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Full length article

FeCoNi coated glass fibers in composite sheets for electromagnetic absorption and shielding behaviors

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ABSTRACT

To evaluate the electromagnetic (EM) absorption and shield of magnetic composite sheet, we prepared the FeCoNi coated glass fibers filled in composite sheet. The FeCoNi was coated by electroless plating on glass fiber as a filler. The coated FeCoNi found that consist of mixtures of bcc and fcc phase. The magnetization and coercivity of coated FeCoNi are about 110 emu/g and 57 Oe, respectively. The permittivity and permeability of the FeCoNi composite sheet were about 21 and 1, respectively. Power absorption increased 95% with the increment of frequency up to 10 GHz. Inter-decoupling of this composite sheet showed maximum 30 dB at around 5.3 GHz, which is comparable to that of a conductive Cu foil. Shielding effectiveness (SE) was measured by using rectangular waveguide method. SE of composite obtained about 37 dB at X-band frequency region.

1. Introduction

Electromagnetic interference (EMI) countermeasures have been very important issues for the enhancement of efficiency and lifetime of electric devices in radio frequency (RF) region. In order to reduce the EMI between signal lines, components and circuits in RF region, the conductive films, the magnetic films and the composites as a EMI suppressor have been widely developed and applied to the electronics [1–4]. Most of the composites and films, the conventional spherical powder and flakes have been used for EMI countermeasure at near-field and far-field region [5–8]. To enhance the EM absorption and shield in electronic components, high conductivity for shield and high magnetic loss for absorption are required simultaneously. In general, metallic powders and chopped fibers are widely used for EMI shielding. However, these fillers are not easy to make conductive network in composites although these composites have good advantages process ability by injection molding and other commonly used polymer processing methods. For these metal-polymer composites, the EMI shielding ability increases with increasing aspect ratio of the filler. Therefore, the attraction of continuous fillers have been expanded the conductive paths even at a low contents, and it can have the light weight and increasing conductivity. These have realized the excellent EM wave absorption and shielding capability. [9,10]. And among many kinds of candidates materials as fillers of composite, FeCo based alloys have attracted great interest in the magnetic property of such as high saturation magnetization, small coercivity, and wide frequency controllable ferromagnetic resonance frequency [11,12]. The magnetic composite filled with FeCoNi coated on continuous glass fibers can be controlled the conducive network in composites as well as permittivity and permeability in comparison with those of FeCo particles or the chopped fibers. Therefore, we evaluated the efficiency of the EM absorption and shielding characteristics of the FeCoNi coated on continuous glass fibers filled in composite sheet using conductive network between fillers. Especially, we employed the IEC 62333 standard evaluation methods for the near-field absorption and shielding effect up to 10 GHz on circuit or component as well as conventional shielding effectiveness measurement by rectangular waveguide at X-band frequency region. [13,14].

2. Experimental

The magnetic composite sheet filled with FeCoNi coated on the glass fibers was prepared by continuous process of the fiber catalysis, the metal deposition and the composite process as shown in Fig. 1. The catalysis of glass fibers (ER 2400 FW, hankuk fiber) were achieved by using sensitization and activation processes and deposition process, respectively. The $SnCl_2$ (200 g) and the concentrated HCl (10 mL) were dissolved in distilled water (10L) for

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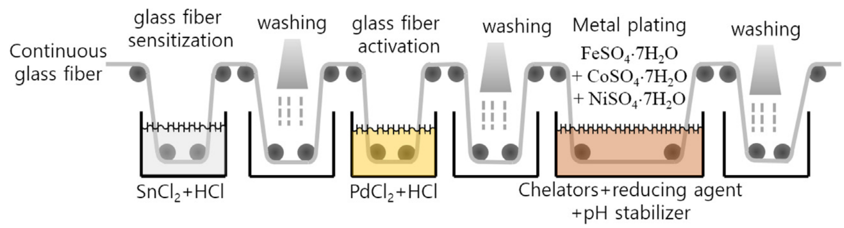

Fig. 1. A schematic of continuous process of fiber catalysis and metal deposition by electroless plating.

