 1. As shown in Fig.1, the RBS yield of He2+ ontained for the sample gave a well-defined composition of the starting film. The RBS spectrum obtained for the samples are shown in Fig.1. During aneealing the sample in-situ, the GISAXS intensity gradually increased both for SAXS part and the diffuse scattering around specular spot. The size of the nanodots was found to increase gradually even during heating to the annealing temperature. A sluggish coarsening was found after the growth as shown in Fig. 2.

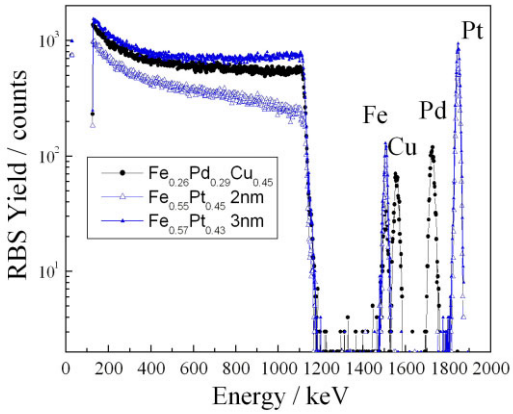

Fig.1 RBS spectrum of the alloy layer obained from 2 MeV of He++. The alloy composition was determined from the yield.

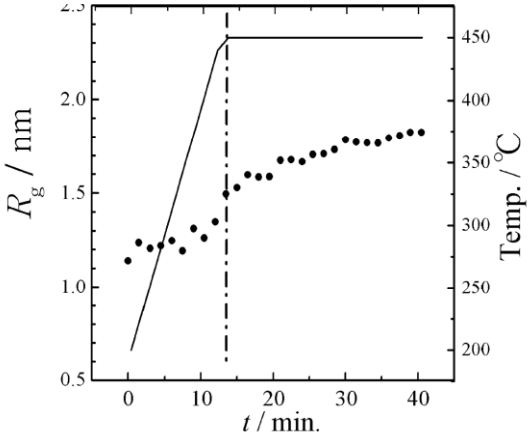

Fig.2 Temporal evolution of the size of self-organized nanodot and the temperature of the substrate.

References

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