Accepted Manuscript

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PII: S1359-8368(17)30615-7

DOI: 10.1016/j.compositesb.2017.06.004

Reference: JCOMB 5110

To appear in: *Composites Part B*

Received Date: 18 February 2017

Revised Date: 14 April 2017

Accepted Date: 10 June 2017

Please cite this article as: Zhang L, De Greef N, Kalinka G, Van Bilzen B, Locquet J-P, Verpoest I, Seo JW, Carbon nanotube-grafted carbon fiber polymer composites: Damage characterization on the micro-scale, *Composites Part B* (2017), doi: 10.1016/j.compositesb.2017.06.004.

Carbon nanotube-grafted carbon fiber polymer composites: Damage characterization on the micro-scale

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Abstract

Multiwall carbon nanotubes (CNTs) – carbon fibers (CFs) hybrid materials were produced by directly growing CNTs on CFs by means of chemical vapor deposition. For the latter, the oxidative dehydrogenation reaction of C_2H_2 and CO_2 was applied, which allows growing CNTs without damaging the CF surface. Uni-directional nano-engineered carbon fiber reinforced composites (nFRCs) were fabricated by impregnating these hybrid materials with epoxy. The nFRCs subjected to single fiber push-out tests revealed a decrease of the interfacial shear strength (IFSS) of about 36% compared to the carbon fiber composites without CNTs. By means of transverse three-point bending tests performed on pre-notched composite beams inside a scanning electron microscope, the fracturing behavior parallel to the fibers was studied in-situ. The nFRCs showed significantly reduced fiber/matrix debonding while CNTs pull-out, CNTs bridging as well as matrix failure occurred. These results demonstrate that the presence of CNTs in nFRCs affects the stress distribution and consequently the damage initiation as well as the damage propagation. The presence of CNTs suppresses the stress concentration at the fiber/matrix interface and reduces the debonding of CFs from the matrix. However, our results indicate that the stress concentration shifts towards the CNTs' ends/matrix interface and causes promoted matrix failure leading to lower IFSS.

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