Licentiate Seminar

Liquid exfoliation of molybdenum disulfide for inkjet printing

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Abstract

Since the discovery of graphene, much efforts have been made in the synthesis and production of 2D materials. Industrial scalable methods to produce high quality exfoliated nanosheets have been a great challenge. One of the most promising methods to achieve this is through liquid based exfoliation.

To date the best solvents to disperse and stabilize nanosheets without additives such as surfactants, were organic solvents but considering the low throughput achieved, the use of organic solvents may not be viable economically and also not environmental friendly. We discuss in this thesis the use of water as a solvent to exfoliate molybdenum disulfide (MoS_2), a layered material like graphene but with the difference of being a semiconductor with a large band gap, especially if exfoliated into a monolayer. The study of such 2D material is fundamental for applications such as transistors where graphene cannot be employed unless a bandgap is introduced into the material by costly engineering methods. The method here described could be easily employed to exfoliate other 2D materials as well, and it consist of two exfoliation steps one in the bulk powder using sand papers and the other in the liquid dispersion using probe sonication.

The dimensions of the nanosheets after liquid exfoliation were around 200 nm, the same range obtained in organic solvents. Electrophoretic mobility measurements indicated that electrical charges may be responsible for the stabilization of the dispersions.

Once the dispersions of 2D materials can be produced in large scale, methods to apply this into large areas are necessary. Here we discuss the use of surfactants such as sodium dodecyl sulfate (SDS) and other adjustments necessary to adapt the dispersions for printing electronics. Inkjet printing methods employ only low amounts of the dispersion, the drops are produced on demand and can be deposited to specific areas of many substrates types, here we used paper and a polyethylene film. Considering the low concentration of these dispersions this may be one of the most suitable methods for transferring the nanosheets from the liquid phase to the substrates. Further development of the dispersions is necessary to adapt to the printing method and is discussed as future work.

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