The strength of graphene and its application in nanocomposites

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ABSTRACT In this work, the deformation and fracture behaviour of the one-atom-thick graphene flake has been studied in detail. Monolayer graphene flakes were prepared by mechanical exfoliation and pressed onto PMMA beams. Uniaxial tensile stress was then applied to the one-atom-thick graphene flake through the van der Waals bonding between the graphene flake and the PMMA beam by bending the beam. Through in situ Raman mapping with 0.5 micron steps at different strain levels, the stress over the whole flake was determined from the shift of the graphene Raman 2D band (Gong et al., 2010; Young et al., 2011). The fracture of the flakes was observed from the development of zero stress lines almost perpendicular to the stress direction as shown in Figure 1. We found that the fracture behaviour is related to the crystallographic direction of the graphene flakes, which can be investigated by G band splitting during deformation (Mohiuddin et al., 2009). Generally, the cracks tend to follow the zig-zag direction of the flakes. It was found that the strength of the monolayer graphene decreases with an increase in the flake width. This indicates the fracture behaviour of the monolayer graphene is defect-controlled. The strength dropped to only 5 GPa for some large flakes, much lower than the reported ~130 GPa for perfect graphene flakes (Lee, Wei, Kysar, & Hone, 2008). The reasons for this will be explained and the implications of this behaviour for the use of graphene to reinforce the nanocomposites will be discussed.

Key words: Strength, Graphene, Raman.

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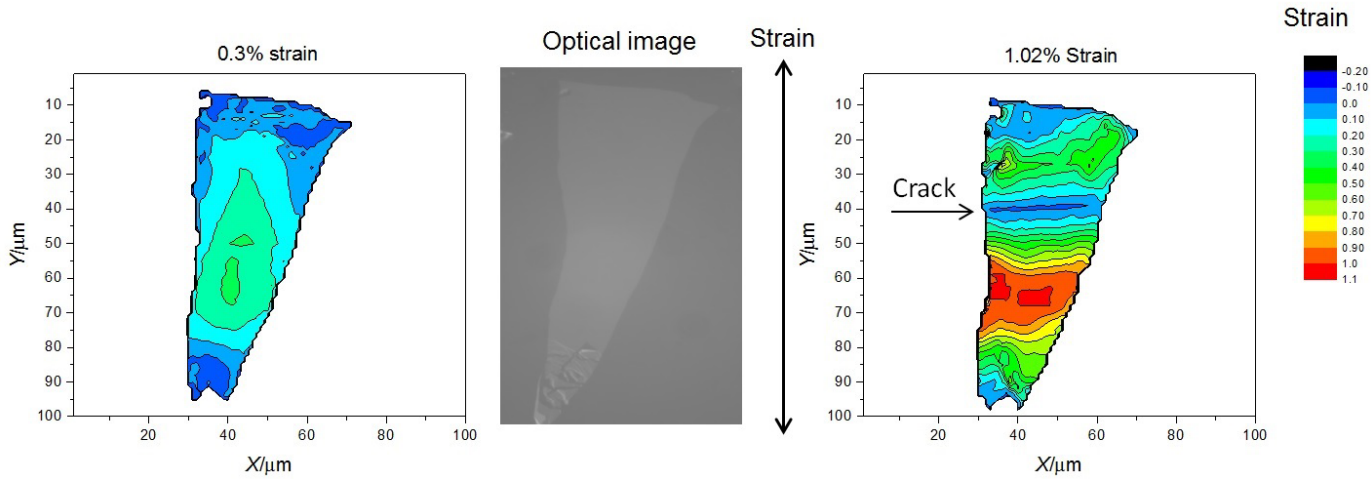

Figure 1. Optical image of a monolayer graphene (middle), initial strain map (left) and strain map up to fracture (right) of the graphene flake.