GRAPHENE AND 2DM VIRTUAL CONFERENCE & EXPO

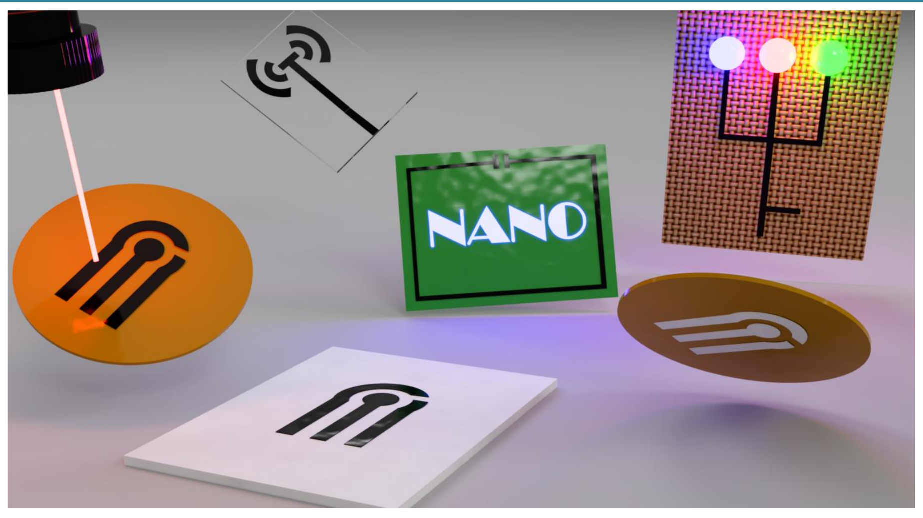
10 ANNIVERSARY

Graphene online 2020

October 19-23

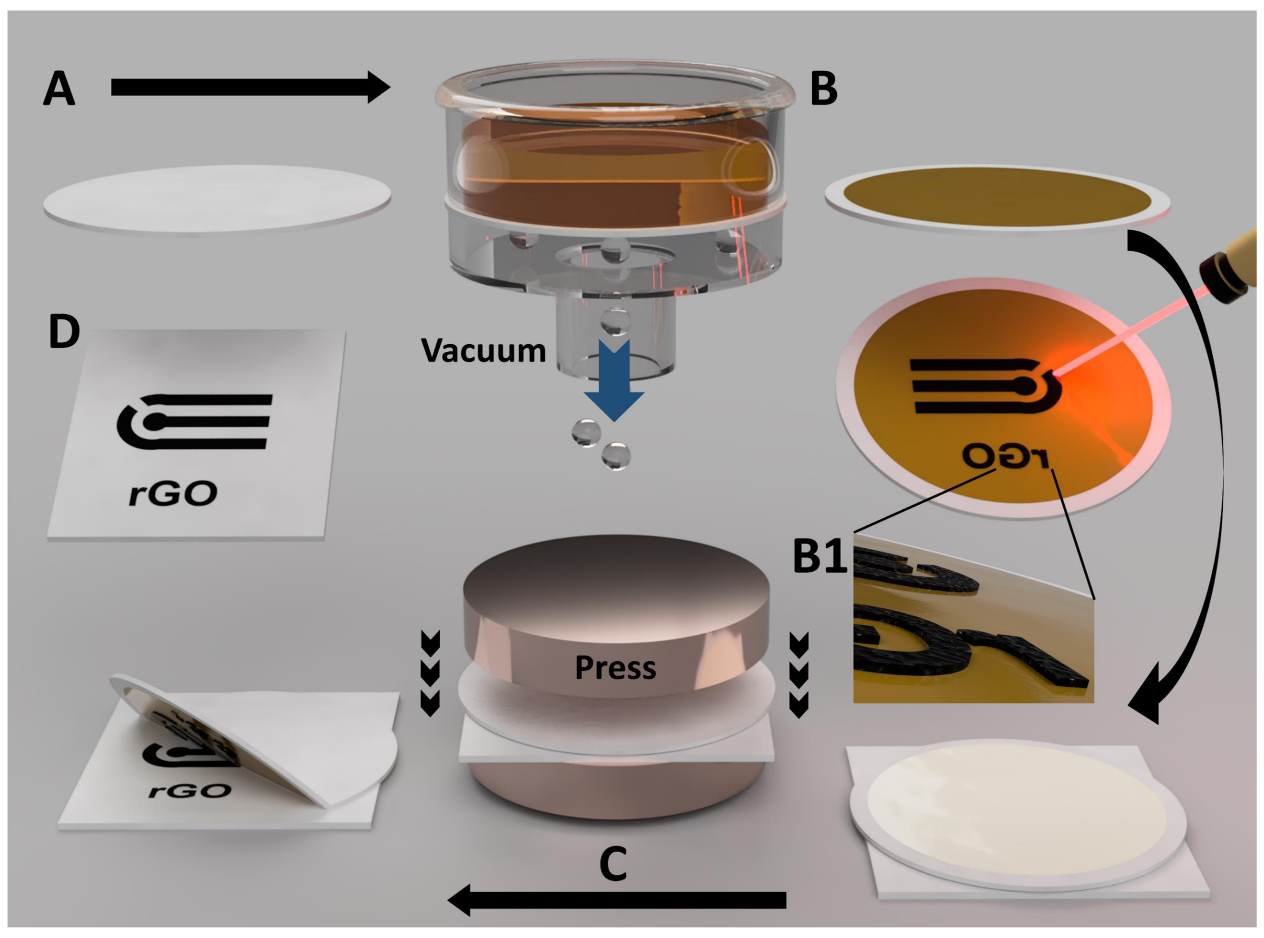
Laser Scribing of Graphene Oxide Yielding Multipurpose Stamped Nano Films

