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Substrates rubbing technology for mass production of mono and few layer graphene and 2D materials

Gagik Sh Shmavonyan[1], **Carlos Vázquez-Vázquez**[2] and **M Arturo López-Quintela**[2]
[1]National Polytechnic University of Armenia, Armenia
[2]University of Santiago de Compostela, Spain

An extremely simple, fast, cost-effective, transfer and chemical-free, reliable non-conventional substrates rubbing technology for mass production of high quality and large size mono- and few layer graphene, hexagonal boron nitride and other two-dimensional (2D) material nanostripes (NSs) consisting of arrays of quantum dots, films and hybrid nanostructures consisting of NSs and/or films on different rigid and flexible inorganic and organic substrates with atomically flat or stepped (*terraced*) surfaces is suggested. 2D materials are obtained manually (homemade) or mechanically (for mass production) by rubbing graphite or other layered bulk materials on dielectric, semiconducting and metallic substrates at atmospheric pressure conditions. The combination of microscopic, spectroscopic and electrical characterization techniques, i.e. optical, atomic force, scanning electron and high resolution transmission electron microscopy, ultraviolet–visible, fluorescence, x-ray photoelectron and Raman spectroscopy, x-ray diffraction and I-V measurements reveal the mechanism of the formation of unique 2D material NSs and films consisting of the NSs on different substrates by defining the efficient rubbing conditions, as well as the requirements to both the substrates and material being rubbed (layered bulk powder, HOPG, fullerene, nanotube). The suggested ecologically clean technology, in contrast to the conventional technologies, drastically decreases the production cost and time, facilitating the making process and avoiding the use of chemicals, solutions and any device, thus paving the way to industrial-scale 2D material production and new applications in next generation ultrathin, lightweight flexible, hybrid and wearable electronics, as well as 2D material enhanced products. The suggested ecologically clean technology, in contrast to the conventional technologies, drastically decreases the production cost and time, facilitating the making process and avoiding the use of chemicals, solutions and any device, thus paving the way to industrial-scale 2D material production and new applications in next generation ultrathin, lightweight flexible, hybrid and wearable electronics, as well as 2D material enhanced products.

gshmavon@yahoo.com