FIELD EMISSION FROM SINGLE AND FEW-LAYER GRAPHENE FLAKES

S. Santandrea[a], **F. Giubileo**[a], **V. Grossi**[b],
S. Santucci[b], **M. Passacantando**[b], **T. Schroeder**[c],
G. Lupina[c] and **A. Di Bartolomeo**[a]

[a]Dipartimento di Fisica, Centro NANO_MATES, Università degli Studi di Salerno,
and CNR-SPIN Salerno, via Ponte don Melillo, 84084 Fisciano (SA), Italy
[b]Dipartimento di Fisica, Università degli Studi dell'Aquila, via Vetoio, 67100 Coppito, LAquila, Italy
[c]IHP, Im Technologiepark 25, 15236 Frankfurt (Oder), Germany

Graphene, consisting of a single- or few-graphite layers, has a very high aspect ratio (thickness to lateral size ratio) and a dramatically enhanced local electric field is expected at its edges; it shares many similar or even superior properties as carbon nanotubes (CNTs) and, as CNTs, has high potentiality for field emission (FE) applications [1-3]. So far, most of the work has been performed on graphene films [4,5] or on graphene/polymer composites [6] reporting FE from graphene edges or pleats at low applied fields; no observation of FE current from the inner, flat part of graphene flakes has been reported [7]. We report observation of FE current from the inner, flat part of single- and few- layer graphene flakes, which can make the fabrication of graphene based cathodes easier for FE applications [8].

Single- and few-layer graphene sheets were prepared by mechanical exfoliation of highly ordered pyrolytic graphite and transferred by scotch-tape method on SiO_2 layer thermally grown on p-type Si substrate. The thickness of the SiO2 layer was chosen to $\sim$300 nm. Raman spectroscopy was further exploited to give confirmation of the single- or few-layer graphene. Taking advantage of a special setup, consisting of a two-probe nanomanipulation system (two tungsten tips with curvature radius $<$100 nm) operating in a scanning electron microscope (SEM) and connected to external source measurement units (SMUs), we investigate FE currents by applying electric fields up to 2 kV/μm. The tips, one in contact with graphene and the second at a varying distance from it, were used as the cathode and the anode, respectively.

We show that a high and stable FE current (up to 1 μA), well described by the usual FowlerNordheim (FN) model over five orders of magnitude, can be achieved with a turn-on field of $\sim$600 V/μm. This high field is not surprising since the electrons are emitted from a flat surface, which do not benefit from the high field enhancement factor of a tiplike shape. We tested also the emission stability from the flat inner part of single-layer graphene flake, due to its relevance for practical applications. Experimentally, we applied a constant bias and monitored the current over periods of several hours, over which a stable process was confirmed.

References

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