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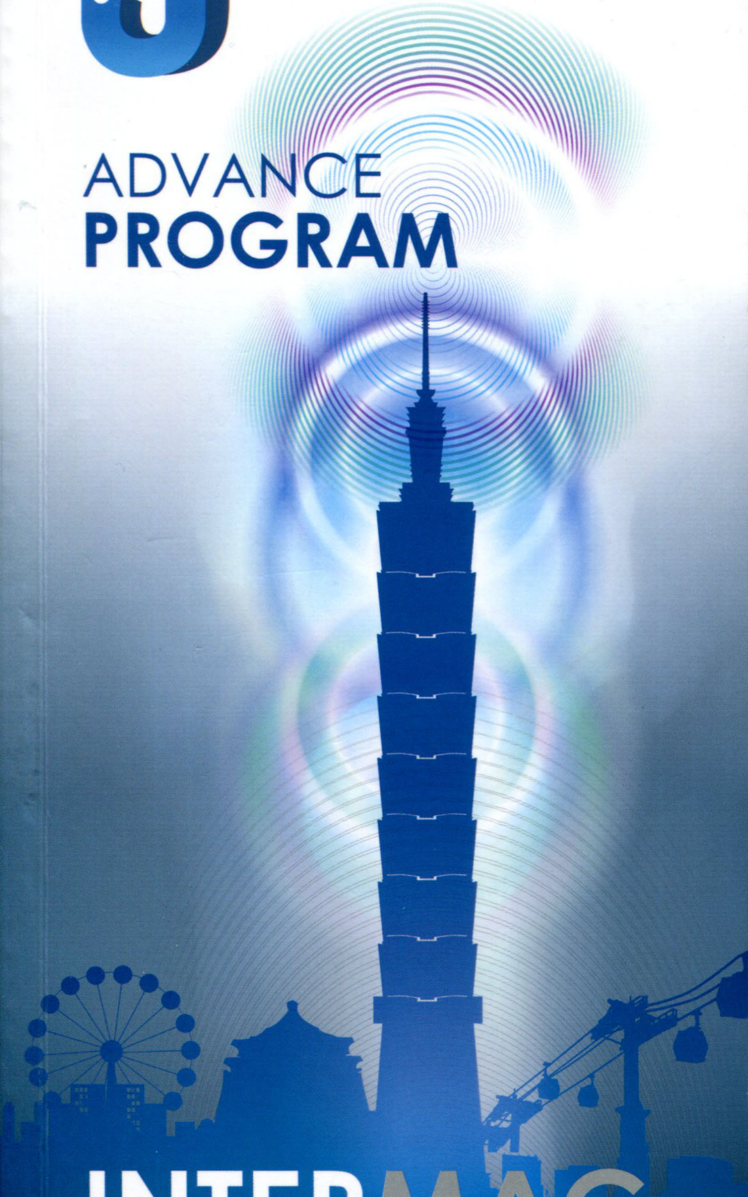

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Preparation and magnetic properties of nano-glass added NiZnCu ferrites for multilayer chip inductors.

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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 oC) is used as the internal electrode material due to its low resisivity 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 oC 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 oC, 2 h and the initial permittivity, 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 oC for 24 h and dried at 120 oC for 48 h in oven. The obtained powder was annealed at 300 oC 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 kgcm-1 to form green toroidal specimens. The specimens were kept at 600 oC for 1 h in order to decompose and vaporize the organic components and then sintered at 840-900 oC for 2 h in air.
Results and discussion
Bi-Zn-Al-B-Si-O nano-glass was prepared by a sol-gel method. The x-ray diffraction patterns of the compounds showed a non-crystalline phase in the Bi-Zn-Al-B-Si-O nano-glass materials. According to SEM images, the particle size was estimated to 60.3 nm with narrow size distribution. In addition to the advantage of low processing temperature, the sol-gel route makes it possible to obtain nanoparticle materials. Using this method, nano-sized glass materials can be obtained, which have larger surface area and larger surface free energy than micron-sized glass materials prepared by the conventional melt-quenching method. 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. The quality factor and saturation magnetization of 0.5 wt% nano-glass added sample for NiZnCu ferrites sintered at 880 oC was about 143 and 386 emu/cc, respectively. As a result, Bi-Zn-Al-B-Si-O nano-glass systems were found to be useful as sintering aids for MLCIs.

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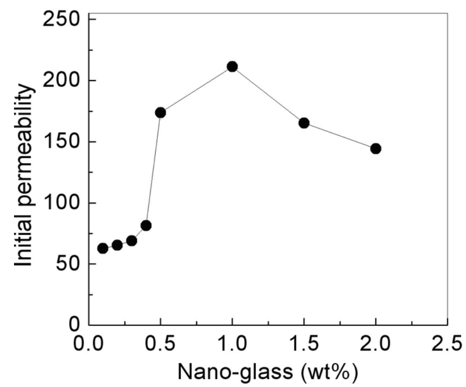

Fig. 1. Initial permeability (at 1 MHz) as a function of the concentration of a sintering additive for NiZnCu ferrites sintered at 880 oC

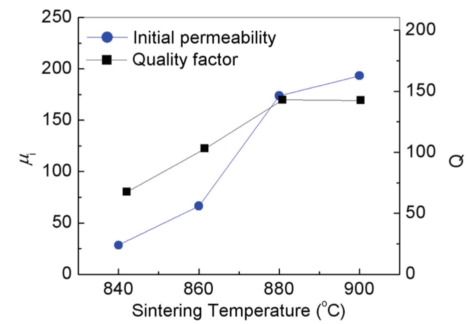

Fig. 2. Initial permeability ui (at 1 MHz) and quality factor Q as a function of sintering temperatures for 0.5wt% nano-glass added NiZnCu ferrites samples.