## PA06

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

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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 ($Li_2O_3$, <150 mm), copper oxide (CuO, <150 mm) and iron oxide ($Fe_2O_3$, <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 $Li_2O_3$/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 (iHc) of the qusai-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.

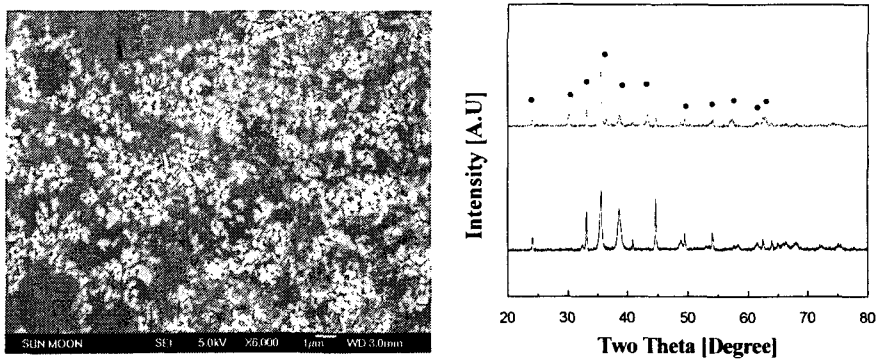


**Fig. 1.** Microstructure and X-ray spectra of SHS products.

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## PA07

# Mechanical Properties of Zigzag Carbon Nanotubes

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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 modellingapproaches 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 modellingapproaches, 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 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 kg · nm/s$^2$ and $EA$ = 837 kg · nm/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.

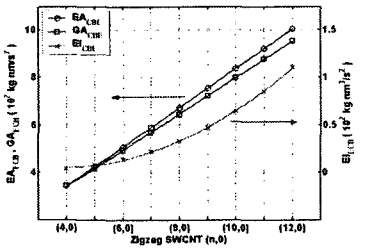


**Fig. 1.** Effective mechanical properties.

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