Nano-scaled fillers (nanotubes, nanosheets): Do they toughness brittle matrices?

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Carbon nanotubes (CNTs) have been shown having excellent potential as reinforcements in a wide range of composite systems, thanks to their exceptional intrinsic mechanical and other functional properties. There has been growing interest in using CNTs in ceramic and/or glass matrices as toughening filler, in the last decade. Also, graphene nanosheets (GNSs) and graphene oxide nanosheets (GONSs) have attracted attention thanks to their unique combination of mechanical, thermal and electrical properties. Graphene thus appears to be an ideal second phase filler in order to modify properties of ceramics. Analogous effects have been newly obtained with boron nitride nanotubes (BNNTs) and nanosheets (BNNSs).

The aim of this contribution is to provide a snapshot of the current state of the art on the real effect of nanoscale fillers incorporated into glass/ceramic matrices on their composite fracture resistance.

For CNTs in silica matrix the fracture toughness KIC increased linearly to 100-120% relative to silica monoliths up to high CNT content (15 wt.%). There was an improvement of 35% in KIC of silica with addition of 2.5% GNSs and GONSs. Toughening mechanisms including GONSs necking, pull-out, crack bridging, crack deflection and crack branching were evidenced for silica matrix composites. Similar effects have been proven in alumina composites, e.g. when incorporating 0.8 vol. % of GNS the improvement of the KIC was more than 40%. BNNT, cylindrical and bamboo-like, incorporated into nanostructured tetragonal zirconia stabilized with 3 mol.% yttria contributed to significant increase of KIC, 2.5 wt. % addition produced 100% increase in KIC compared to the monolithic zirconia. Exploitation of BNNSs in borosilicate glass matrix resulted in about 45% KIC increase.

The main effect of nanoscale filler has to be seen not only in producing synergy of several toughening mechanisms active during crack initiation/propagation but also in affecting microstructures formation during sintering.

Speaker Biography

Ivo Dlouhý has been affiliated with Institute of Physics of Materials, Czech Academy of Sciences, Brno, as a head of Brittle Fracture Group. He is employed at Brno University of Technology, Institute of Materials Science and Engineering, as professor and institute director. He graduated at Faculty of Metallurgy and Materials, TU Ostrava in 1979. His got his PhD degree from Institute of Physics of Materials, Czech Academy of Sciences, in 1984. Since 1992, he is active as senior scientist at the Department of Mechanical Properties. Since 2008, he is the professor of materials strength, experimental fracture mechanics and mechanical testing of materials at Faculty of Mechanical Engineering, Brno University of Technology. Except for research reports, author 210 papers registered by Web of Science, h-index 19. He is the member of editorial boards of journals Engineering Fracture Mechanics, International Journal of Applied Ceramic Technology and Metal Physics and Advanced Technologies.

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