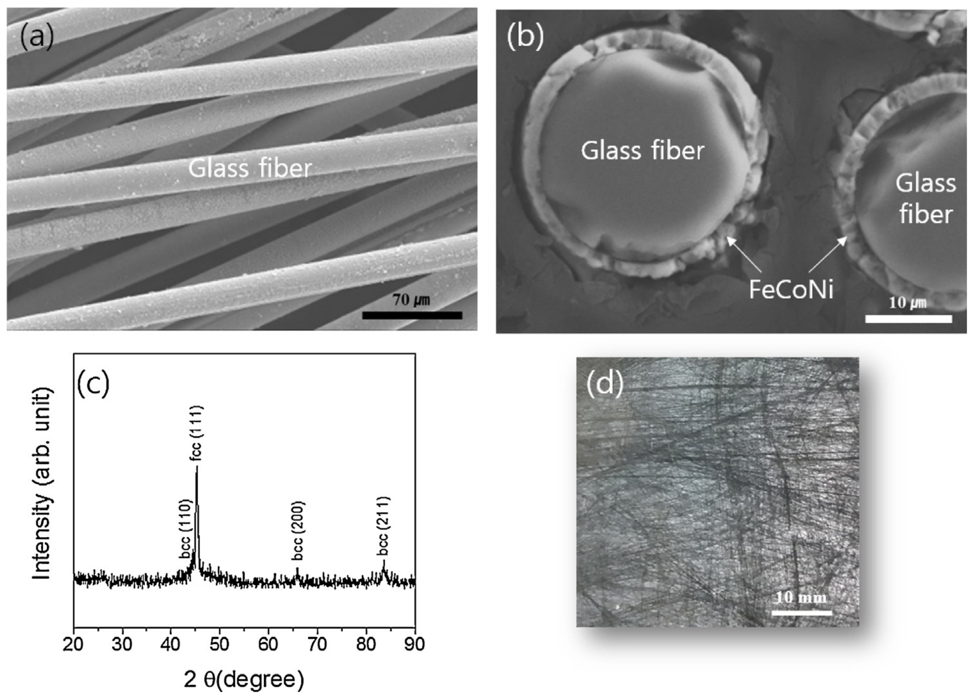

Fig. 2. FE-SEM images of (a) glass fibers and (b) FeCoNi coated on glass fibers, (c) XRD peaks of FeCoNi coated on glass fibers and (d) optical image of the fabricated composite sheet.

sensitization. The sensitized glass fibers were recovered by vacuum filtration. And then, Palladium chloride (2 g) solution with hydrochloric acid (100 mL) and water (10 L) was prepared for activation. After the activation of glass fibers in palladium chloride solution for 30 min, the Pd-catalyzed glass fibers. To deposit the magnetic-metal layer, the electroless plating method was employed. The plating bath (20 L) was comprised of source metal ions ($FeSO_4{\cdot}7H_2O$, $CoSO_4{\cdot}7H_2O$ and $NiSO_4{\cdot}7H_2O$, 1:6:0.7), metal chelators (sodium citrate dehydrate and sodium tartrate dehydrate), reducing agent (DMAB) and pH stabilizer ($(NH_4)_2SO_4$). The pH of plating bath was adjusted to 6.5 using sodium hydroxide and heated to 75 °C. Sensitizing, activating and plating bath were arranged in order and the sinks for wash were placed between two baths. Glass fibers were passed sensitizing, activating and plating bath in sequence and the exposure time of each process were 30, 30 and 60 min, respectively. After the deposition, FeCoNi-coated glass fibers were washed fresh water and obtained by hot-air drying. Finally, to obtain the magnetic composite sheets, the polycarbonate (PC) film was sunk to water bath and FeCoNi coated chopped fibers were dispersed on to PC film using surface tension of water. After the dry of film and fibers, the resulting material was compression molded to 0.5 mm of thickness using press and a temperature of 210 °C, respectively.

The surface and cross-section morphology, phase and microstructural analysis of FeCoNi coated glass fiber were performed by scanning electron microscopy (SEM), X-ray diffrac-

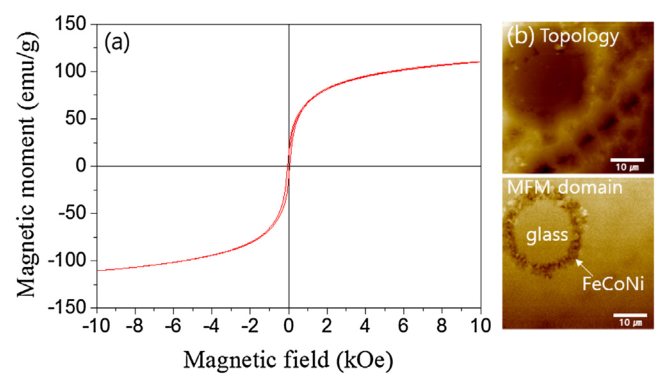

Fig. 3. (a) Magnetization curves and (b) MFM magnetic domain image of FeCoNi coated glass fibers.

tometer with monochromatic Cu-K_α (λ–1.542 Å) radiation. The magnetic characterization of the glass fibers in composite sheet were analyzed by using a vibrating sample magnetometer. To evaluate the EM characteristics of the composite sheets filled with FeCoNi coated glass fibers, the complex permittivity and permeability were measured by using 7 mm coaxial transmission line and vector network analyzer (VNA, HP 8510C) with the frequency range from 0.5 GHz to 18 GHz. The microwave power absorption was measured by microstrip line (MSL) method and

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