Laser-patterning of graphene oxide beyond the diffraction limit

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Graphene oxide (GO), same as graphene itself, attracted a tremendous attention since its re-discovery in 2004. [1]. Main advantages of GO are: water dispersible, flexible and the greatest one its tunable conductivity. Conductivity changing due to reduction process, during which dielectric GO becomes to conductive reduced graphene oxide (rGO). Reduction could be done in different ways, but all of them are either chemical or thermal [2].

The most part of reduction methods are ex-pensive and not scalable, for example reduction using atomic force microscopy (AFM) tip or electron beam [3][4]. The other limitation of these methods is that they attracted all volume of material.

We used laser irradiation to provide external energy for the thermal annealing at the local area of GO thin film (selective reduction). From other side this method is cheap, eco-friendly and easy to perform.

Using this method, anyone can make electrical circuits of different shapes at the flexible transparent substrates with carbon nanowires, made beyond the diffraction limit without special equipment and conditions. To pattern rGO conductive lines we used different substrates and different lasers: CO2 laser with λ=1064 nm and portable laser engraver with λ=405 nm. Figure 1 demonstrated rGO pattering by the laser irradiation.

The key result of this contribution came out after applying the highest laser power. Even though the patterned material was completely ablated in some regions, we still observed a significant electrical conductivity along the pattern (Figure 2). This observation implies that by optimizing the laser parameters, and under higher power than has been reported previously, it is possible to achieve confined rGO regions: the edges of the patterns. Conductive rGO patterns can thus be achieved with spatial dimensions much smaller than the laser spot size.

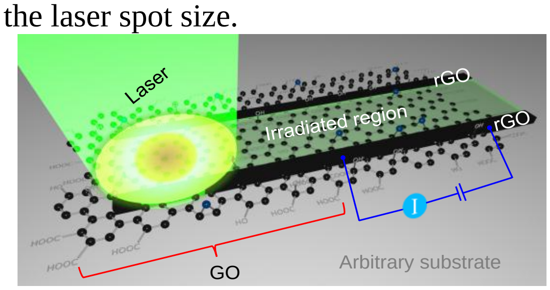

Figure 1: Schematics of the laser reduction of graphene oxide.

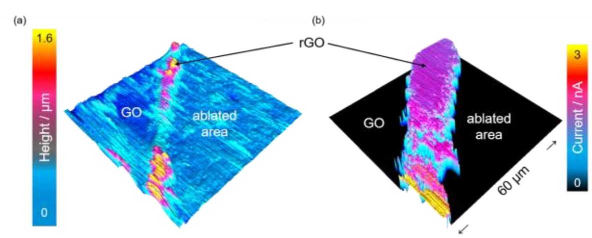

Figure 2: a) Topology of one rGO line.b) Current map of the same single rGO pattern.

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