High-quality graphene-based dispersions for flexible electronics

Pedro Alpuim[1,2]
Sergej Tkachev[1], Miguel Monteiro[1], Andrea Capasso[1], Pedro Marques[3]
[1]*International Iberian Nanotechnology Laboratory, Av. Mestre José Veiga s/n, Braga, Portugal*
[2]*Department of Physics, Universidade do Minho, Campus de Gualtar, Braga, Portugal*
[3]*Displax, S.A. Rua Soldado Manuel Pinheiro Magalhães 68, Braga, Portugal*
pedro.alpuim.us@inl.int

Abstract

The development of graphene-based nanomaterials for flexible electronics is of high interest for the industry [1]. Graphene-based liquid dispersions are suitable for the deposition of films with high electrical conductivity, transparency, and flexibility at low cost that are compatible with a wide range of substrates [2,3]. To date, graphene dispersions present some limitations, in particular the use of efficient, yet hazardous solvents with limited substrate compatibility, high boiling point and toxicity, which are all undesirable features for industrial production. We propose a novel approach to produce graphene-based dispersions with high yield and control on the material properties. By using a combination of shear mixing and ultra-sonication with tuned conditions (such as time, frequency, and power), we obtained stable graphene dispersions with concentrations above 4 mg/mL (with lateral size of the graphene flakes between 30 and 500 nm, fig.1). The dispersions can then be deposited by several techniques (e.g., spray coating, inkjet and screen-printing, etc.) on various substrates to fabricate films with desired levels of transparency and conductivity. In our tests, specific formulations for spray coating were prepared by mixing the graphene-based dispersions with polymeric additives. These formulations were used to spray-coat films on flexible PET and glass substrates, achieving an optical transmission (in the visible range) of 70-91% and a sheet resistance of 0.35-4 kΩ/□. An essential contribution towards the use of graphene inks is provided in this work by the use of a new green carbon solvent – Cyrene, which was able to replace toxic and hazardous solvents such as NMP and DMP in the exfoliation process, and allowed to produce highly concentrated and stable graphene-based dispersions with a very narrow distribution of graphene flake sizes.
As a proof of concept, a 20x20 channel multi-touch screen prototype was successfully fabricated on PET by spray coating our graphene ink through polymeric masks cut in a microplotter (see fig.1). Silver inks were prepared for the contacts, providing electrical connection to the graphene sense channels. PET films were treated in plasma for 5 sec to improve the wettability and adhesion.
.

REFERENCES

[1] W. Kong, H. Kum, H., S. Bae, et al., Nat. Nanotechnol. 14 (2019) 927.
[2] Y. Hernandez, V. Nicolosi, M. Lotya, F.M. Blighe et al., Nature Nanotech. 3 (2008) 563.
[3] A. Capasso, A.E. Del Rio Castillo, H. Sun, A. Ansaldo, et al. Solid State Comm. 224 (2015) 53

FIGURES

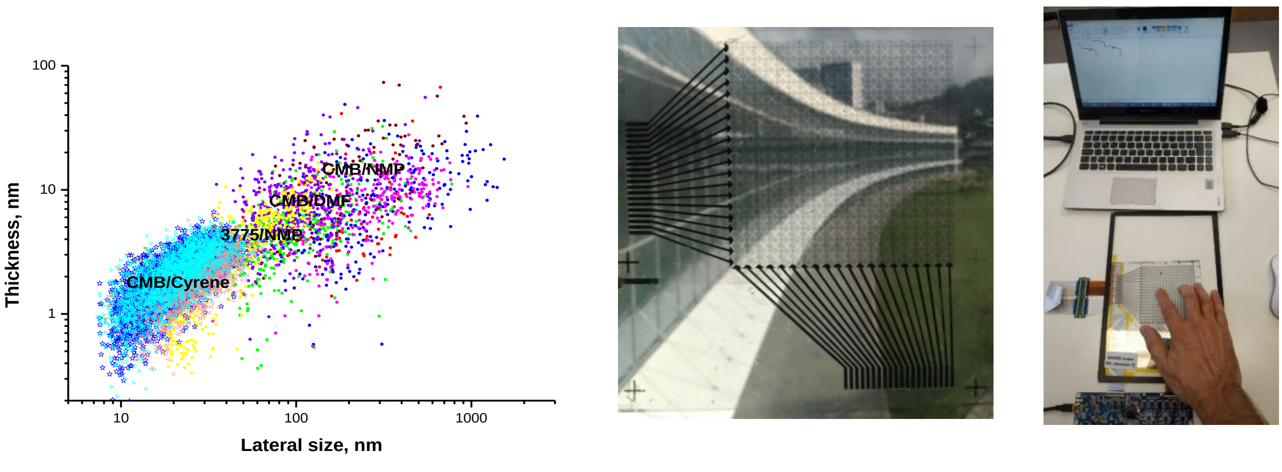

Figure 1: (left) AFM study of graphene flakes selected from their dispersions in different solvents (NMP, DMP, Cyrene); (center and right) graphene 20x20 channel multi-touch screen fabricated on PET.