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Characteristics of Magnetic Film Inductors with FePt Nano-Dots

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1. Introduction

The strong demands high frequency mobile communications generate new requirements of improved high frequency properties and miniaturized magnetic components in electronic equipment. One of the key elements for small-sized and high performance electronic components is the thin film inductors. A high performance inductors having a soft magnetism and enabling a multi-layer magnetic device have been developed in the industry [1-3]. Here, we adopted the FePt-MND (Magnetic nano-dot) layer in the copper coil inductor device. The FePt-MND has high magnetic permeability μ. Recently we investigated the effects of magnetism on the FePt-MND layer for the magnetic flash memory applications [4].

2. Experiments

The structure of coil inductor with magnetic FePt nano-dot (MND) thin film is shown in Fig. 1. Inductors were fabricated having various numbers of turns of 3.5, 5.5 and 7.5 with 10μm line width and 1μm depth sizes. First, the coil pattern was fabricated on SiO_2 isolation layer by using I-line photolithographic techniques. The FePt-MND layers in a SiO_2 film were formed by a self-assembled nanodot deposition (SAND) method where FePt and SiO_2 were co-sputtered in a high vacuum RF magnetron sputtering equipment with 100nm thickness. Figure 2 shows a process flow of the fabrication Cu coil inductor with FePt-MND layer. Forming a shape of coil in the FePt-MND layer, Ar ion milling was used for MND layer etching, and continuous CF_4 and H_2 etching were performed for the isolation SiO_2 layer. For a electrical isolation between FePt-MND layer and Cu coil, we used laminated silicon oxide layers which formed by plasma TEOS CVD. Then, Cu coil processes were progressed using Cu electroplating and CMP (Chemical Mechanical Polishing) planarization techniques. After fabrication, we compared inductances characteristics under various frequencies, We also simulated the standard Cu coil inductors at the same conditions for experimental validation using high frequency electromagnetic simulator. The photograph of fabricated Cu coil inductor with FePt-MND layer on the Si substrate is shown in Fig. 3.

3. Results and Discussion

Figure 4 shows a cross-sectional SEM image of the fabricated Cu coil inductor with FePt-MND layer. The magnetic FePt-MND layer was clearly observed in this figure. As shown in Fig. 5, we compared the magnetic permeability of coils with and without FePt-MND layer. From this result, we confirmed that the magnetic FePt-MND film can be applied to a magnetic film in high performance inductor. It was also confirmed that high permeability played important roles in the enhancement of inductance [5]. Figure 6 shows the frequency dependence of impedance. Inductance without FePt-MND layer was simulated with the same device structure. The FePt-MND inductor shows the inductance of 8nH, whereas the inductance of general type was 2nH. The roll-off of inductance occurring at 12GHz seems to be associated with LC resonance [6]. It is clearly indicated an effectiveness of having a FePt-MND layer in the inductor. We successfully fabricated the high performance inductor for ultra high frequencies by the utilization of FePt-MND thin film.

4. Conclusion

We fabricated the Cu coil inductor with FePt MND layer for RF communication. Inductance of the Cu coil with FePt-MND layer of 8nH which is proved to be extremely higher than that of the standard Cu coil inductor. In addition, we successfully obtained the resonance frequency at 12 GHz which is due to the FePt-MND inductor.

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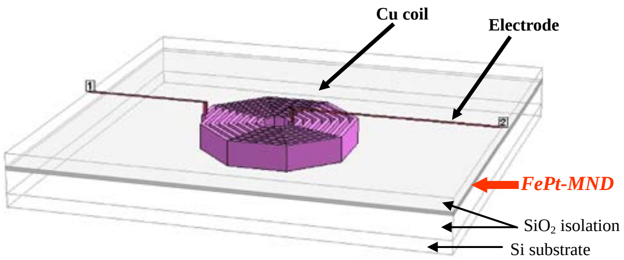

Fig. 1. Configuration of novel Cu coil inductor with FePt-MND layer.

