# AFM/ Raman spectroscopy of CVD graphene onto PET substrate

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Wrinkles are realizations of buckling, a mechanical instability whereby, above a critical applied load, a flat thin film develops out-of-plane undulations. They emerge as a result of the compression of a stiff thin film that is attached to a soft foundation [1]. Wrinkles in ageing skin and drying fruit are characteristic examples of wrinkling in day life thin films. At the nanoscale, graphene as a two dimensional crystal, is a highly compliant material, due to its extremely low bending rigidity [2]. Therefore, wrinkling is an inherent property in graphene and can be easily formed when transferring onto various substrates as a result of the replication of the substrate topography and the transfer process itself. In particular, graphene grown on large area copper foils by chemical vapour deposition (CVD) has to be transferred to other substrates, such as poly(ethylene terephthalate) (PET). During transferring wrinkles are induced as a result of the different

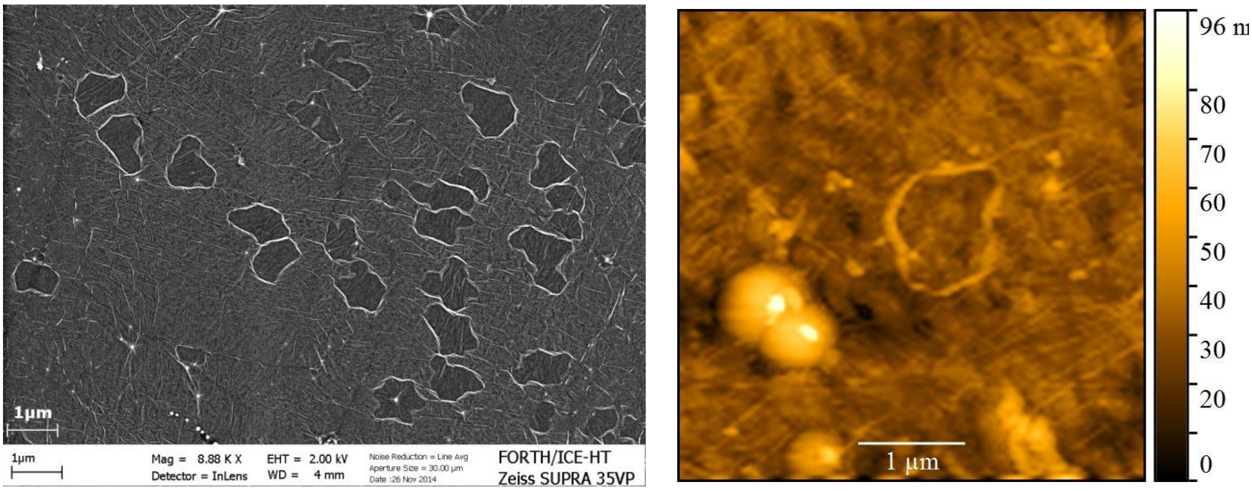


**Fig. 1** a) SEM microphotograph from the CVD graphene laid on a PET substrate, b) AFM image showing an isolated island formed by wrinkling. The height scale bar is in nm.

thermal expansion of the substrates[3]. These wrinkles strongly affect the electronic and mechanical properties of graphene and consequently the optical and electrical properties of graphene-based structures such as transparent electrodes, flexible displays etc.[4,5].

In the present work, Atomic Force Microscopy (AFM) combined with Raman spectroscopy are employed to investigate the wrinkling morphology of monolayer CVD graphene on a PET substrate (CVD graphene/PET). The PET film is nearly flat but the graphene is wrinkled as shown in Fig. 1(a). The wrinkles have the effect of separating the graphene into isolated islands with size of about 1.5 μm, in which the wrinkle height is of the order of 15 nm (Fig. 1b). By conducting a detailed Raman mapping on various islands on the CVD graphene/PET, the Raman fingerprint of the wrinkles is recorded. A simple continuum model that explains the mechanism of the wrinkle formation on CVD graphene/PET is also presented.

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