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# New macroscopic ferrimagnet in the system Co-TbN

Taewan Kim* and Sung-Chul Shin
Department of Physics, KAIST

## I. INTRODUCTION

Macroscopic ferrimagnets are a new class of phase separated magnetic materials which have been recently discovered.[1] The macroscopic ferrimagnets consist of magnetic phases with a negative magnetic exchange at the phase boundary. The term "macroscopic ferrimagnet" was adopted to distinguish them from ferrimagnets in which the antiferromagnetic exchange couples individual atoms. A prototypical example is the Co-EuS system which has 10 nm particles of EuS in a Co matrix. It has been found that these materials display unusual magneto-optical[1] and magneto-transport[2] properties. A new macroscopic ferrimagnet, Co-TbN, was proposed in this study. The Co-TbN system has TbN precipitates in a Co matrix. The TbN precipitates provide the higher Curie temperature and thus stronger exchange coupling with the Co matrix than EuS, which are caused by conduction electron mediated exchange of the RKKY type. Therefore, the improved magneto-optical and magneto-transport properties can be expected in the Co-TbN system.

## II. EXPERIMENTS

Amorphous $Tb_xCo_{1-x}$ thin films were prepared by facing target magnetron sputtering with a composite target. The film compositions were controlled changing the Ar sputtering gas pressure (5 ~ 15 mTorr). Nitrogen was introduced into amorphous TbCo thin film by annealing at 400 and 650 °C for 12 hours with a continuous flow of 10 % $H_2$-balance $N_2$ gas mixture in order to induce the phase separation of Co and TbN. Phase analysis was made with x-ray diffraction and with secondary electron images on a field emission SEM. Magnetization and magnetization vs temperature were made in the temperature range –100 to 400 °C up to 13 kOe fields using a vibrating sample magnetometer (VSM) and in high field up to 30 kOe were measured at temperature from 20 K to 300 K using a SQUID magnetometer.

## III. RESULTS AND DISCUSSION

Fig. 1 exhibits the saturation magnetization and coercivity changes as a function of temperature in the Co-TbN film with the composition of 32 % TbN, which are typical for the Co-TbN macroscopic ferrimagnets. The saturation magnetization curve shows a small break at about 150 °C in the center, which suggests two different magnetic phases with different Curie temperature in the macroscopic ferrimagnet. Fig 2 shows that the increase in magnetization with temperature and the broad minimum in magnetization in a field of 1 kOe are clear indications of the ferrimagnetic behavior of Co-TbN. The small jump in the magnetization curves in the fields of 10, 20 and 30 kOe at 50 K indicate that at these high fields the magnetic moments of TbN precipicates are ferromagnetically alligned with the Co matrix. The Curie temperature of TbN can be estimated as about 75 K by extrapolating from the break in the magnetization curve at 30 kOe field.

## IV. CONCLUSION

The new macroscopic ferrimagnet, Co-TbN, consisting of TbN precipitates in a cobalt matrix, demonstrated typical macroscopic ferrimagnet property which is a magnetic compensation point. It was suggested that the magnetization processes at low and high temperatures takes place by a different mechanism. The magnetization decreases with decreasing temperature in 1 kOe which indicated that the TbN magnetization and/or the ferromagnetic exchange coupling at the phase boundary increase with decreasing temperature.

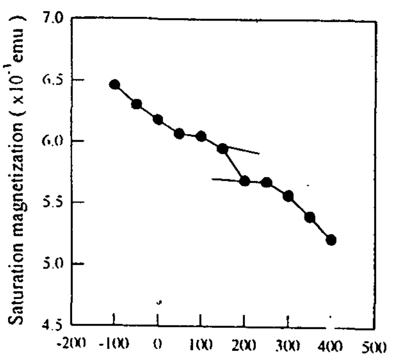


Fig. 1 The saturation magnetization change with temperature

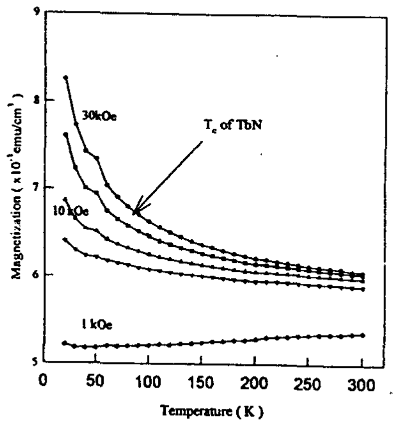


Fig. 2 Magnetization of Co0.68-(TbN)0.32 with temperature at various applied fields

## V. REFERENCES


[1] R. J. Gambino, R.R. Ruf and N. A. Bojarczuk, J. Appl. Phys. 75, 1871(1994)

[2] R. J. Gambino, J. Wang and T. R. McGuire, IEEE Trans. Magn. 31, 3915(1995)