Poster Session
Subject areas: Polymers, Materials- Nanotechnology

On the compression behaviour of multilayer graphene flakes embedded in gel matrices

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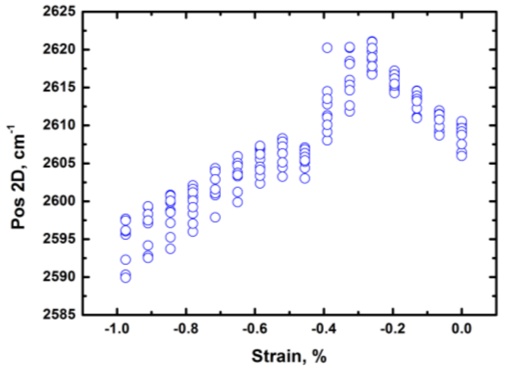
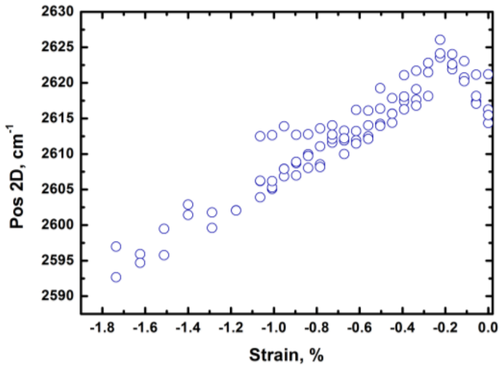
Abstract

In the present study the compression behaviour of multi-layer (≥ two layers) graphene flakes embedded in gel matrices is examined using Raman spectroscopy. The samples were prepared by mechanical exfoliation of graphite and deposited on plastic bars. A thin photoresist polymer film was spin coated on top of the flakes to create a sandwiched sample. The photoresisit polymer is initially in liquid form and after evaporation of the solvent a soft layer is created. Strain is induced on the graphene flakes by bending the plastic bars using a four-point-bending apparatus. The strain is applied incrementally with fine steps (less than 0.1%). At every loading step Raman measurements are collected simultaneously for the 2D and G Raman bands. By monitoring the shift of the Raman bands with respect to the applied strain the compressive behaviour of the graphene, such as the critical strain to failure and the polymer to graphene stress transfer efficiency, can be educed.
The critical strain to failure was found to be about –0.20 % for bilayer graphene, which reduces slightly as the number of layers increases. To obtain some insight on the failure process we performed molecular dynamics simulations employing the AIREBO potential. The interaction of graphene with the simulated walls of the enclosure was adjustable. For a bilayer sample the simulations reveal initiation of wrinkling at multiple points upon compression.
Interestingly, in these experiments an unusual post buckling behaviour of the graphene sheets is observed. First, phonon hardening is observed as expected when the compressive strain is applied. As the applied strain increases a plateau is observed that corresponds to the critical strain of failure (see figure). After the plateau, a phonon softening is observed throughout the range of the applied strain. The interesting part is that the graphene reaches the zero stress state and then is stressed under Poisson induced tensile loading. Since graphene can sustain tensile deformations up to 30%[1], this means that when a multi layer graphene is embedded in gel matrices it can be compressed elastically up to 90 % depending on the Poisson's ratio of the surrounding material. This property makes graphene a unique material for the fabrication of flexible electronic devices and strain sensors.



bilayer



trilayer

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