Metal-doped graphene monolayers on plastic : a highly flexible 2D superconducting film

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Graphene, with its exposed 2D gas of high mobility charges, is the ideal platform for the realization of hybrid devices obtained by direct physisorption of electronically active adsorbates. For example, a global superconducting 2D material can be obtained[1] by deposition of superconducting metal clusters (submicron tin dots) directly on the graphene surface.

Previous studies have shown that such a tin/graphene hybrid acts as a gate tunable superconducting to insulator material[2]. Graphene is also seen as a wonder material for the field of flexible electronics[3] because it can maintain its outstanding properties while being integrated with flexible substrates.

Here, we combine those two fields to create an ultrathin and flexible hybrid superconductor made of graphene.

We realize a large-scale (>10 cm^2) metal/graphene hybrid on polymer thin films (Fig1a). The material is fabricated by depositing 20 nm of tin (Sn) by Physical Vapour Deposition (PVD) on a CVD-grown graphene monolayer previously transferred on a 10µm-thick polymer film. Due to the high surface mobility of tin on graphene, a random non-percolating network of tin clusters is naturally formed by self-assembly (Fig1b), leading to a 2D array of Josephson junctions. We probe at low temperature this ultrathin superconductor with super-high mechanical flexibility.

Our measurements highlight both its high transversal magnetic field susceptibility and its high critical current (Fig2).

The high sensitivity of the superconducting current to the transverse magnetic field is a hallmark of 2D superconductivity. This new material could have applications in cryogenic systems requiring thermal or mechanical isolations while maintaining zero resistance electrical connectivity.

References

[1] B. Kessler et al. Physical Review Letters 104 (2010) 047001
[2] A. Allain et al. Nature Materials 11 (2012) 590-594
[3] D. Sun et al Small, 9, No. 8, (2013) 1188–1205

Figures

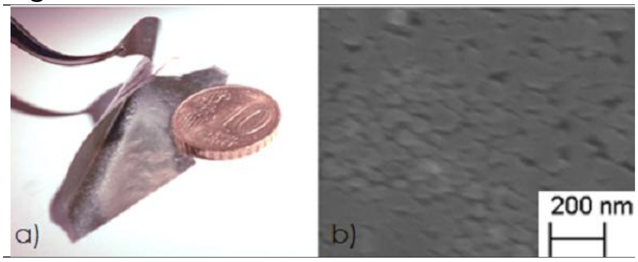

Figure 1: a)Photograph of the superconducting flexible film, composed of a metal-doped graphene sheet transferred on a polymer film. b)Scanning electron micrograph of tin clusters evaporated on a graphene sheet

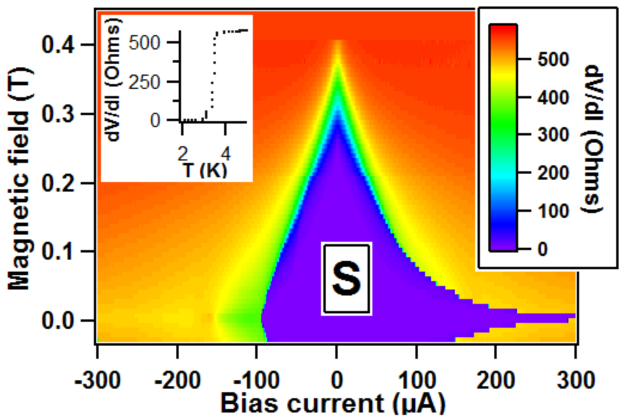

Figure 2: Four-probe measurement of the magnetoresistance of the metal-decorated graphene transferred on plastic as function of a DC bias current. The "S" region is the superconducting domain, in which the differential resistance is zero (purple).
Inset: Evolution of the hybrid structure resistance as function of the temperature. The critical temperature is 3.6K.