Energy storage in 3D graphene composites

Meganne Christian[1]
Zhenyuan Xia,[2] Luca Ortolani,[1] Rita Rizzoli,[1] Francesca De Giorgio,[3] Catia Arbizzani,[3] Vincenzo Palermo,[2] Vittorio Morandi[1]

1. *IMM, CNR, Bologna, Italy*
2. *ISOF, CNR, Bologna, Italy*
3. *Department of Chemistry, University of Bologna, Bologna, Italy*

christian@bo.imm.cnr.it

Ultra-light 3D graphene structures called graphene foams may be produced top-down via chemical exfoliation methods,[1] but they suffer from relatively poor electrical conductivity due to oxidation defects and poor mechanical robustness. Alternatively, high quality graphene foams with very high conductivity may be produced bottom-up via Chemical Vapour Deposition.[2] These unique structures have been investigated for a wide range of applications, such as electrodes in batteries and supercapacitors, biological scaffolds, sensing, and many others.

We describe our research into using these graphene foams in supercapacitors. Alone, the capacitance of the foams is very low, but it may be significantly improved by the addition of a coating of metal oxide nanoparticles such as Fe_2O_3. We developed and optimised an electrochemical procedure for the deposition of Fe_2O_3 nanowalls uniformly across the whole structure. In this way, we could reach a capacity of over 300 F/g. However, the capacity significantly decreased over extended cycling due to detachment of and damage to the metal oxide layer.

To overcome this problem, we added a protective layer of electrochemically-exfoliated graphene oxide (EGO, Figure 1), which successfully stabilised the structure during cycling, with capacities reaching 400 F/g (Figure 2). Using this technique, it will be possible to produce optimised graphene foam composites with very high capacities and even hybrid structures using other metal oxides.

References

[1] Xia et al., Carbon, 84 (2015) 254-262
[2] Chen et al., Nature Materials, 10 (2011) 424-428

Figures

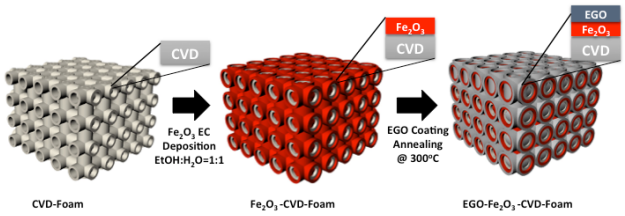

Figure 1: Procedure for the production of EGO-Fe_2O_3-GF composites

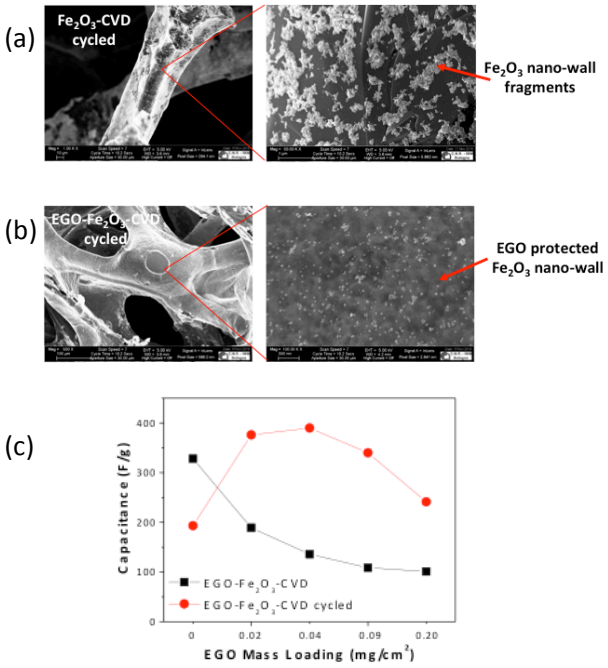

Figure 2: SEM images of (a) Fe_2O_3-GF and (b) EGO-Fe_2O_3-GF composites after cycling, and (c) capacitance behaviour at different loadings, showing the successful protection of the structure by the EGO layer