Laser-assisted synthesis of porous graphene-like structures for electrochemical energy storage

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3D graphene-based porous networks have proven to be excellent candidates for electrochemical energy storage as they combine a considerable specific surface area with good electronic conductivity and light weight. Currently, most synthesis protocols rely on wet-chemistry or high temperature processes, often requiring the use of harmful reagents or inert atmosphere. An alternative synthesis method involves the use of laser sources. Laser-induced graphitization relies on the high energy of the laser pulses which can decompose a carbon-based precursor and form a porous 3D graphene-like network. Laser-based approaches have been recently employed by our group for the "dry" preparation of turbostratic graphene-based structures by decomposing a diverse group of precursors including biomass [1], phenol-based resins [2] and polymers [3]. The simultaneous irradiation of two different precursors can provide graphene-/nanoparticles hybrids with enhanced functionalities [4]. The use of industrial-type laser sources operating at ambient conditions testify towards a "green" process, able to provide electrode materials. The process is compatible with additive manufacturing, providing the flexibility to directly fabricate patterned electrodes onto a desired substrate. Such a material synthesis approach enables the fabrication of flexible or even stretchable electronic components, which are compatible with smart textiles. Here, we will present recent results on the production of porous graphene-like structures and nanohybrids arising from the decomposition of various precursors. Physicochemical characterization revealed that the materials exhibit high sp^2/sp^3 and C/O ratios. Also, the graphene-like structures are highly crystalline and demonstrate increased interlayer spacing, i.e. turbostratic arrangement. The graphene-like materials were evaluated as supercapacitor electrodes.

References

[1] Athanasiou M. et al., Carbon, 172 (2021) 750-761
[2] Samartzis N. et al., Chem. Eng. J., 430 (2022) 133179
[3] Samartzis N. et al., Carbon, 201 (2022) 941-951
[4] Bhorkar K. et al., npj 2D Mater. Appl., 6 (2022) 56

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Figures

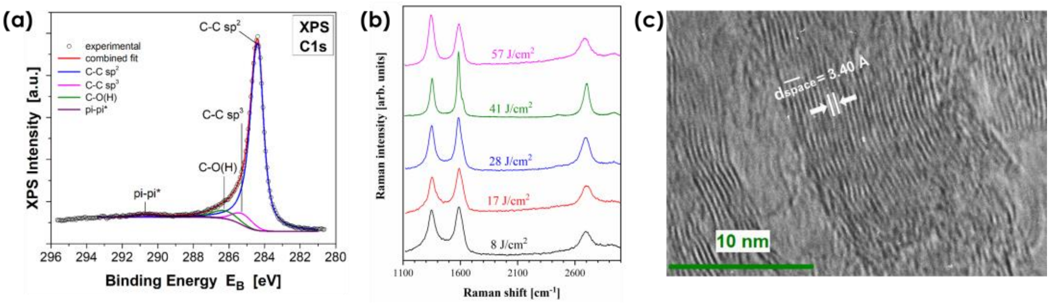

Figure 1: (a) C1s XP spectrum of laser-induced graphene, (b) Raman spectra dependence on laser fluence, and (c) TEM image of laser-induced graphene.