Caterina Giacomelli, Ruslan Álvarez-Diduk, Anna Testolin, Arben Merkoçi *



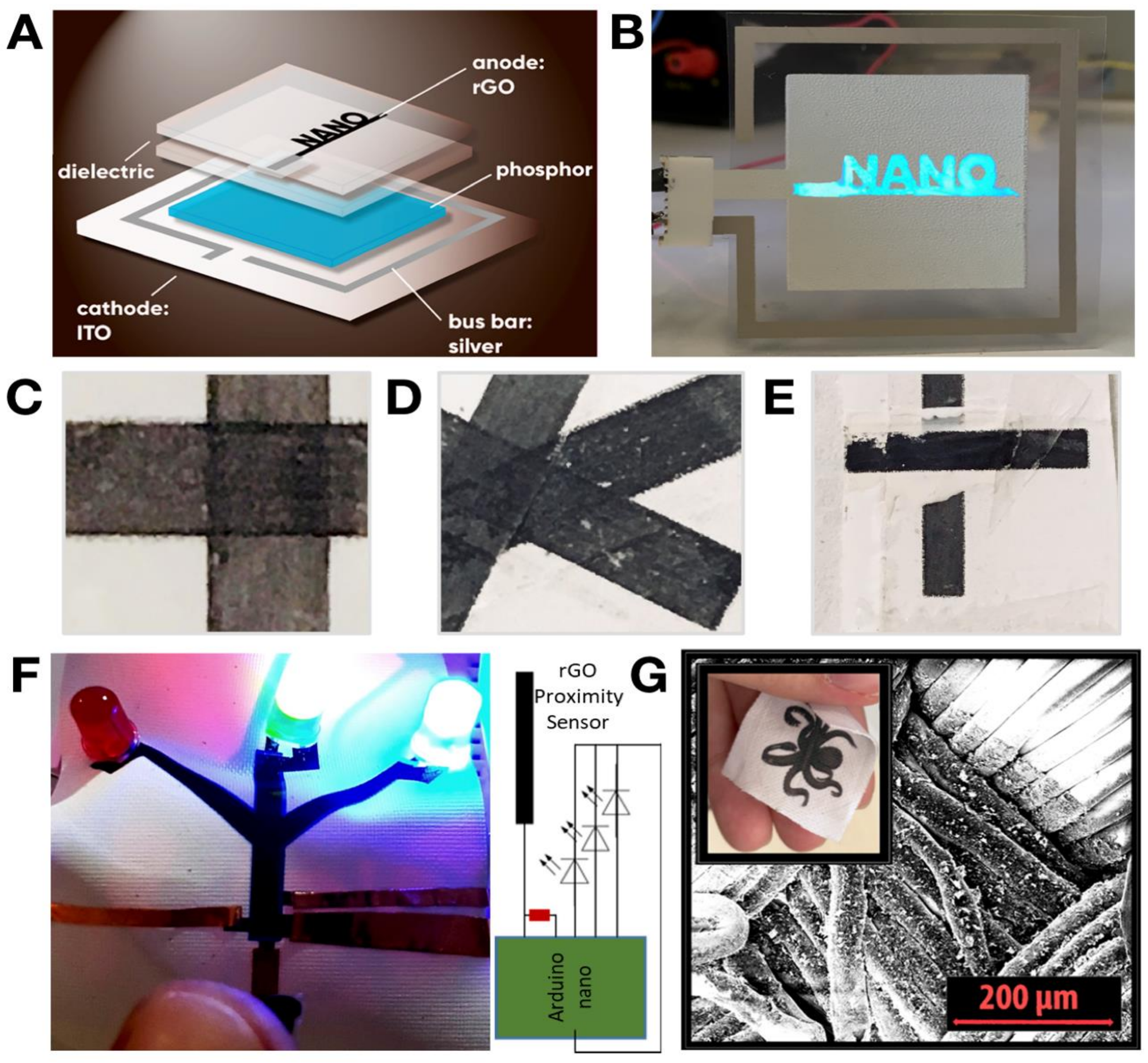
A rapid low-cost technology to produce highly conductive laser-scribed reduced-graphene oxide (rGO) thin films on flexible substrates is developed. Isolated rGO films, up to 30nm thick and with a conductivity of 10^2 S/m are produced at room temperature in a three-step process: filtering the graphene oxide (GO) solution through nitrocellulose membranes, reduction of GO surface using a DVD-burner laser and solvent-free transfer of the resulting rGO pattern onto new substrates via pressure-based mechanism. The loss of density in the rGO increases the thickness and therefore it is possible to transfer only the reduced part. The rGO is characterized with several analytical techniques, and its reduction degree, thickness, morphology, electrochemical and electromechanical properties are investigated and optimized. The validation of the technology is tested using a wide variety of substrates, and its applicability as a sensing platform for dopamine detection and back electrode in an electroluminescent lamp is demonstrated, opening the venue for a plethora of other new applications.

