R-5

The study of microfabrication and characteristics of thin film inductors using Co-Ni-Fe magnetic cores

KIST	Y. M. Kim*, S. H. Han, H. J. Kim
Myongji Univ.	D. Choi
Hanyang Univ.	J. Kim

한국과학기술연구원	김윤명*, 한석희, 김희중
명지대학교	최 덕
한양대학교	김종렬

1. Introduction

The thin film magnetic devices have been confronted with a strong demand for further miniaturization and high frequency operation. For example, planar inductive devices operating in higher frequencies have many advantages over their conventional counterparts for power electronics applications such as switching converters and inverters. Some progress has been made in improving inductance characteristics of magnetic inductors. When applying magnetic thin film inductive devices to MHz switching converters, they should have an inductance of the order of micron-henries and a quality factor sufficiently larger than unity (Q>1). Therefore, we fabricated the rectangular dual spiral type sandwiched magnetic thin film inductors through wafer process in order to obtain high performance inductors for DC/DC converters.

2. Experimental

A rectangular dual spiral inductor, which is composed of magnetic layer (Co-Ni-Fe)/insulation layer (polyimide)/spiral coil (Cu)/insulation layer (polyimide)/magnetic layer (Co-Ni-Fe) is designed. The Maxwell EM-3D simulator, which employs the finite element method (FEM), has been used to obtain numerical results for inductors. The polyimide as an insulating layer was spin-coated between the magnetic layer and the Cu coil. The as-deposited $Co_{24}Ni_{29}Fe_{47}$ (at.%) films as a lower and upper magnetic layer with about 5 μm thick respectively are deposited by N_2 reactive rf magnetron sputtering

In order to deposit Cu coil, seed layer, Cr(200 Å)/Cu(2000 Å), is deposited by rf magnetron sputtering. After photoresist masking of coil patterns with about 20 μm thick on seed layer, Cu coils are selective-electroplated to a thickness of about 15 μm. The electrolyte for Cu electroplating is composed of $CuSO_4$, H_2SO_4 and DI water. After the photoresist is removed, the seed layers eliminated by wet etching. The polyimide upon the electrode part is removed by reactive ion etching. The values of inductance are measured using HP 4192A impedance analyzer from 1MHz to 10 MHz.

3. Results and Discussion

From the results of inductor simulations, the values of inductance (L) and quality factor (Q) are decreased with the increment of insulator thickness. It is estimated that there are caused by increasing of the magnetic reluctance by means of the extension of the gap between the magnetic cores. On the contrary, the values of L and Q are increased with the increment of magnetic core thickness. The values of L and Q exhibit a tendency to decrease the ratio of increment as increasing the magnetic core thickness Therefore, to improve the performance, it needs to reduce the insulator and proper magnetic core thickness as well as the coil design. The nanocrystalline $Co_{24}Ni_{29}Fe_{47}$ films with 5 μm thick as a magnetic core material has a good soft magnetic property, which is $4\pi M_s$ ~ 19.6 kG, $H_{c,hard}$ ~ 1.8 Oe, H_k > 15 Oe, ρ ~ 30 μΩcm and μ_{eff}(10 MHz) ~ 1000. The results of fabricated thin film inductors are obtained inductance with the range of 1.1~1.7 μH. Also, a quality factor of 12 ~ 30 and coil resistance of 3~ 9 Ω are achieved at 8 MHz with the variation of switching frequency and coil turns. The inductance is increased with the increment of number of turns. When the number of turns increase two fold from 4 turns to 8 turns, the inductance values are increased to the ratio of 40~50%. The Q values are decreased as increasing the resistance due to increase the number of turns. With the increment of switching frequency, inductance is gradually decreased. The change of Q factors and resistance as increasing the frequency are linearly increased to 8 MHz that there are tendency to decrease above 8 MHz.