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MWCNT Modified Structure-Conductive Composite and Its Electromagnetic Shielding Behavior

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Abstract: In this paper, a structure-conductive carbon fiber reinforced composites (CFRPs) were fabricated. Its mechanical and electrical properties were characterized. The contribution of its modifier, multi-wall carbon nanotube (MWCNT) to the overall EMS (electromagnetic shielding) effectiveness of CFRP was analyzed. To simultaneously enhance the mechanical strength and electrical conductivity, the MWCNT was well dispersed into aerospace grade epoxy base resin. Afterward, The MWCNT carrying resin was impregnated over unidirectional fiber yarns to produce unidirectional prepreg, and MWCNT modified CFRP (MWCNT-CFRP) laminates were molded in an autoclave. The static mechanical strength, electrical conductivities, and electromagnetic shielding (EMS) effectiveness of MWCNT-CFRPs were tested. Relative analysis verified the conductivity dependence of their EMS performance, indicating the promising prospect of MWCNT-CFRPs for EMS structural composite.

Keywords: A. multi-wall carbon nanotube, B. carbon fiber reinforced composite, C. electrical conductivity, D. electromagnetic shielding.

1. Introduction

The feeble electromagnetic compatibilities of CFRPs underlined the necessity to electromagnetically secure the airplanes and avionic system made of CFRP, which were already became the major material in the modern aviation industry [1]. Without proper treatment, in scenarios such as encountering cumulonimbus, direct lightning strike and civil/military electromagnetic interferences, aircrafts would be jeopardized by avionics interference and overload [2, 3].

Use conductive materials other than CFRP or appending conductive coatings (e.g. iron/cobalt carrying coatings, fabrics incorporated with metal fibers [4, 5]) on the surface of CFRP parts was the state of art technique to enhance their skin effect and improve their capabilities to shield the electromagnetic interferences. However, additional accessories would potentially increase the cost and the complexity of fabricating CFRP parts [6]. Moreover, most of them are deleterious to the integrity of CFRP structure, which might reduce their durability [7].

An alternative solution for the aforementioned electromagnetic protection issue is to fabricate conductive CFRP, by incorporate conductive fillers into their insulated components, which is the resin [8, 9]. But in many occasions, the weak interfaces introduced by heterogenic infillings would inevitably compromise the cohesive strength of resin, especially when their dosage is high [10, 11]. To ameliorate the mechanical performance of a conductive resin, the intrinsic properties and the geometry of the conductive fillers should be deliberately designed. For instance, CNT (Carbon Nano Tube) were considered as one of the most adequate conductive fillers for high performance polymers [12].

CNT are nano-scale monatomic hollow tubes with ultra high L-D ratio, discovered by Iijima in 1991[13]. Benefited from their unique geometry and physical properties, the percolation threshold of the MWCNT in epoxy resin could be decreased to 0.01-15%. The corresponding resistivity of the modified resin could reach as high as 50 S/m [14]. The surfacial sheet resistance of a 10μm isotropic coating layer made of such polymer would be lower than $2\times10^{-2}\Omega/\square$ [15].

As reported, CNT could be dispersed in thermosetting resins by multiple measures [16]. A. B. Ripoll et al. prepared electrical conductive composite laminates via electro-spun CNT doped epoxy resin onto aligned carbon fiber yarns and carbon fiber fabrics. By integrated with CNT, the modified composites exhibit excellent conductivity and capable of withstanding a