V-2

RF NOISE SUPPRESSION ON COPLANAR TRANSMISSION LINE USING LOSS GENERATION OF THE SOFT MAGNETIC FILMS

Research Institute for Electrical Communication, Tohoku Univ., Japan — Ki Hyeon Kim, Shinji Ikeda, Masahiro Yamaguchi, Ken-Ichi Arai

The Research Institute for Electric and Magnetic Materials, Japan — Hideaki Nagura, Shigehiro ohnuma

Introduction

Recently, a countermeasure for the electromagnetic noise emission on RF integrated transmission line using the loss generation of ferromagnetic thin films is briefly suggested [1,2]. Without the magnetic film, the noise harmonics of the signal pass through the transmission line with only a little attenuation. The ideal role of magnetic film is not to raise insertion losses in the pass-band and to give as large attenuation as possible to eliminate the noise harmonics at the stop-band, the frequency range higher than the meaningful signal as shown in Fig. 1. and Fig. 2.

We systematically studied here the RF electromagnetic noise attenuation using the various types of soft magnetic films (CoPdAlO, CoZrO and CoNbZr) on the transmission line.

Experimental

The coplanar transmission line with characteristic impedance of 50 Ω is designed with 50 μm width of signal line and 3 μm thickness on the 7059 corning glass (permittivity, $\varepsilon_r = 5.84$) substrate. The Cu transmission lines are deposited by electroplating method. The amorphous $Co_{85}Nb_{12}Zr_3$, $Co_{67}Zr_8O_{25}$ and $Co_{53.4}Pd_{19.4}Al_{8.1}O_{18.1}$ magnetic films and non-magnetic Cu film are deposited by rf magnetron sputtering on the glass substrates, respectively, separating from transmission line. In order to align the direction of spins and increase the magnetic anisotropy field (H_k), magnetic films are annealed at about 300°C during 1 hour with external magnetic field (~ 3 kG) after patterning with the size of 2 mm × 15 mm using ion milling. The electric performance is measured with two GSG (Ground-Signal- Ground pins) type wafer probes mechanically touched at the left and right most ends of the transmission line using HP 8720D network analyzer from 0.1 GHz to 20 GHz.

Results and Discussion

The saturation magnetization ($4\pi M_s$) of the CoNbZr, CoZrO and CoPdAlO films are about 10 kG and in-plane magnetic anisotropy field (H_k) is 6.8 Oe, 89 Oe and 230 Oe, respectively.. The ferromagnetic resonance (FMR) frequency of the film exhibits about 0.7, 2.6 and 4.3 GHz, respectively. Fig. 3 shows the experimental and simulated values of transmission s-parameter (S_{21}) and power loss on the coplanar line with the increment of the CoNbZr magnetic film thickness in comparison with that of without magnetic films and non-magnetic metal. The S_{21} is attenuated entirely due to eddy current loss as increasing thickness of the magnetic films. The experimental qualitative attenuation due to FMR is well matched with simulated values. And the tendency of attenuation is changed at a specific frequency region, which is related with the loss generation of FMR. The dip points in signal attenuation are determined by the FMR frequency, which is governed by the natural FMR frequency and the demagnetizing effects with the change of effective dimension of magnetic films. Fig. 4 shows the values of transmission parameter (S_{21}) of the coplanar transmission line with the different magnetic films. Among these films, the slope of attenuation and FMR loss is more significant on the CoPdAlO film. As a result, the noise suppression can be tuned signal frequency and the magnitude of attenuation by controlling the dimension of the magnetic film with the relation for demagnetizing factors as well as eddy current loss and the FMR loss generation. As a result, the soft magnetic film is well applicable to the rf noise suppression in comparison with the nonmagnetic film and without magnetic film.

Acknowledgement

This work was supported in part by the Japan-Korea Basic Scientific Cooperation Program (JSPS: Development of thin film inductive devices operating in GHz frequency range), Telecommucations Advancement Organization of Japan (Development of high performance electromagnetic wave absorber by nano structure-controlled thin film material) and Ministry of Education, Culture, Sports, Science and Technology (Development of micromagnetic technology using room-temperature fabricated highly insulative ferrite films.).

References

1. Masahiro Yamaguchi, Ki Hyeon Kim, Takashi Kuribara and Ken-Ichi Arai, IEEE Trans. Magn., **38(5)**, 3183-3185 (2002)

2. S. Yoshida, H. Ono, S. Ando, F. Tsuda, T. Ito, Y. Shimada, M. Yamaguchi, K.I. Arai, S. Ohnuma, T. Masumoto, IEEE Trans. Magn., 37, 2401, (2001)

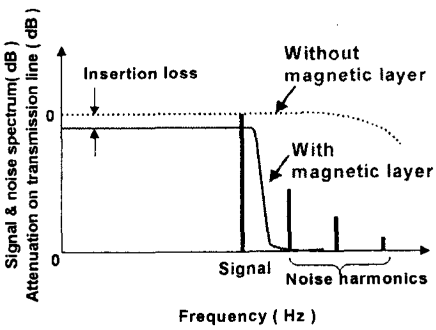
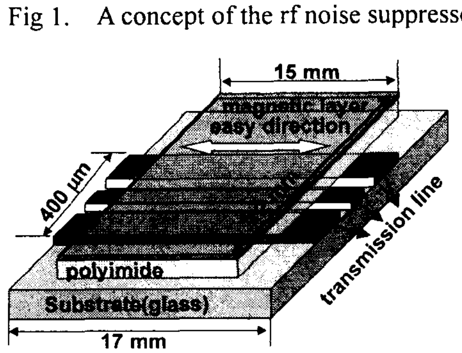


Fig 1. A concept of the rf noise suppressor



2. A schematic of the rf noise suppressor

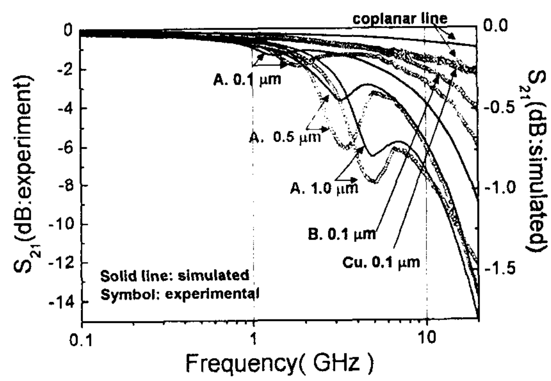


Fig. 3. The measured and simulated S_{21} values in comparison with the nonmagnetic film and without magnetic film

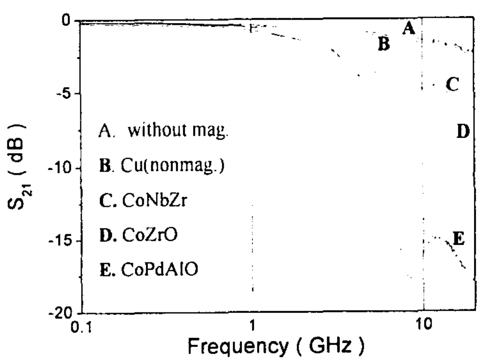


Fig. 4. The Comparison of the S_{21} values for CoNbZr, CoZrO and CoPdAlO magnetic films.