Graphene-based Materials for Supercapacitors

Daniele Pontiroli[1]
Giacomo Magnani[1], Silvio Scaravonati[1], Laura Fornasini[1], Giovanni Bertoni[2] and Mauro Riccò[1]

1-Dipartimento di Scienze Matematiche, Fisiche e Informatiche, Università degli Studi di Parma, Parma, Italy
2-IMEM-CNR, Parma, Italy

daniele.pontiroli@fis.unipr.it

Supercapacitors (SCs) are devices for energy harvesting and storage, bridging the gap between capacitors and rechargeable batteries, based on the electrostatic charges accumulation at the surface of highly porous electrodes [1]. The ideal material for SCs is carbon, thanks to its low cost, good electrical conductivity, high polarizability, excellent mechanical strength and large specific surface area (SSA, theoretical 2630 m2/g in graphene) [2].
In this work we exploit several graphene materials, either in their pristine form, or decorated with metal oxide nanoparticles (NPs), as novel electrodes for high-performance SCs. Graphene was obtained from the thermal decomposition of graphene oxide (GO), following two different approaches. In the first case, GO (Brodie method) was exfoliated by thermal treatment in an oven under dynamical vacuum (TEGO) [3]. The material (SSA~ 600 m^2/g) was decorated with Ni NPs with average diameter of 20 nm (Ni-TEGO) following a precise synthesis protocol [4]. Samples were then dispersed in H_2O and ethanol, mixed with a binder and the slurry was drop-casted in a PTFE die and dried, to obtain the electrode disks. In the second case, GO (Hummers method) was dispersed in H_2O, spread on a PVC foil and cut in order to cover the writable surface of a DVD. Then, the GO film was burnt with the laser of a DVD writer (LightScribe® technology[5]) and converted in graphene (LSGO). Decoration of LSGO with TiO_2 nanoparticles (diameter down to 5 nm) was obtained by mixing the GO solution with Ti-isopropoxide before the laser treatment (TiO_2-LSGO). TEGO and Ni-TEGO SCs have been assembled in coin cells (CR-2032) with aqueous electrolyte (KOH). On the contrary, LSGO and TiO_2-LSGO SCs have been manufactured with a planar and flexible geometry, with interdigitated electrodes covered by a gel electrolyte (H_2SO_4- or H_3PO_4-PVA). Specific capacity (C_s) of TEGO SCs has enhanced by 70% by Ni NPs. In case of LSGO SCs, C_s has increases by 300% in the presence of TiO_2 NPs, reaching the highest value of 150 F/g for devices operating with H_3PO_4-PVA electrolyte [6]. The improvement of performances was ascribed to the combination of the graphene-based material with metallic oxides NPs, to form a nanoscale-mixed composite electrode.

References

[1] F.Beguin et al.,Adv.Mater. 26(2014) 2219.
[2] E.Frackowiak et al.,Carbon 39(2001)937.
[3] M.Riccò et. al.,Nano Lett. 11 2011)4919.
[4] M.Gaboardi et al., J.Mat.Chem.A 2 (2014) 1039.
[5] M.F.El-Kady et al.,Nat.Com.4(2013)1475.
[6] D.Pontiroli et al., man. in preparation.

Figures

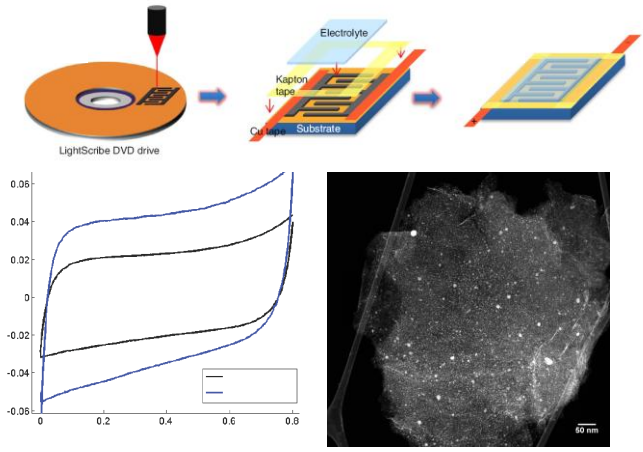

Figure 1: *Up:* Sketch of the preparation of interdigitated TiO_2-LSGO SC (ref. 5). *Left:* CV measurements on TEGO and Ni-TEGO SCs. *Right:* STEM image of a TiO_2-LSGO flake.