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Transport of sulfur species in a microwave argon plasma column for functionalization of CVD-grown graphene films

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Abstract content

Synthesis of graphene-sulfur compounds has recently been demonstrated in a two-chamber quartz ampoule with distinct temperature treatment conditions [1]. While the sulfur's chamber is heated to 200 °C for graphene atomization, the graphene's chamber is heated to 370 °C for hours for graphene functionalization. This experience is realized in an enclosed system in an argon atmosphere at around 10 Torr. While graphene-sulfur compounds show a brilliant future for the development of cheap and green energy storage devices, the original technique proposed by Martel and al. [1] produces only a limited amount of graphene-sulfur bonds. In line with the initial idea, we have examined the possibility to sustain a microwave plasma in the quartz ampoule in order to promote sulfur atomization and transport from one chamber to the other and/or to enhance graphene functionalization. The objective is to rise the process efficiency for technological applications.
As a first step, the microwave argon plasma was sustained using a surfatron at 915 MHz without sulfur, the argon plasma is always localized and contracted at the top of the discharge ampoule. In such conditions, optical emission spectroscopy mostly reveals emission lines from Ar 2p-1s transitions without any significant contribution from impurities. Detailed analysis of the broadening of the Ar 2p2-1s2 and 2p3-1s2 emission lines at 826 nm and 841 nm [2] further indicates significant neutral gas heating. This result is consistent with the relatively high electron densities in the plasma channel estimated from microwave interferometry.
Time and space-resolved optical emission spectroscopy was then used to track sulfur species with solid sulfur placed in the first-chamber quartz ampoule with the plasma on. In such conditions, significant blue emission linked to the B-X system of S_2 was seen. Such emission being a very sensitive measure of the sulfur concentration [3], it was used to probe the onset of sulfur atomization as well as its transport properties. In upcoming weeks, plasma treatments of CVD-grown graphene films with and without sulfur will be realized. Plasma-treated graphene will be characterized by hyperspectral Raman Imaging [4].

References

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