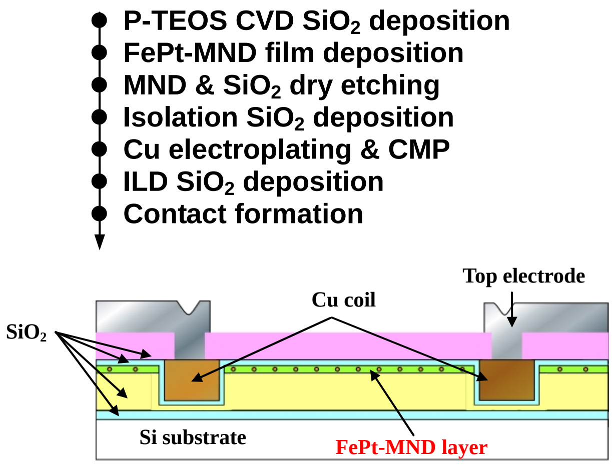

Fig. 2. Process flow of Cu coil inductor fabrication.

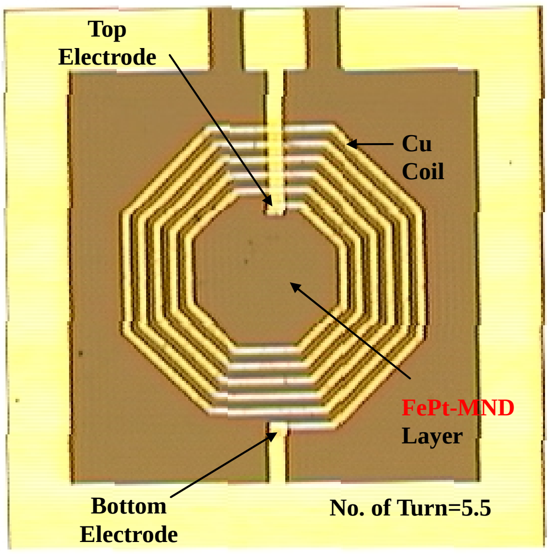

Fig. 3. Photograph of fabricated Cu coil inductor with FePt-MND layer.

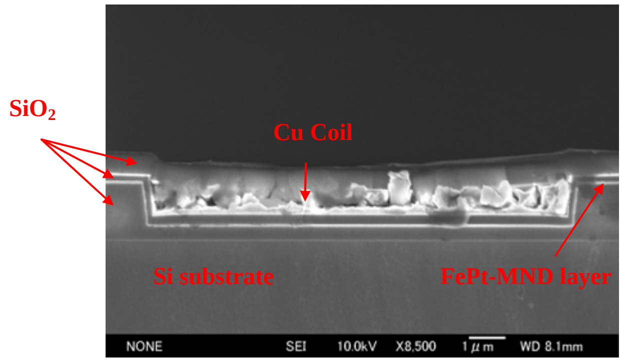

Fig. 4. SEM image of a cross-sectional view of the fabricated Cu coil inductor with FePt-MND layer

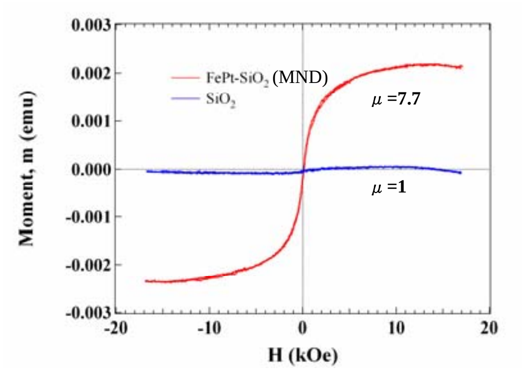

Fig. 5. Comparison magnetic permeability characteristics between $FePt-SiO_2$(MND layer) and general SiO_2 layer at RT.

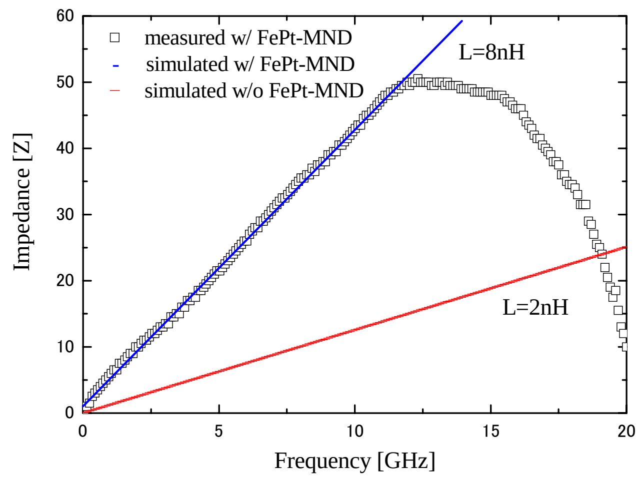

Fig. 6. Frequency characteristics of FePt-MND layer inductor. The coils have a number of winding N=5.5.