PREPARATION



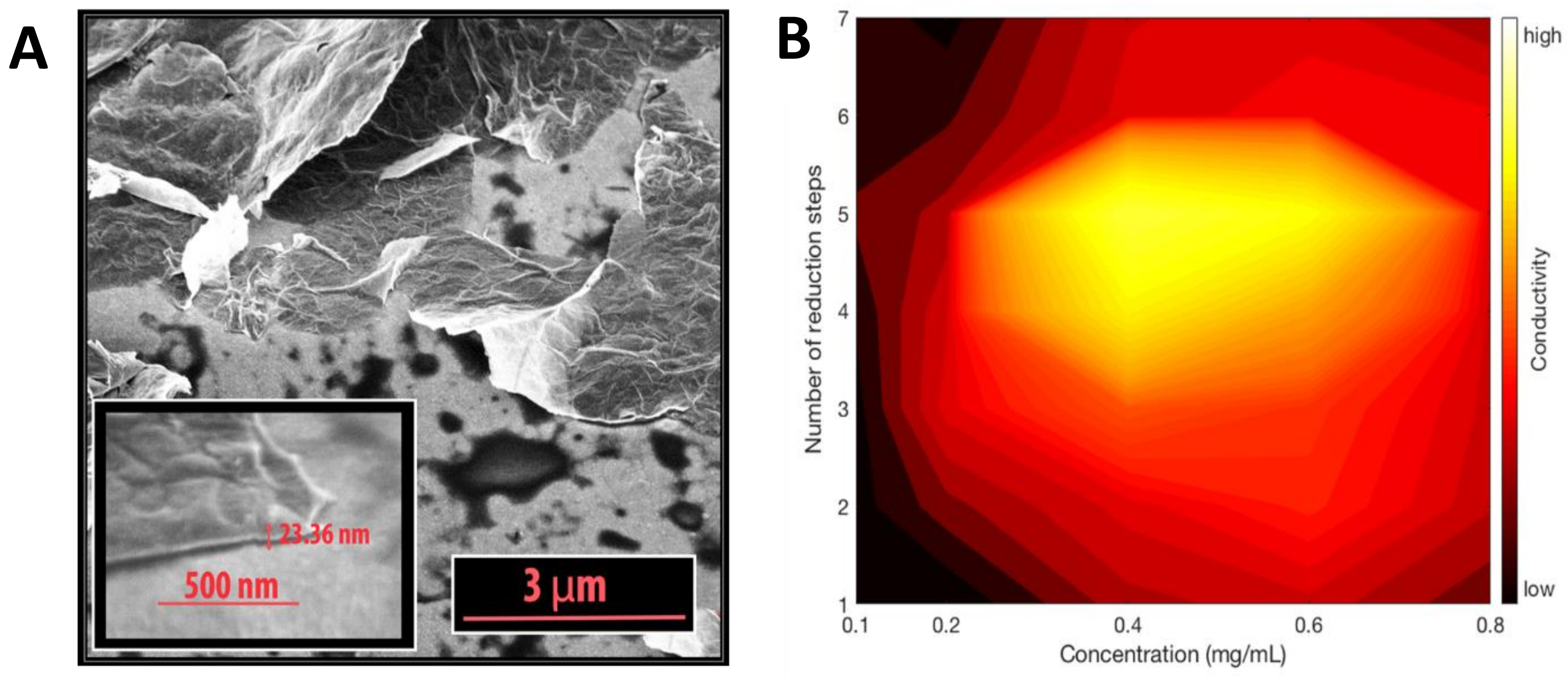
Schematic representation of the technique. (A) GO solution is filtered through a nitrocellulose membrane under vacuum conditions. (B) Thin films of GO on the membrane are reduced with laser to the desired pattern and positioned upside down on the desired substrate. (B1) An increase in the thickness of the reduced part is observed. (C) The assembly is placed in a hydraulic press and the membrane is carefully removed from the substrate. (D) Final look of the rGO nanofilms stamped on the substrate.

