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Magnetic Properties of Quasi-Nano Li-Cu Ferrite Powders by Self-propagating High Temperature Synthesis

Y. Choi*¹ and S. S. Kim²

¹Department of Electronic Materials Eng., Sunmoon University, 100 Kalsan-Ri, Tangjeong-Myun, Asan, Chungnam 336-840, Korea
²Department of Materials Science Eng., Chungbuk National University,
 12 Gaesin-Dong, Heungduk-Gu, Chungju, Chungbuk 361-763, Korea

*Corresponding author: yochoi@hanmail.net. Phone: +82 41 530 2342, Fax: +82 41 541 7426

Since diminishing of the average particles size exhibits a change from anti-ferromagnetic to ferromagnetic behavior, it is important to produce very fine ferrite powders for engineering point of view.[1,2] In this study, Li-Cu ferrites with quasi-nano size were produced by self-propagating high temperature synthesis (SHS) reaction with various oxygen pressure and determine their magnetic properties. Reagent grade iron powders with 7 mm of average particle size and various size of lithium oxide (Li₂O, <150 nm), copper oxide (CuO, <150 nm) and iron oxide (Fe₂O₃, <1 mm) powders were used as starting materials. The reactant powder mixture was ignited at oxygen pressures of 0.1-1.0 MPa in SHS chamber. The combustion temperature and velocity tended to be increased with oxygen pressure and Li₂O/CuO molar ratio in the initial composition of reactant powder mixture. Average combustion temperature and combustion velocity were in the range of 860 and 1208 K and 4.9-6.0 mm/sec, respectively. The maximum magnetization (Ms), residual magnetization (Mr) and coercive force (Hc) of the quasi-nano Li-Cu ferrite particles formed by SHS are 40.43 emu/g, 7.94 emu/g and 122.07 Oe for 0.25 of the initial molar ratio of lithium oxide to copper oxide, 54.82 emu/g, 8.51 emu/g and 143.44 Oe for 1.0 of the initial molar ratio of lithium oxide to copper oxide, respectively.

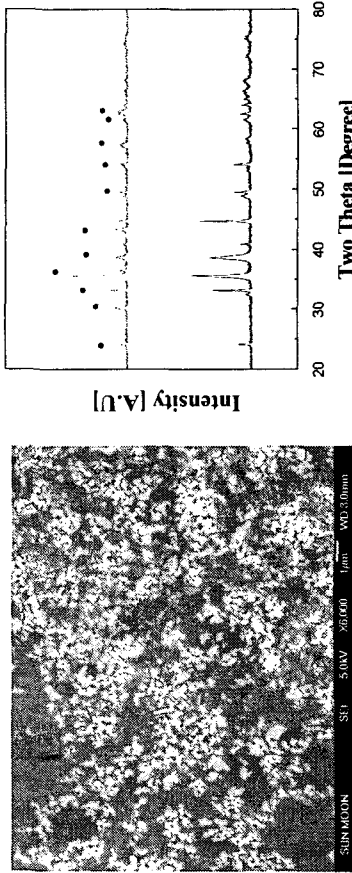


Fig. 1. Microstructure and X-ray spectra of SHS products.

ACKNOWLEDGEMENTS

Neutron Beam Application Lab carried out this work that was supported by the Korea Science and Engineering Foundation (KOSEF) through the National Research Lab. funded by the Science and Technology. (Grant number M1060000024806J000024810)

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PA07

Mechanical Properties of Zigzag Carbon Nanotubes

Ustik Lee*¹ and Hyukjin Oh¹

¹Department of Mechanical Engineering, Inha University, 256 Yonghyun-Dong, Nam-Gu, Incheon 402-751, Korea
 *Corresponding author: ulee@inha.ac.kr. Phone: +82 32 860 7318, Fax: +82 32 866 1434

Since the pioneering paper on carbon nanotubes (CNTs) by Iijima [1], extensive studies on CNTs have been conducted to investigate that CNTs exhibit superior mechanical properties over any other existing materials. To evaluate the mechanical properties, atomistic modeling approaches and continuum modeling approaches have been used. As the atomistic modeling is more expensive for most large atomic systems, the continuum modeling approach can be practically used. In continuum modeling approaches, CNTs have been represented by the space frame structures, the tube or shell model and the plate model for graphene sheet. However, due to the ambiguity of the wall thickness of CNTs, some different values of wall thickness h have been assumed by many researchers to report a wide range of inconsistent effective elastic modulus E . To avoid such a problem, Ru [2] proposed that the effective flexural rigidity of the plate, $D = Eh^3/12(1-\nu^2)$, should be regarded as an independent material parameter for CNTs. However, we still need the wall thickness h to accomplish the structural analysis for the CNTs by using effective elastic modulus or flexural rigidity D of the plate.

Thus, this paper proposes a dynamic continuum modeling method to evaluate the effective mechanical properties of zigzag CNTs without needing to assume their wall thickness. The proposed continuum modeling method consists of the following four steps. The first step is to represent each carbon-to-carbon (C-C) bond within a zigzag CNT by an equivalent rod element connecting two carbon atoms by using the molecular mechanics. The second step is to represent all C-C bonds by identical equivalent rod elements and to regard the zigzag CNT as an equivalent space lattice structure (LS). As the LS model for a zigzag SWCNT is composed of many identically constructed repeating cell units (RCUs), the third step is to isolate an RCU from the periodic LS model and to represent it as an equivalent continuum beam model. The last step is to extract effective structural and dynamic properties for continuum beam model by using the strain and kinetic energies equivalence principle.

The proposed continuum modeling method is applied to various single-walled zigzag CNTs denoted by $(n, 0)$ to evaluate their effective structural properties. The coupling rigidities and the effective first moment of mass are found to be very small due to the nearly axisymmetry of zigzag CNTs. It is also found that zigzag single-walled CNT $(n, 0)$ has extremely high transverse shear rigidity GA , larger than about 95% of the corresponding extensional rigidity EA ; for instance, $GA = 798 \text{ kg} \cdot \text{mm}^2/\text{s}^2$ and $EA = 837 \text{ kg} \cdot \text{mm}^2/\text{s}^2$ for the zigzag single-walled CNT (10, 0). For the case of steels, the transverse shear rigidity GA is known to be less than about 40% of the extensional rigidity EA for a given cross-sectional area. This may imply that the effects of transverse shear deformation can be neglected in the structural analysis for zigzag CNTs.

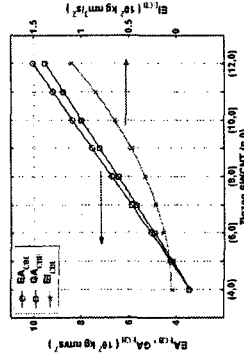


Fig. 1. Effective mechanical properties.

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