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Effect of Hierarchical Structure on Electrical Properties and Percolation Behavior of Multiscale Composites Modified by Carbon Nanotube Coating

Jie Zhang,[a,*] Alexei A. Bokov,[b] Shang-Lin Gao,[c] Nan Zhang,[a] Jian Zhuang,[a] Wei Ren,[a] Zuo-Guang Ye [a,b,**]

[a] Electronic Materials Research Laboratory, Key Laboratory of the Ministry of Education & International Center for Dielectric Research, School of Electronic and Information Engineering, Xi'an Jiaotong University, Xi'an 710049, China

[b] Department of Chemistry and 4D LABS, Simon Fraser University, Burnaby, British Columbia, V5A 1S6, Canada

[c] Leibniz - Institut für Polymerforschung Dresden e.V. Hohe Strasse 6, Dresden 01069, Germany

Corresponding Author

*Email: jzhang12@xjtu.edu.cn, zye@sfu.ca

ABSTRACT

The hierarchical composites integrated by micro-/nano- fillers have been considered to be the multifunctional materials of the next generation. However, the effects of the hierarchical architecture on the electrical properties of composites remains poorly understood. Here, the fabrication of polymer-based multiscale composites with hollow glass fibers coated by carbon nanotubes (CNTs) and the investigation of their morphology, conductivity and dielectric properties are reported. Owing to CNTs introduced into the interfaces, various electrical parameters of the composites are obviously improved. The composite exhibits a stronger anisotropy than that of carbon fiber or CNTs filled composites and an ultralow percolation threshold. These unique behaviors are shown to be related to the hierarchical morphology giving rise to the existence of two percolation levels with different thresholds: a local threshold in the nanoscale CNT networks at the fiber-polymer interfaces and a global threshold in 3D network formed by the fibers. Furthermore, we find and explain some behaviors uncharacteristic of binary composites and the other hierarchical composites. This work provides a deeper understanding of the relationship between the structure and properties of multiscale composites and other complex percolating systems, potentially opening up new ways for designing novel materials.