APPLICATIONS

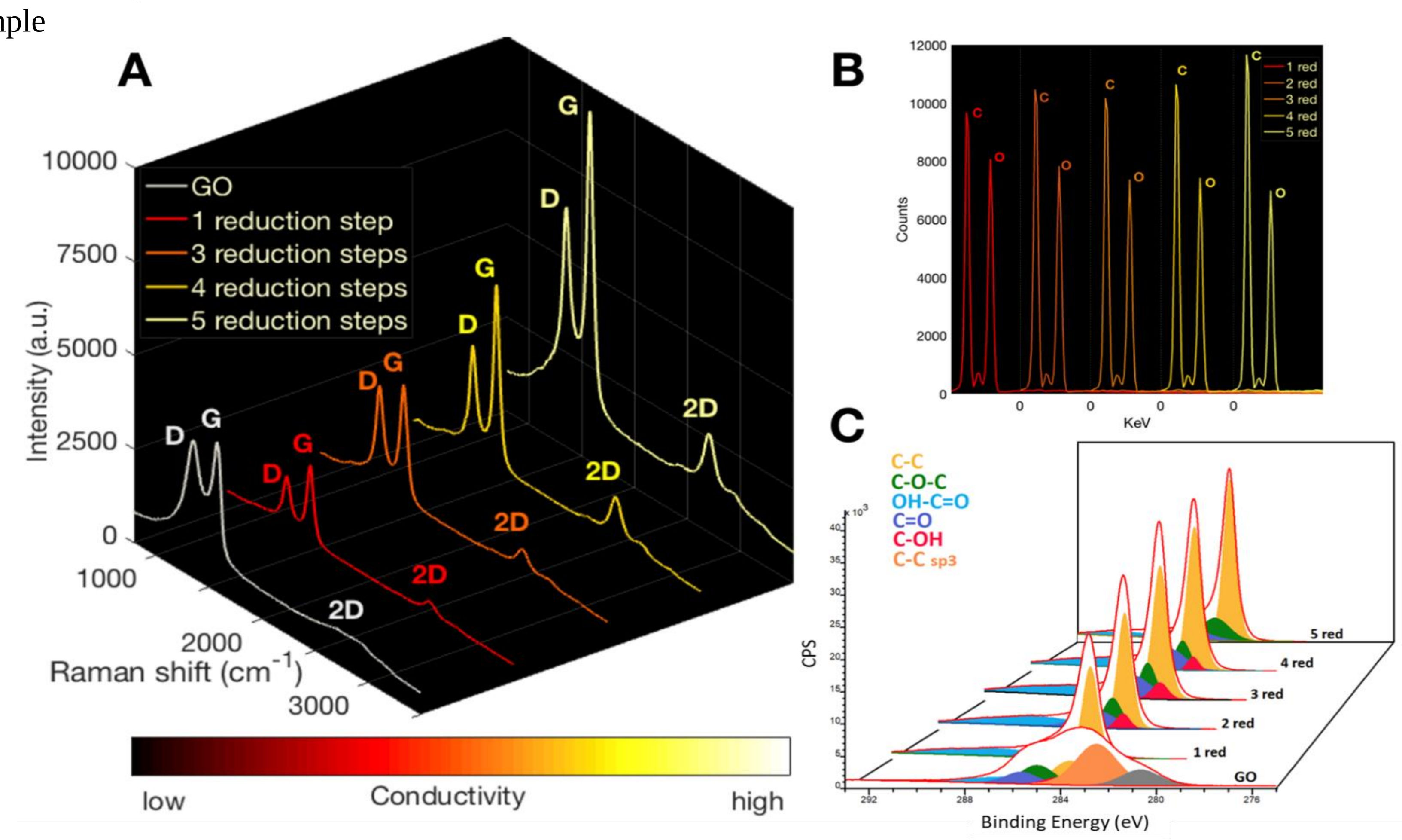


Possible applications of the technique. (A) Schematic representation of the electroluminescent lamp components. (B) Electroluminescent lamp with the transferred rGO as rear electrode. 3D transfer: (C) double layer transfer, (D) triple layer transfer, (E) double layer transfer with dielectric ink. (F) rGO 3D circuit on fabric and diagram including the rGO proximity sensor. (G) SEM image on the rGO transferred on fabric.

CHARACTERIZATION



