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Phase Transformation and Physical Properties of Al N-Co Film†

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Annealing techniques were applied to induce phase transformations and phase separations in Al N-Co thin films with various Co contents and Al N-Co multilayer thin films with various layer-thicknesses were prepared by a two-facing-target type DC sputtering system. X-ray diffraction and electron diffraction techniques were used to examine the behaviour of phase transformations and phase separations. The transmission electron microscopy was also used to evaluate the microstructure changes in the films. Magnetization and resistivity of the films were evaluated by vibration sample magnetometer and four-probe method respectively. It was found that magnetization and resistivity were sensitive to the phase transformations and phase separations as well as the changes in the microstructure of the films.

Key Words: Phase transformations, Al N-Co thin films, Al N-Co multilayer thin films, Microstructure, Magnetization, Resistivity.

INTRODUCTION

It is well known that the properties and performance of polycrystalline materials including polycrystalline thin films, are strongly affected by their microstructures. Therefore, when one forms valuable phases in these films, it is necessary to quantify the crystal structure of reactants or product phases and to evaluate their natures during reaction. Continuing experimental and theoretical interest in such phase formations in polycrystalline thin films is driven by the importance of these reactants in technological applications. The formation plays an important role in metallization schemes in micro-electronics. In many applications, in addition to determining the thickness and identity of the product phases, it is becoming increasingly necessary to specify the grain structure.

For high frequency devices, high resistive metal films possessing a very fine two-phase hetero-amorphous structure have been studied. A magnetic granular system, where magnetic particles are embedded in an insulator matrix, has also been studied[1,2]. Moreover, multilayer films showed better soft magnetic properties than monolayer films[3]. An ideal high-density recording magnetic material must have high permeability, high electrical resistivity and large saturation magnetization coupled with low energy loss and also a high corrosion resistance. This is why we used AlN as a highly resistive and high corrosion resistant insulator matrix and Co as magnetic panicles embedded or dispersed in that matrix.

EXPERIMENTAL

An Al (99.95 % pure) was used as an upper target while a composite target of Al (99.95 %) and Co (99.98 %) with different area fractions of Co[Co/(Al+Co)=TAF] was used as a lower target[4,5]. The microstructure of prepared films was examined by X-ray diffraction and electron microscopy observations. Atomic percentage of the contents of the films was checked by energy dispersive spectroscopy. Magnetic and electrical properties were measured by a vibration sample magnetometer (VSM) and the four-probe method, respectively. All the measurements were performed at room temperature.

RESULTS AND DISCUSSION

Anneal-induced crystallization and phase formations in amorphous films very fast change the microstructure of the films. As a result, physical properties also fast change. We have got the results of the structure characteristics and related magnetic and electric properties observed after heat treatments for Al N-Co monolayer and multilayer thin films.

Conclusion

Anneal-induced microstructure evaluation as well as phase formation and phase transformation in Al N-Co monolayer films Al N-Co multilayer films were studied by using TEM and XRD. And their magnetic and electric properties were examined by vibration sample magnetometer and four-probe

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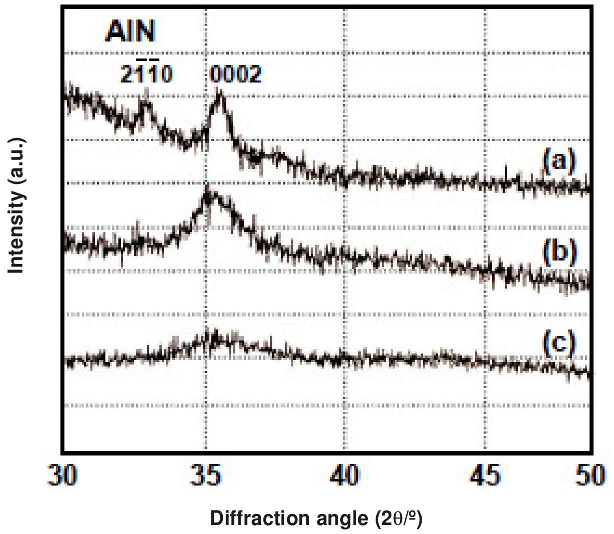

Fig. 1. XRD profiles of as-deposited films containing Co at % of (a) 10, (b) 20 and (c) 25

