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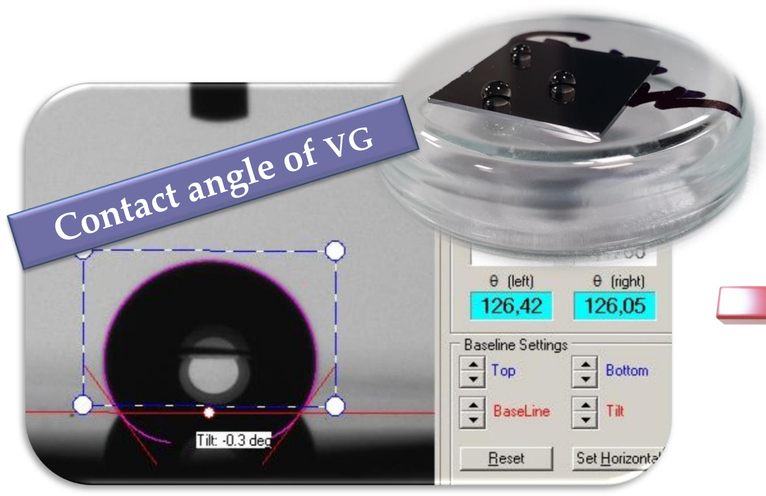
Preparation and characterization of vertical graphene-based nanocomposites for electrochemical applications

Vasilica Țucureanu, Octavian-Gabriel Simionescu, Marius Stoian, Gabriel Craciun, Cristina Pachiu, Alina Matei

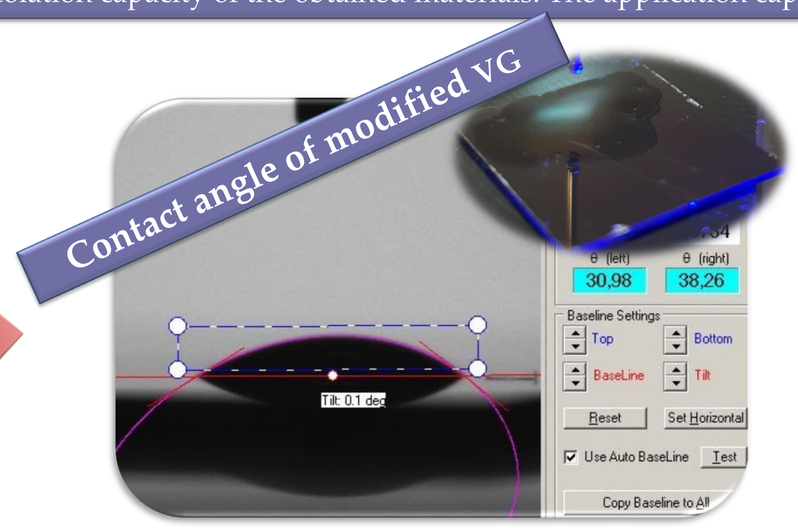
National Institute for Research and Development in Microtechnologies, IMT-Bucharest

*Corresponding authors: e-mail: vasilica.tucureanu@imt.ro; alina.matei@imt.ro;

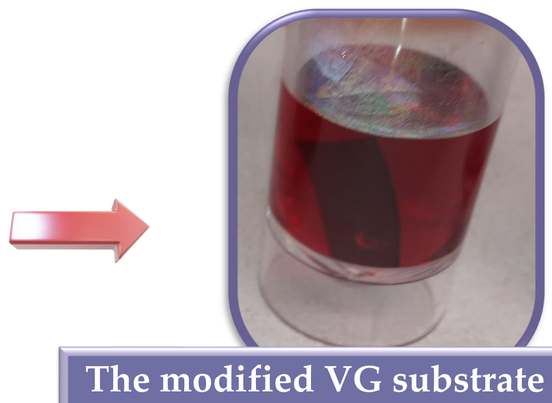
Graphene or carbon nanowalls, graphene sheets, and graphene nanoflakes are other names for vertical graphene (VG), a three-dimensional form of graphene. Compared to conventional horizontally oriented or randomly arranged graphene, the interest in vertically oriented graphene can be attributed to its unique geometry and open three-dimensional lattice, which allows easier access to the graphene edges, higher surface-to-volume ratio, high electrochemical activity, and electrical conductivity. The electrochemical properties of VG can be improved by incorporating nanoparticles that can change the major type of charge carriers, increase the specific surface and prevent the aggregation of graphene sheets. In this paper, we established a process for synthesising VG-based nanocomposites by treating graphene in an acid solution and then decorating the sheets with gold nanoparticles. The vertical graphene obtained by the chemical vapour deposition process on the Si/SiO_2 substrate is subjected to a treatment with H_2SO_4 and HNO_3 to improve the wetting capacity. The anchoring of the metallic nanoparticles is carried out through an ex-situ process, which involves 2 stages, in the first part the synthesis of the metallic nanoparticles is performed, and in the second step, the GV substrate is immersed in the gold NPs solution. Gold nanoparticles are obtained using chloroauric acid, as a precursor, and trisodium citrate, as both reducing agent and electrostatic stabilizer of the nanoparticles to avoid agglomeration. Using SEM microscopy, the shape, size, and distribution of metal nanoparticles inside the graphene were evaluated. Spectroscopy was used for the structural analysis, and goniometric studies revealed the wetting and percolation capacity of the obtained materials. The application capacity was demonstrated by cyclic voltammetry.