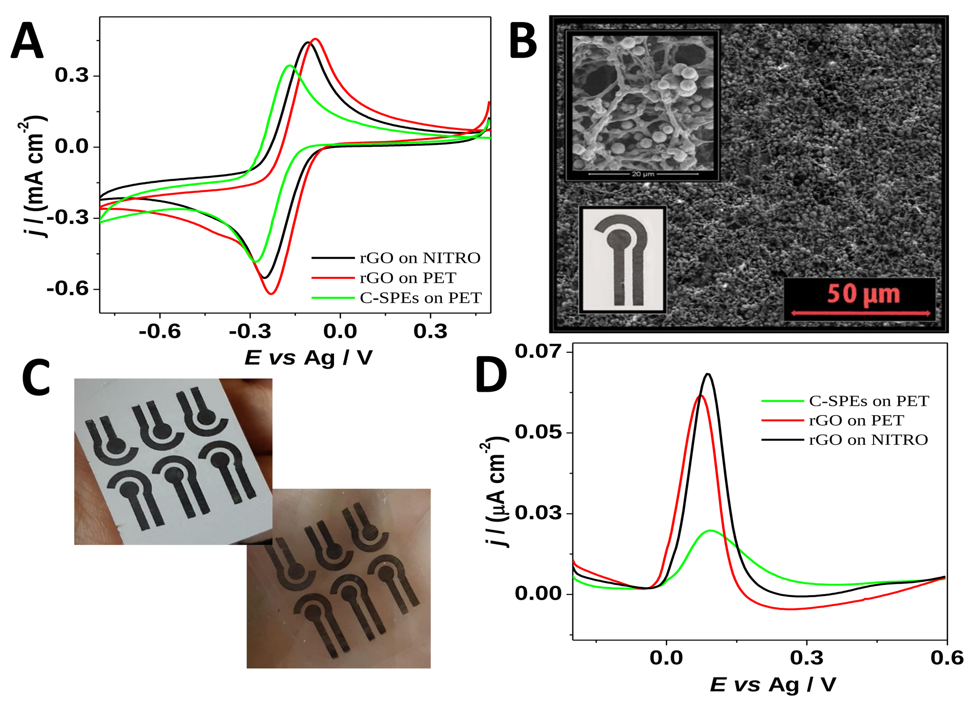
(A) SEM images of rGO 0.1 mg/mL 5 mL on ITO: the low concentration and the conductive surface of ITO allow to isolate single flake layers of rGO. (B) Conductivity map (contour map) for different reduction steps and several concentrations of GO in 5 mL volume solution. As evidence, five reduction steps and a concentration around 0.4 mg/mL turns out to be the combination of factors that leads to the more conductive and more stable sample



