Transferring Graphene Nanostructures onto a Transparent Flexible Substrate

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Transparent flexible substrates such as polyethylene terephthalate (PET) plastic and polydimethylsiloxane (PDMS) have been ideal substrates for graphene in the application of photovoltaics and flexible electronics [1]. Patterning and transferring large-area graphene nanostructures are crucial to prepare the conductive, transparent, and flexible substrates. Here we introduce a facile and reliable method of patterning graphene directly on a copper substrate [2], followed by transferring the patterned graphene sheet onto a PMDS substrate, maintaining the integrity of its pattern and quality, as illustrated in **Figure 1**. To transfer graphene nano/micro structures, we first patterned the graphene sheet on a copper foil via photolithography followed by an oxygen plasma etching. After removing the photoresist by acetone, we cast PDMS directly on the patterned graphene. In this process, the PDMS pre-polymer and curing agent were mixed by the volume ratio of 10:1 in a plastic cup. The liquid PDMS was then deposited on the patterned graphene, placed in vacuum chamber to remove bubbles. After curing the PDMS for 1 hour at 80 degrees, the copper foil was etched off, resulting in the transfer of the micropatterned graphene sheet on a PDMS substrate. As shown in **Figure 2**, the Raman spectrum of graphene on PDMS exhibits peaks from both PDMS and graphene, with very low D peak from graphene, which is comparable to the signature from graphene patterns before the transfer, indicating that the transfer process is of high quality. The result shows that the method for direct patterning of graphene on copper foil and transferring the patterned graphene sheet onto PDMS substrate provides a facile and reliable way to create graphene patterns on transparent flexible substrates.

[1] *D. Akinwande, N. Petrone, and J. Hone, Nat Commun* ***5*** *(2014).*
[2] *J. Ding, K. Du, I. Wathuthanthri, C.-H. Choi, F. T. Fisher, and E.-H. Yang, J. Vac. Sci. Technol., B* ***32*** *(6) (2014).*

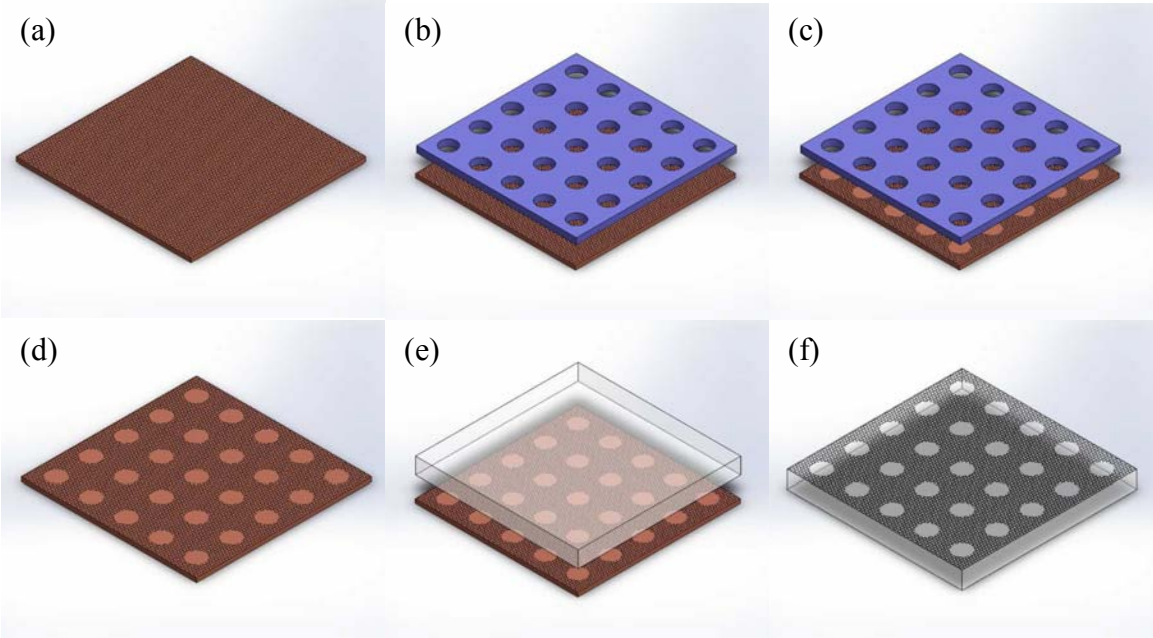

***Figure 1**: Schematic of the fabrication sequence of a micropatterned graphene sheet onto a flexible substrate. (a) A graphene film is grown on a copper substrate by CVD. (b) The graphene stack is spin-coated with photoresist, which is patterned by photolithography. (c) The micropattern is transferred from photoresist onto graphene by oxygen plasma etching. (d) The photoresist atop graphene is removed by acetone, leaving micropatterned graphene on copper foil. (e) Liquid PDMS is directly cured on graphene surface. (f) By etching off copper foil, the graphene structures on transparent flexible substrate is obtained.*

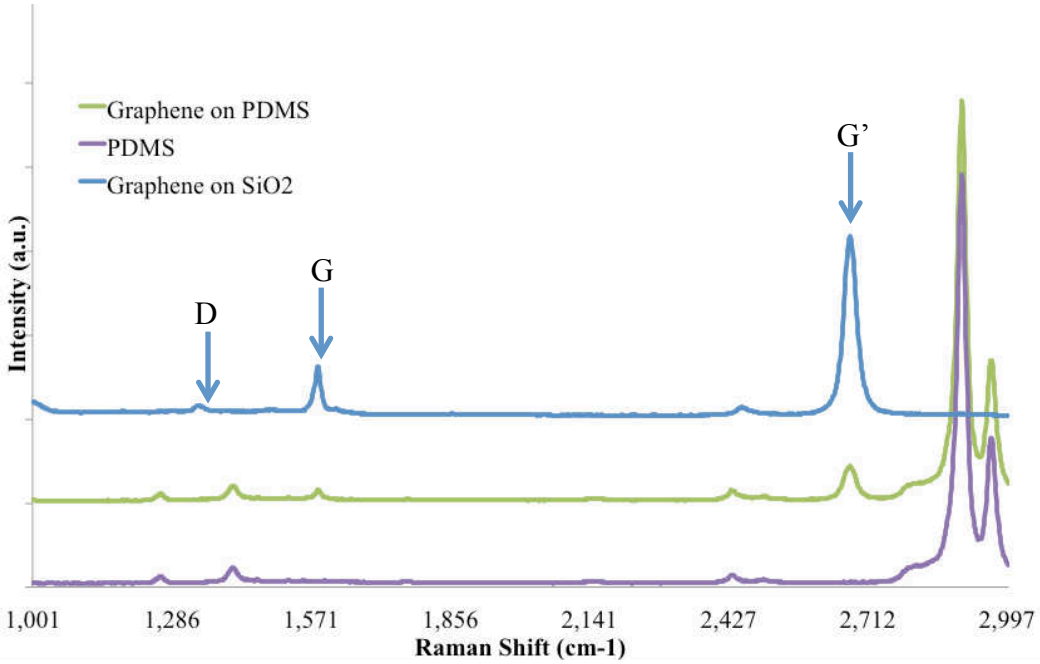

***Figure 2**: Raman spectra of PDMS, graphene on SiO_2, and graphene on PDMS.*