Graphene Capture Using Nanowebs for Sensor Applications

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Abstract

Graphene (G) has attracted considerable attention because of its excellent physical properties and potential electronic and spintronic applications. Synthesis is most commonly by chemical vapor deposition (CVD) and surface precipitation methods on transition metals such as copper (Cu) and nickel (Ni). To capture the G layer without damage or distortion, it is first coated with a supporting material such as a polymer and the metal etched away from below. The supported graphene is then transferred to another substrate such as glass or silicon and the supporting layer is removed. The advantage of these methods is that large areas of defect-free G can be obtained.

The most common supporting materials are poly(methylmethacrylate) (PMMA) or polydimethylsiloxane (PDMS). However, it is difficult to remove the polymer support after transfer. The R2R (Roll to Roll)[1] transfer using thermal release tapes is particularly efficient for flexible target substrates. Nevertheless, this method is not suitable for rigid substrate such as ITO, glass or silicon.

We have developed novel transfer techniques using Nanowebs for the first time as supporting structures which allow CVD graphene to be transferred directly onto chosen polymers or substrates for certain applications without the use of PMMA or PDMS coatings. We use materials such as directly spinnable carbon nanotube (DSCNT) webs and electrospun (E-spin) nanowebs of any required polymer. The nanowebs are deposited directly onto the graphene/metal substrate and are able to efficiently support the Graphene during etching.

The DSCNT was prepared according to our published methods[2]. From one to eight layers of highly aligned web was used to recover the Graphene. E-spun nanoweb was prepared as previously reported[3] using PVDF for this study. Fig. 1 illustrates DSCNT and E-spun nanoweb respectively being deposited onto the Graphene sheet.

These techniques can be used to fabricate a number of devices such as flexible electronics, solar cells, batteries, sensors etc. To test the effectiveness of graphene captured using nanowebs we've fabricated sensors made from CNT-web- (8 layers) and electrospun-supported Graphene for biosensor. We have obtained sheet resistance of 240 Ω/ sq for DSCNT, 600 Ω/ sq for Graphene, 156 Ω/ sq for G on DSCNT webs (8 layers) and 1070 Ω/ sq for G on PVDF nanowebs.

Fig 2a and b show cyclic voltammetry results using potassium ferrocyanide as redox probe. Higher electron transfer rates for CNT and E-spun supported Graphene were achieved when used to modify electrodes compared with bare glassy carbon electrodes.

We also capture G with a single layer of CNT web and fabricated organic bulk heterojunction devices for transparent electrode solar cell devices. Table 1 shows that G captured by PMMA has maximum efficiency of 1.64%, while DSCNT web (1 layer) has 1.84%. Significant improvement was found for device from G on DSCNT web. Although the transparency was lower,it is still within the acceptable range for transparent solar cells.

References

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Figures

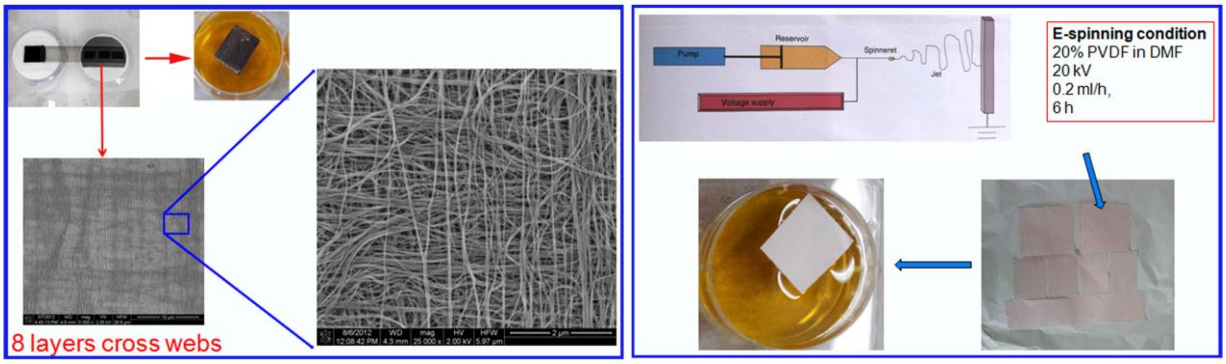

Figure 1. DSCNT and E-spun nanoweb is being deposited over the Graphene sheet respectively (from left to right)

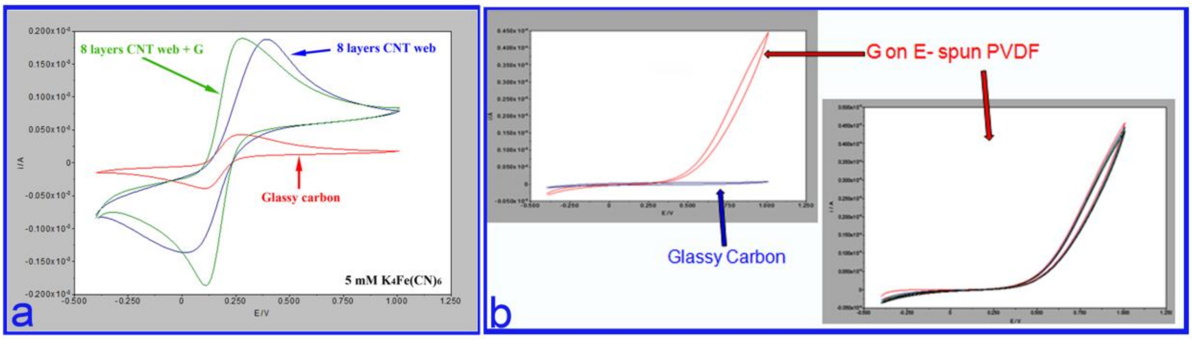

Figure 2. Cyclic voltammetry using $K_4Fe(CN)_6$ for G on DSCNT webs (a) and G captured by E-spun nanowebs (b)

Solar cell samples	Max efficiency (%)	Transparency
ITO	3.3	85.00
Graphene captured using PMMA	1.64	77
DSCNT Web	1.84	80
Graphene on DSCNT web (no PMMA)	2.25	68

Table 1. Maximum efficiency (%) and transparency for organic bulk heterojunction devices