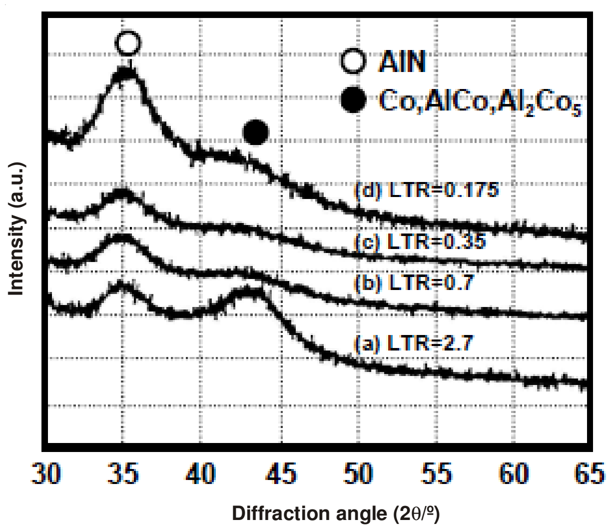

Fig. 2. XRD profiles of as-deposited films with different LTRs

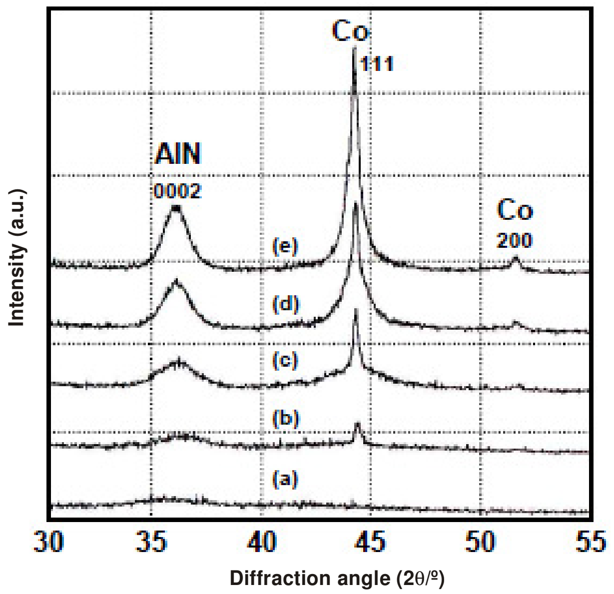

Fig. 3. XRD profiles of Al-Co-N films (25 at % Co); (a) as-deposited and (b), (c), (d), (e) annealed at 673 K, 773 K, 873 K, 973 K for 10.8 ks

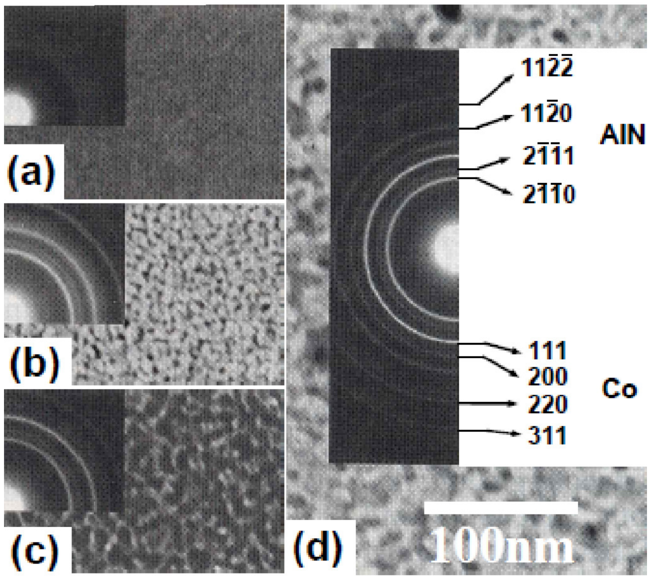

Fig. 4. TEM images and SAED patterns of Al-N-Co films (25 at % Co); (a) as-deposited and annealed at (b) 773 K, (c) 873 K and (d) 973 K for 7.2 ks

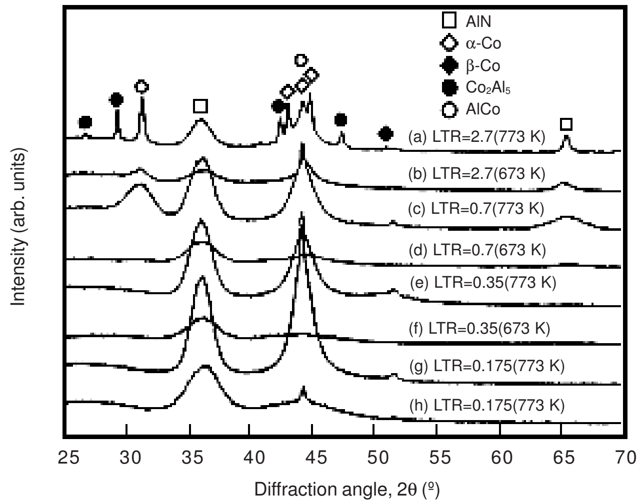

Fig. 5. Typical XRD profiles of films with different LTRs, annealed at different temperatures for 120 ks

method, respectively. It was found that as-deposited films show amorphous-like behaviour and are incompatible for any potential practical uses. Anneal-induced phase formation and phase separation allow us to tailor specific microstructures to have favourable properties in the films for a potential practical use.

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