The substrate matters in the laser-reduction of graphene oxide

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Graphene oxide (GO), same as graphene itself, attracted tremendous attention since its re-discovery in 2004 [1]. GO is water dispersible, flexible material with the advantage of tunable conductivity. Conductivity changes due to the reduction process, during which dielectric GO converts to conductive reduced graphene oxide (rGO). The reduction could be made in different ways, but all of them are either chemical or thermal [2].

Most reduction methods are either expensive or not eco-friendly, and the main problem for its application in microelectronics is the reduction of full film area [3][4]. Based on these shortcomings we use laser irradiation to perform the reduction. This method is inexpensive, 'green,' and allows us to make a local reduction in arbitrary patterns.

Using this method, anyone can make electrical circuits of different shapes on flexible substrates with carbon microwires, made without special equipment and conditions. To pattern rGO conductive structures we used different substrates and laser engraver with λ=405 nm.

We report a significant difference in the degree of reduction between samples with different substrates (the degree of reduction determined by optical, thermal, and electrical properties) with other parameters the same (laser and atmosphere). For example, on glass, the reduction is inferior with resistance more than 500 kOhm, but on PET the rGO resistance decreased to 1 kOhm. The difference in the degree of reduction and was so evident that the naked eye could see it.

We decided to investigate how the degree of reduction depends on the substrate, and which substrate properties make the most influence on the laser reduction of GO (optical, chemical, or thermal). We use two types (white and transparent) plexiglass substrates to investigate polymer substrates with different chemistry. Using a 4 point-probe experiment, we obtain the following results: Transparent PMMA@89.4 Ω/sq and white PMMA @104.7 Ω/sq.

Therefore, contrary to our initial expectations, it is not the optical properties of the substrate what plays the most significant role but the thermal conductivity. This is evidenced by the thermal conductivity differences $1.05 \cdot 10^{-2}$ for glass *vs.* $0.2 \cdot 10^{-2}$ *W/(cm·K)* for PET and PMMA.

References

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3. Jeffrey M. Mativetsky et al., Am. Chem. Soc., 132 (2010) 14130 –14136
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Figure

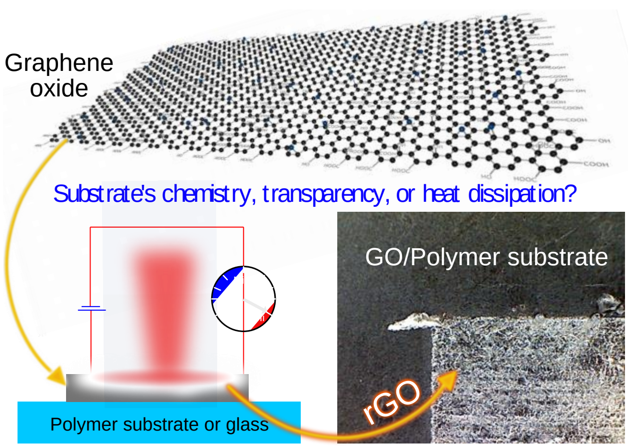

Figure 1: Sketch of the main experiment and the substrate parameters determining the level of laser reduction of GO.