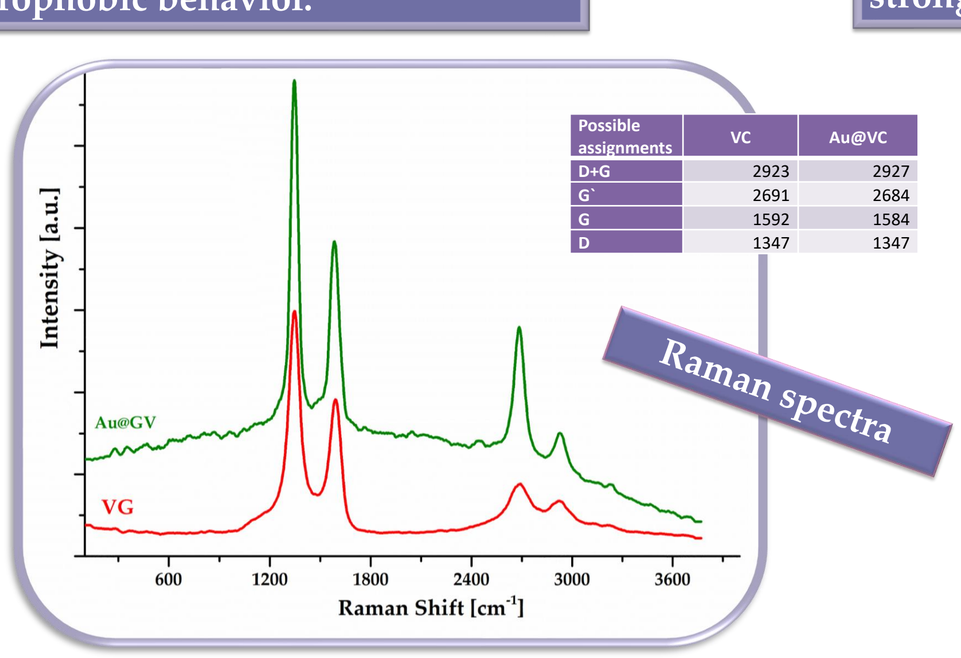
The distribution of water droplet on the surface of VG sheets shows hydrophobic behavior.



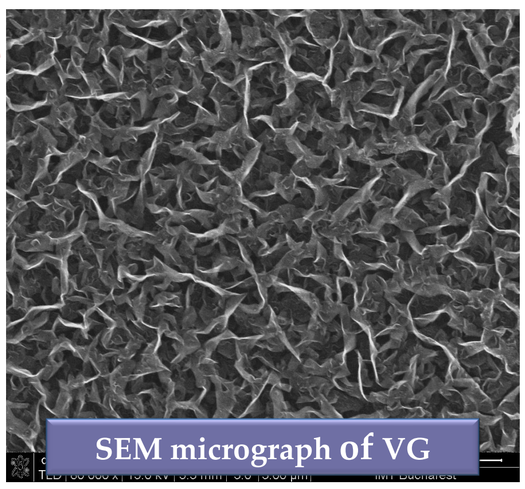
Water droplet distribution on the surface of modified VG exhibits strong hydrophilic behavior..

