Preparation and magnetic properties of nano-glass added NiZnCu ferrites for multilayer chip inductors.

S. An¹, I. Kim¹, S. Son¹, S. Song¹, J. Hahn¹, I. Park², C. Kim²
¹. EMC R&D Group, Samsung Electro-Mechanics, Gyunggi-Do, Republic of Korea; ². Department of Physics, Kookmin university, Seoul, Republic of Korea

Introduction

Recently, with the rapid development of mobile communication and miniaturization of electronic devices, low-cost are greatly demanded. NiZnCu ferrites are extensively used in the fabrication of multilayer chip inductors (MLCI) because of their relatively low sintering temperatures, high permeability in the high frequency region, high electrical resistivity, mechanical hardness, and chemical stability [1-2]. To fabricate MLCIs, ferrite layers and internal conductors are alternately laminated and then co-fired to form the monolithic structure. In MLCIs, Ag (melting point=961°C) is used as the internal electrode material due to its low resistivity and lower cost as compared to other noble metals/ alloys such as Ag-Pd alloy. For successful fabrication of MLCI, the sintering temperature of NiZnCu ferrite should be reduced to 900°C to realize the co-firing of the ferrite and Ag electrode materials. In this work, Bi-Zn-Al-B-Si-O nano-glass was used as a sintering aid for the densification of the NiZnCu ferrites. The nano-glass was prepared by a sol-gel method. The ferrite was sintered with nano-glass sintering aids at 840-900°C, 2 h and the initial permeability, quality factor, density and saturation magnetization were also measured.

Experiments

Bi(NO₃)₃-5H₂O, Al(NO₃)₃-9H₂O, Zn(NO₃)₂-6H₂O, C₃H₉BO₃ and Si(OC₂H₅)₄ were dissolved in 2-methoxyethanol and acetic acid. The solution was refluxed at 60°C for 24 h and dried at 120°C for 48 h in oven. The obtained powder was annealed at 300°C for 2 h in air and finely nano-glass powdered. NiZnCu ferrites powders were mixed with an appropriate amount of 0.1-2.0 wt% Bi-Zn-Al-B-Si-O nano-glass powders. The granulated powder with an amount of 0.5 wt% polyvinyl alcohol as a binder was pressed at a pressure of 2000 kg/cm⁻¹ to form toroidal specimens. The specimens were kept at 600°C for 1 h in order to decompose and vaporize the organic components and then sintered at 840-900°C for 2 h in air.

Results and discussion

Fig. 1. Initial permeability (at 1 MHz) as a function of the concentration of a sintering additive for NiZnCu ferrites sintered at 880°C

As shown in Fig. 1, permeability increases with the increase in the nano-glass content in NiZnCu ferrite. The increase in initial permeability with nano-glass content may be primarily attributed to the increase in bulk density. It is known that ferrites with higher density and larger average grain size possess a higher initial permeability [3]. The initial permeability of 0.1 wt% nano-glass added sample was about 62.6. It should a sharp increase from 0.4 wt% to 0.5 wt% nano-glass addition, and then reached the maximum value (211.2) at 1.0 wt% addition level. Beyond 1.0 wt% addition level the initial permeability decrease again with further increase in the nano-glass content. Figure 2 shows initial permeability and quality factor as a function of the sintering temperatures for 0.5wt% nano-glass added NiZnCu ferrites samples.


Fig. 2. Initial permeability u₁ (at 1 MHz) and quality factor Q as a function of sintering temperatures for 0.5wt% nano-glass added NiZnCu ferrites samples.