Liquid phase exfoliation of graphene in hydrocavitating labs-on-a-chip

X. Qiu[a], V. Bouchiat[b], D. Colombet[a], F. Ayela[a]

[a] *LEGI, Univ. Grenoble Alpes, 38000 Grenoble, France*
[b] *Institut Néel, Univ. Grenoble Alpes, 38000 Grenoble, France*

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Abstract

Graphene, a single layer of graphite, has attracted a great deal of interest due to its extraordinary properties in mechanical and electronic domains. However, massive production of few layers graphene has so far been very limited. Nowadays, liquid phase exfoliation is considered as one of the most promising process for production of multi-sheets on a large scale. Acoustic cavitation has been widely used by researchers because of its simplicity of implement, but ultrasound leads to damage in the graphene structures. Hydrodynamic cavitation and single liquid phase have been reported to exfoliate graphite as well. However, input pressure should increase up to 200 bar. Indeed, bubbles collapse and flow shear rate have both been proposed as possible exfoliation mechanisms. From a fundamental and application point of view, it would be interesting to know which force could lead a more effective exfoliation. These questions reach to the core of our research project devoted to the liquid phase exfoliation of graphene in labs-on-a-chip. In our application, lab-on-a-chip is a silicon Pyrex microfluidic device that integrates a localized micro step giving way to a gap of height $\approx 130\ \mu m$. The main advantage provided by this system lies in the wide range of the flow regimes that can be studied with a given set of reactors, such as laminar or turbulent single liquid phase flow, and cavitating two phase flow, with a pressure drop below 10 bars[1]. Fig.(1) shows an outline of graphene exfoliation by lab-on-a-chip. Up

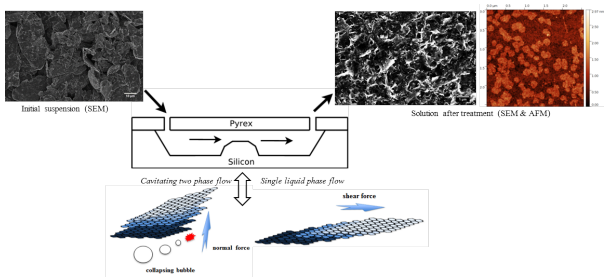

Figure 1: Liquid phase exfoliation of graphene in lab-on-a-chip

to now, we have studied microflows in which exfoliation is the consequence of the high shear rate of the flow and of the collapse of bubbles. The solution was initially a graphite powder suspension with a solid concentration of 50 g/L. The aqueous suspension is stabilized by a surfactant. It was processed during 2016 cycles, under a pressure drop of 10 bar and with a flow rate of 16 liters per hour. The effective time during which each microparticle has been submitted to high shear rate and cavitation is around 6 seconds. Recent results have demonstrated that such hydrodynamic cavitation on a chip could exfoliate the graphite suspension in a homogenous way. Monolayers and multilayers of graphene have been obtained after the cavitation treatment. The production of monolayers and multilayers of graphene with a high yield and a low cost is promising for many applications.

References

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