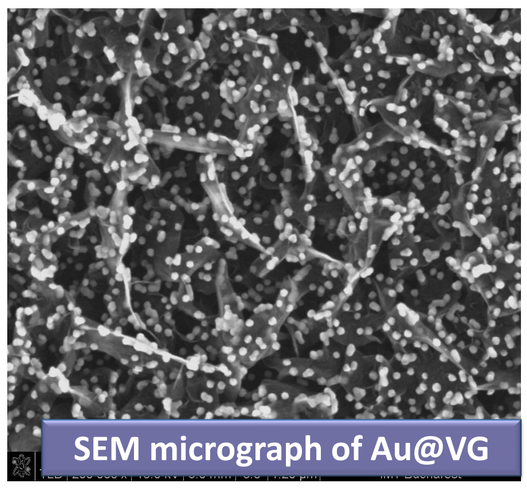


The modified VG substrate was inserted into the Au NP solution



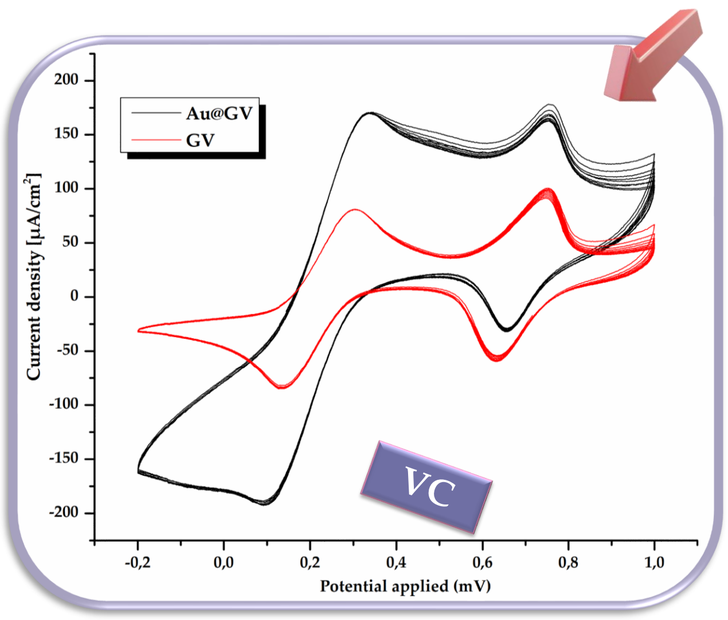
Possible assignments	VC	Au@VC
D+G	2923	2927
G`	2691	2684
G	1592	1584
D	1347	1347

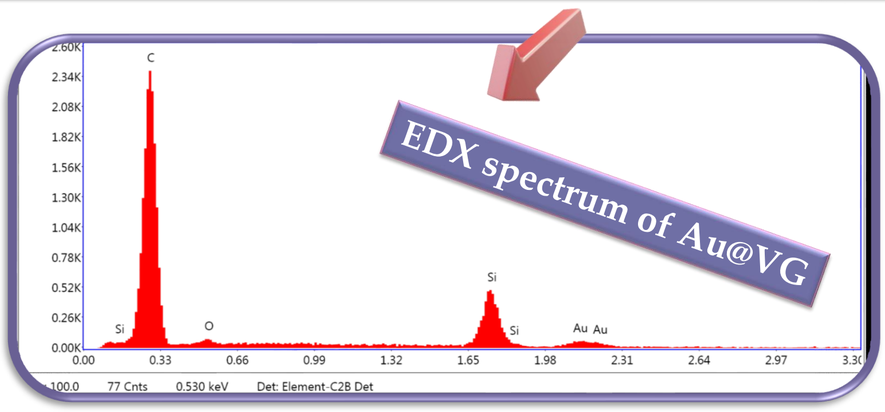




An average size of Au NPs of about 20 nm was estimated, without affecting the initial morphology of the VG.

The decoration of vertical graphene with gold nanoparticles is confirmed by the increase in the SERS signal compared with the control sample





After incorporation of Au NPs into VG sheets, the electrochemical capacity of the electrode increases.

In the spectrum of the sample, peaks corresponding to the constituent atoms of the substrate, C(K) at 0.22 keV, O(K) at 0.52 keV, Si(K) at 1.739 keV, and the gold atom, Au(M) at 2.1 keV, can be observed.

References:

1. Z. Wang, H. Ogata, S. Morimoto, Y. Hashimoto, M. Endo, cap 2. "Vertical graphene for biosensors", Graphene Bioelectronics, Advanced Nanomaterials, 37-56 (2018), doi: 10.1016/B978-0-12-813349-1.00002-0
2. M. Geramilla, C. Muthukumaravel, U. Karunakaran, T.N. Sairam, "Gold nanoparticle decorated vertical graphene nanosheets composite/hybrid for acetone sensing at room temperature", Materials Science and Engineering: B, 288, (2023) 116211, doi:10.1016/j.mseb.2022.116211.

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