Graphene ink created for ink-jet printing of electronic components

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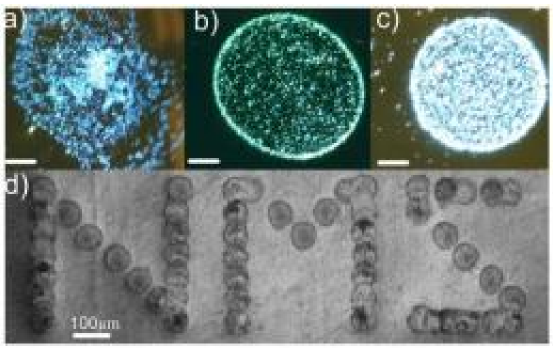

Dark field optical micrograph of inkjet printed drops on a) plasma cleaned, b) pristine and c) HMDS treated substrate. Scale: 20μm. d) SEM micrograph of printed pattern. Image from arXiv:1111.4970v1 [cond-mat.mtrl-sci]

(PhysOrg.com) -- A group of UK scientists has created a graphene ink that can be used to ink-jet print electronic devices such as thin film transistors.

Professor of Nanotechnology, Andrea Ferrari, and colleagues from the Engineering Department at the University of Cambridge have developed a method of creating a graphene ink that can be used with a modified ink-jet printer. Graphene consists of a hexagonal lattice of carbon only one atom thick, and has great advantages over polymer inks because of its greater electron mobility and electrical conductivity. Electronic components such as thin film transistors (TFTs) can already be created using ink-jet printing with ferro-electric polymer inks, but the performance of such components is poor and they are too slow for many applications.

Beginning with flakes of pure graphite, the team exfoliated layers of graphene using liquid phase exfoliation (LPE), which consists of sonication of the graphite in the presence of a solvent, N-Methylpyrrolidone (NMP). The graphene layers were ultracentrifuged and then filtered to remove any particles large enough (>1μm in diameter) to block the ink-jet printer heads. The graphene flakes were then used as the basis for a graphene-polymer ink, which was printed, using a modified ink-jet printer, onto Si/SiO_2 substrates and the transparent substrate borosilicate glass. The final step in the process was annealing at high temperature to remove the solvent.

They demonstrated the new transparent graphene ink by using it to ink-jet print thin-film transistors, which they made by printing the graphene ink on Si/SiO_2 wafers. They used chromium-gold pads to define the source and drain contacts, and they then printed a layer of an organic polymer, PQT-12, on top.

The team achieved promising results at least comparable to current inks. They achieved mobilities of up to around $95cm^2V^{-1}s^{-1}$, about 80% transmittance and 30kohm sheet resistance. Non-graphene polymer inks typically achieve mobilities of less than $0.5cm^2V^{-1}s^{-1}$, while adding carbon nanotubes can increase this to around $50cm^2V^{-1}s^{-1}$.

The results should improve as the method is refined and enhanced. Their successful first demonstration paves the way for the development of flexible and cheap electronics that can be printed on a wide variety of substrates. Devices printed using graphene inks could include wearable computers, electrical paper, sensors, electronic tags, and flexible touch screens.

The paper is available online from arXiv.org.

More information: Ink-Jet Printed Graphene Electronics, arXiv:1111.4970v1 [cond-mat.mtrl-sci] arxiv.org/abs/1111.4970

Abstract
We demonstrate ink-jet printing as a viable method for large area fabrication of graphene devices. We produce a graphene-based ink by liquid phase exfoliation of graphite in N-Methylpyrrolidone. We use it to print thin-film transistors, with mobilities up to~95cm^2V^(-1)s(-1), as well as transparent and conductive patterns, with~80 % transmittance and~30kOhm/sq sheet resistance. This paves the way to all-printed, flexible and transparent graphene devices on arbitrary substrates.