TB15

Preparation of Terfenol-D Films on PMN-PT Single Crystal Substrates for the study of Voltage-control of Magnetization Easy Axis

Ju-hyun Kim*[1], V.ravindranath[1], and Sung-chul Shin[1]
[1] Department of Physics and Center for Nanospinics of Spintronic Materials, Korea Advanced Institute of
Science and Technology, Daejeon 305-701, Korea
*Corresponding author: kchuhyun@kaist.ac.kr, Phone: +82 42 869 8167, Fax: +82 42 869 8162

To achieveultra-high density integration in a magnetic random access memory (MRAM), suitable data recording and retrieval methods have to be determined. The conventional method of data recording using a magnetic field obtained from a current carrying conductor hassevere limitations, in that, it is difficult to localize the magnetic field in the vicinity of the nano-sized data bit necessary for ultra-high density memories. Hence, there is a need to explore alternate data recording methods which can aid ultra-high density integration. Recently, a method of controlling the direction of the magnetization easy axis using voltage has been reported in the Pd/Co$_{1-x}$Pd$_x$/PZT/Pt/MgO heterostructures [1]. This is achieved by a coupling between the inverse piezoelectric effect of the ferroelectric film and the inverse magnetostrictive effect of the magnetic film and is a promising recording method in ultrahigh density memories since it uses a voltage applied locally to the data bit under consideration. In the present work, an attempt has been made to optimize the deposition parameters of Terfenol-D films on PMN-PT single crystal substrates for the study of voltage-control of magnetization easy axis.

Terfenol-D ($Tb_{0.3}Dy_{0.7}Fe_{1.92}$) films were deposited on commercially available PMN-PT single crystal substrates by the dc magnetron sputtering method. 100 nm thick films were deposited at a sputtering power of 50 W, 5 mTorr Argon pressure and at room temperature. The magnetic hysteresis (M-H) loops of these films were measured using a home-made magneto-optic kerr effect (MOKE) magnetometer. A voltage was applied across the PMN-PT substrate by the Au-electrode attached to the backside of the substrate and the Pt capping layer deposited on the Terfenol-D film. The M-H loops at different applied voltages were measured. For a voltage variation from 0 - 90 V, an increase in coercivity from 400 Oe to 450 Oe has been observed. Further studies are underway.

REFERENCES

[1] Jeong-Won Lee, Sang-Koog Kim and Sung-Chul Shin, Appl. Phys. Lett. **82** (2003), 2458.

TB16

Mechanical Properties of Zigzag Carbon Nanotubes

Usik Lee*[1], Hyukjin Oh[1] and Hansuk Go[1]
[1] Department 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 modelling 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 modelling 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 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 mechanicalproperties 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 equivalentrod 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.

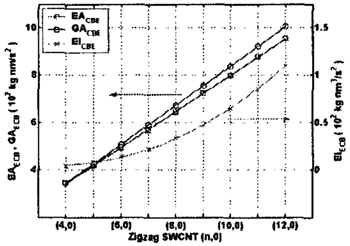

Fig. 1. Effective mechanical properties.

REFERENCES

[1] S. Iijima, nature, **354**, 56 (1991).
[2] C. Q. Ru, phys. rev. (b), **62**, 9973 (2000).