Surface characterization of GO 0.4 mg/mL in 5 mL and rGO for different reduction degrees. (A) Raman spectra of GO 0.4 mg/mL in 5 mL (white line) and on the reduced GO patterns from one (red line) to five (yellow line) reduction steps. (B) EDX results of the rGO platforms reduced from one (red line) to five (yellow line) times. (C) XPS analysis of the bare GO 0.4 mg/mL in 5 mL and rGO reduced one (1red), three (3red) and five (5red) times.

Link to the Article

ELECTROCHEMICAL



(A) Cyclic Voltammetry (CV) recorded at 50 (mV/s) of the rGO electrodes and C-SPE in PBS 0.01 M the presence of 3 mM $[Ru(NH_3)_6]Cl_3$. (B) SEM image of the rGO electrode on nitrocellulose paper. (C) Image of the transferred rGO electrodes on nitrocellulose (upper panel) and PET (bottom panel). (D) Differential Pulse Voltammetry (DPV) of the rGO electrodes on PET and NITRO and C-SPE in the presence of 10^{-4} M of dopamine in 0.01 M of PBS solution as supporting electrolyte (pH 7.4).

Conclusions. A fast and extremely low-cost technology for the production of highly conductive laser-scribed rGO thin films on flexible substrates has been developed. The process allows to prepare isolated rGO films up to 30nm thick with a conductivity of 10^2 S/m at room temperature. This simple methodology consists of three main steps, involving vacuum filtering of a GO solution through nitrocellulose membranes, reduction of the GO surface using a laser, and solvent-free transfer of the resulting rGO pattern onto new substrates via pressure-based mechanism. The material produced has been characterized with several techniques, namely AFM, SEM, EDX, XPS, Raman spectroscopy and four-points probe method, and its synthesis, thickness, morphology, electrochemical and electrical properties have been optimized. The potential of the technology has been demonstrated by transferring the rGO sheets onto a wide variety of rigid (glass, silicon) and flexible (PET, PAN, ITO, cotton, plaster, aluminum foil, nitrocellulose, filter paper, office paper) substrates. Finally, rGO sheets have been used as electrical component for flexible electronics (employing it as rear electrode in an electroluminescent lamp and 3D circuits) and as sensing platform for electroanalytical applications.

CONTACT PERSON

Prof. Arben Merkoçi

arben.merkoci@icn2.cat

REFERENCES

Giacomelli, C., Álvarez-Diduk, R., Testolin, A., & Merkoçi, A. (2020). Selective stamping of laser scribed rGO nanofilms: from sensing to multiple applications. *2D Materials*, 7(2), 024006.

ICN2 Institut Català de Nanociència i Nanotecnologia — Excelencia Severo Ochoa

NANO Bioelectronics & Biosensors Group

GRAPHENE FLAGSHIP

Graphene online 2020