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Design of multifunctional composites and their use for the 3-D printing of microsystems

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DESIGN OF MULTIFUNCTIONAL COMPOSITES AND THEIR USE FOR THE 3-D PRINTING OF MICROSYSTEMS

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Many of today's high-tech products are approaching their technological limits. For example, the microelectronics community is faced with overheating devices with a demand for compact three-dimensional (3D) architectures and lower power consumption, whereas the aerospace industry is seeking lighter, stiffer and more electrically conductive materials for the creation of more energy efficient aircraft. A promising solution is to capitalize on the amazing electrical, thermal and mechanical properties of some nanoscopic materials (one billionth of a meter). However, several challenges in material processing and manufacturing must be resolved, namely exploiting these properties at the industrial scale and overcoming the current planar configuration with a truly 3D method.

The nature of work presented is mainly on the development of high-performance materials for the manufacturing of microscopic or larger systems featuring multiple functionalities. On the material side, the design of polymer-based nanocomposite coatings used to protect aerospace composite structures against lightning strike will be presented. A comparative analysis between the standard copper meshes and our novel coating designs (e.g., wet chemical metallization, heterogeneous distribution of conductive fillers, hybrid fillers deposition) was performed under high current (up to 50 kA). On the manufacturing side, different 3D printing methods will be explained. These methods were used to build complex 3D shapes at the microscopic scale and above such as helical freeform microcoils, microstructured fibers and nanocomposite liquid sensors. In conclusion, we believe that the fabrication techniques presented provide an original and promising approach to resolve the aforementioned issues, thus making nanotechnology more accessible to industry, especially in aerospace, microelectronics and biomedicine.

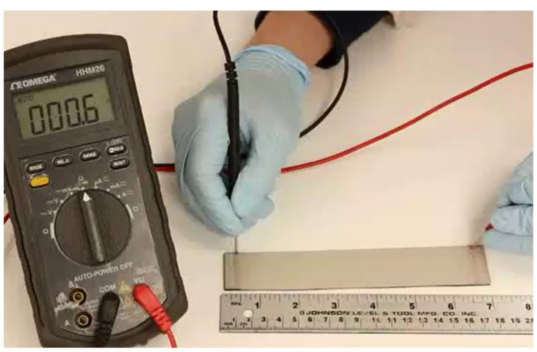

Figure 1 - Resistivity measurement (~0.6Ω) of hybrid conductive coating on top of composite laminate

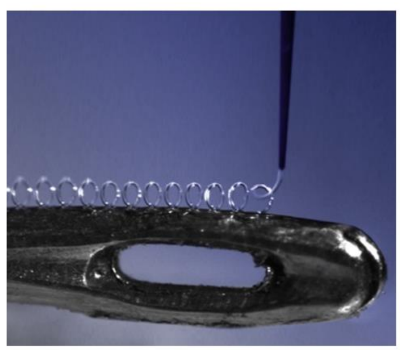

Figure 2 - Microstructured fibers printed on top of a sewing needle

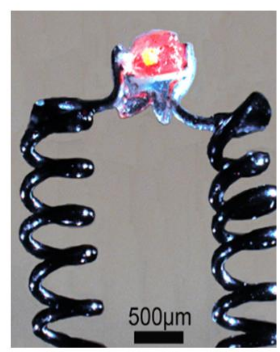

Figure 3 - Conductiv structure (PLA with 5w MWCNTs)