Abstract #95, 223rd ECS Meeting, © 2013 The Electrochemical Society

Investigation of Electromagnetic Properties of Carbon Nanotube-Silica Nanowire Composite

Praveen K.Sekhar[1], Hanna Mekonen[1], Tutku Karacolak[2], and Mustafa Asili[3]
[1]Nanomaterials and Sensors Laboratory, School of Engineering and Computer Science, Washington State University Vancouver
[2]RF Research Laboratory, School of Engineering and Computer Science, Washington State University Vancouver
[3]Department of Electrical and Computer Engineering, Mississippi State University

Electromagnetic interference (EMI) shielding is required for protecting electronics, avoiding unauthorized surveillance and negating electromagnetic forms of spying. Failure in electronics system can be hazardous, as the electronics can be associated with strategic systems such as aircraft, nuclear reactors, transformers, control systems, communication systems, etc. Previous reports [1, 2] indicate carbon nanotubes (CNTs) can be utilized to impart electrical conductivity to dielectric hosts, thereby improving electrostatic charge dissipation and electromagnetic shielding. However, the investigation of CNTs for EMI shielding in severe environment (high temperature) is limited [3]. In this study, the electromagnetic properties of CNT-SiO_x nanowire composite will be investigated from room temperature to 600^0 C.

CNT Growth: Clean Si substrates with a native oxide layer were sputter deposited with Fe film of thickness 20 nm. The sample was then loaded into a horizontal tube furnace under an Ar flow of 100 SCCM and a low flow of Hydrogen. The CVD reactions were conducted at 800^0 C with methane as the feedstock. After 10 mins of heating at 800^0 C, the furnace was cooled down. The growth on the substrate was inspected using SEM and TEM. Multi-wall CNTs of an average diameter of 8 nm were grown.

SiO_x Nanowire Growth: Prime grade Si wafer pieces (2 cm x 2 cm) were used as substrates for metal catalyst deposition and subsequent. Pd of thickness of 5 nm was sputtered onto Si substrate, which served as the catalyst. The growth temperature of nanowires was 1100^0 C. High purity Ar was chosen as carrier gas in an open tube furnace and was set to 30 SCCM throughout the course of the experiment. Initially the furnace was flushed with Ar to minimize interference from gaseous impurities. The base support Si wafer acts as Si vapor source. The nanocomposite was fabricated using the hot-pressing technique.

Measurement: The dielectric properties (relative permittivity (ε_r) and loss tangent ($tan\delta$)) of samples were measured between 500 MHz and 20 GHz for 1500 frequency points. An E8362B PNA network analyzer and Agilent's 85070E dielectric probe kit were used for the dielectric measurements. The slim form probe with a diameter of 2.4 mm had been used during measurements due to its high accuracy. In order to ensure data reliability, each sample was measured three times, and the averages and standard deviations were calculated for the frequency band of interest. Note that the probe position was changed at each of these measurements. The sample of plain CNTs, plain SiO_x and the composite was used to gain an understanding of EMI shielding ability of the individual components.

Figure 1 and figure 2 shows the dielectric permittivity and loss tangent of silica nanowires as a function of frequency. The permittivity was found to be 4 and loss tangent around 0.1-0.2.

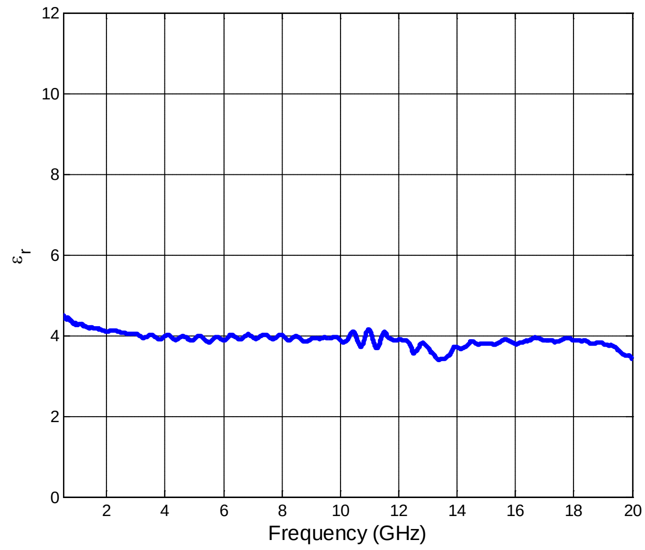

Figure 1. Dielectric Permittivity of Silica Nanowires as a Function of Frequency.

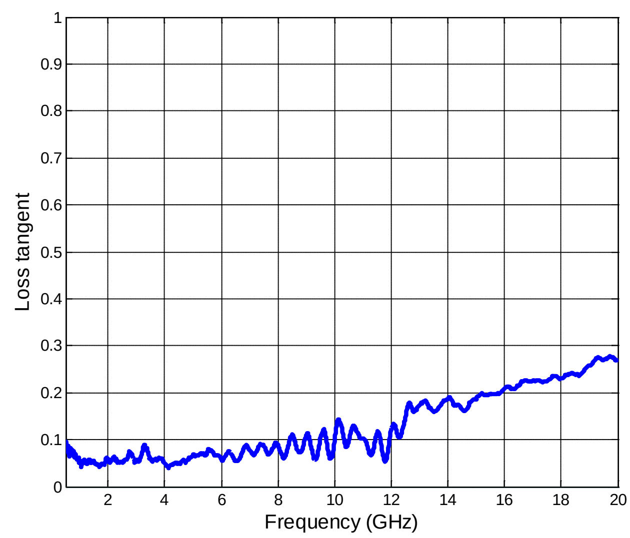

Figure 2. Loss Tangent of Silica Nanowires as a Function of Frequency

References

[1] C.Xiang, Y.Pan, X.Liu, X.Sun, X.Shi and J.Guo, Appl.Phys.Lett **87**, 123103:123103-3 (2005).
[2] E.Vazquez and M.Prato, ACS Nano **3**, 3819-3824 (2009).
[3] W-L.Song, M-S.Cao, Z-L.Hou, J.Yuan and X-Y.Fang, Scripta Materialia **61**, 201-204 (2009).