Fe₃O₄/CdS Multi-Layered Films Synthesized from Aqueous Solution

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Abstract: Fe₃O₄/CdS multilayered films were prepared from aqueous solution at 80°C on glass substrates, combining the ferrite plating using aqueous solutions of FeCl₂ and NaNO₂ with a chemical synthesis of CdS using those of CdCl₂ and CH₃CSNH₂. The saturation magnetization of the Fe₃O₄ layers decreased as their thickness decreased (from 1600Å to 320Å), possibly indicating a decrease in magnetization in surface, or intersurface layer.

1. INTRODUCTION

The ferrite plating facilitates synthesis of oxide ferromagnetic films from an aqueous solution [1], and a chemical process is reported by which such II-VI sulfur semiconductors as CdS and PbS are synthesized from an aqueous solution [2]. Combining the two chemical aqueous processes, we have successfully synthesized in this study ferrite/CdS multilayer films in a reaction cell [3]. To our knowledge, chemical aqueous syntheses of semiconductor/ferrite multilayers have not yet been reported, though metal multilayers, as of CoNiCu/Cu [4] and Co-Cu [5] for the purpose of GMR head application, have been synthesized by electroplating.

Our novel type of the ferrite-semiconductor multilayers described here will be useful for studying the magnetic characteristics of the initial layers in the ferrite plating.

2. EXPERIMENTAL AND RESULTS

The ferrite and semiconductor layers were alternately deposited on glass substrates (18x18x0.15mm³) at 80°C by "thin liquid film" method [6] in a reaction cell made of stainless steel. For the ferrite synthesis, a reaction solution (pH=6.8) of FeCl₂+CH₃COONH₄ (pH buffer) and an oxidizing solution of NaNO₂+CH₃COONH₄ (pH buffer) were mixed at the inlet of the reaction cell to flow along the gap (0.5mm) between the substrate and the cell wall. For the semiconductor synthesis, aqueous solutions (pH=7.0) of CdCl₂ and CH₃CSNH₂ were mixed to flow along the gap.

As examined by X-ray diffractometry, the ferrite layers were polycrystalline with single phase spinel (Fe₃O₄) structure having no crystallographic preferential orientation. The semiconductor layers were polycrystalline with hexagonal CdS structure having (002) preferential orientation, though we could not definitely deny the existence of cubic CdS phase whose strongest (111) scattering line superimposes the (002) line of hexagonal CdS phase.

As Fig.1 shows, we made three multilayers composed of one, two, and five Fe₃O₄ layer(s); 0.16, 0.08, and 0.032µm in thickness, respectively; which were intermediated and sandwiched by CdS layers. The total thickness (synthesis time) of the Fe₃O₄ layers in every multilayer was made of the same value, 0.16µm (30min). Each CdS layer was synthesized for 30min to get 0.1µm in thickness; an SEM observation (Fig.2) revealed that ~20min was required to obtain a continuous CdS layer.

The CdS layers transmit light with wavelength shorter than ~530nm, as shown in Fig.3.

As Fig.4 shows, the saturation magnetization per unit mass of Fe in the Fe₃O₄ single layer (0.16µm in thickness, sandwiched by CdS layers), is practically equal to the value (shown by dotted line) reporter for bulk Fe₃O₄ samples. However, the magnetization decreases as the number (thickness) of the layers increases (decreases), reaching to ~55% of the bulk

sample value in the thinnest (320Å) layers. This may be indicating a decrease in magnetization in initial, or intersurface, layers of the ferrite plating.

3. CONCLUDING REMARKS

Combining the ferrite plating with a chemical aqueous synthesis of CdS, we have successfully prepared ferrite/semiconductor multilayers for the first time. The ferrite, or Fe_3O_4 , layers decrease in magnetization, probably due to decrease in magnetization in initial layers.

References

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Fig. 1 Multilayered films prepared in this study.

Fig. 3 Optical transmittance spectra of a CdS film 0.2μm in thickness.

Fig.2 SEM observation of CdS films prepared for (a) 10min, (b) 20min, and (c) 30min.

Fig. 4 Saturation magnetization (per unit mass of Fe) of $\text{Fe}_3\text{O}_4/\text{CdS}$ multilayered films, vs. the number of Fe_3O_4 layers.