Electromagnetic analysis of FMR performance on multilayered Co-Zr-Nb film integrated on MSL

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1. Introduction

A new method for noise suppression using magnetic film was proposed. With this magnetic film implemented with RF IC chip, good noise suppression was demonstrated [1]. In order to understand the mechanism of this magnetic film, this paper discussed the IC chip level noise suppressor model consisting of MSL (microstrip line) covered with a multilayered Co-Zr-Nb film on the top by using a finite element method full wave electromagnetic simulation.

2. Approach

Fig. 1 shows a simulation model of a MSL covered with a magnetic film on the top. The signal line was 160 μm wide and 20 mm long. The magnetic film was 10×10 mm in sizes and set 10 μm above the singal line of MSL. The film was composed of a stack of SiO_2 (50 nm) / [Co-Zr-Nb (250 nm)/Air (5 nm)] ×4 and the film's easy axis (e.a.) was set running parallel to the length direction of MSL (hereafter MSL//e.a.). The full wave electromagnetic simulation model (HFSS, Ansys Co) had the same structure and dimension of MSL and magnetic film as experiment we have done before[2]. The model area is noted as the part in the dotted line in Fig. 1.

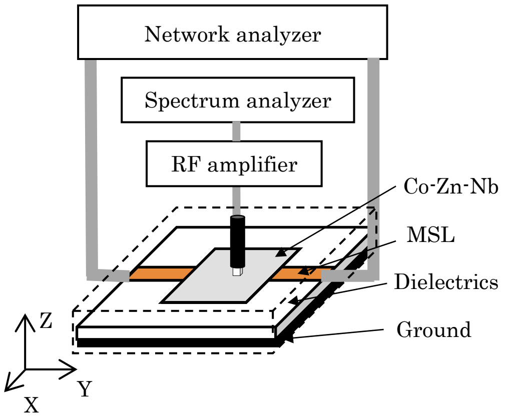

Fig. 1 Experimental setup: magnetic film 10 μm above the MSL with input power -5 dBm.

3. Results and discussion

Fig. 2 shows the calculated and measured results. They agreed in both magnetic near field probe output and conduction losses P_{loss}/P_{in} ($P_{loss}/P_{in} = 1 - (|s_{11}|^2 + |s_{21}|^2)$) . At 1.1 GHz the shielding effectiveness became the highest. Compering with blank (without film), a 16 dBm near field intensity dip was observed. The peak of conduction noise suppression P_{loss}/P_{in} was in 2 GHz which should include magnetic and eddy current losses, indicating that FMR frequency shifted to 2 GHz and led to the peak of P_{loss}/P_{in}. The demagnetization factor N_d was determined by the shape of magnetic film where the effective film's length l_{eff} depended on the film relative permeability μ. That was $(1/N_d) \propto l_{eff} \propto \mu$. Therefore FMR frequency $f_{rd} = \gamma/(2\pi)\sqrt{(M_s(H_k + N_d M_s)/\mu_0}$ [3] depends on the frequency profile of permeability. In simulation we calculated the effective film length l_{eff} and corresponding FMR frequencies as shown in Fig. 3. The calculated FMR frequencies were around 2 GHz and approximately independent of the frequency profile of the permeability.

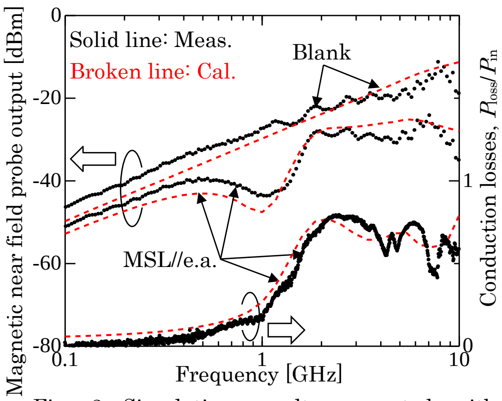

Fig. 2 Simulation results competed with experiment results: magnetic near field probe output and conduction losses P_{loss}/P_{in}

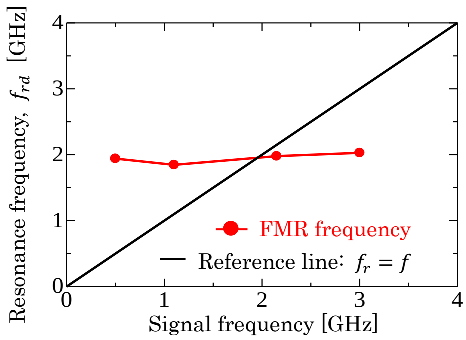

Fig. 3 Calculated FMR frequency f_{rd} in each signal frequency

4. Conclusion

A full wave electromagnetic simulation that corresponded to the experiment was built. Based on this simulation setup it's possible to analyze the noise suppression mechanism of the Co-Zr-Nb magnetic film. It's clear that the FMR happened in the frequency of 2 GHz and caused the peak of conduction losses P_{loss}/P_{in}.

References

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3)C. Kittel:"固体物理学入門", 丸善出版 (2005).