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Graphene Grown on ASTM A36 Steel by Chemical Vapor Deposition (CVD)

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This study investigates the synthesis of graphene by chemical vapor deposition (CVD) of ASTM A36 steel at low pressures (LPCVD), considering different surface preparations as well as variable operating conditions. However, it is crucial to be aware of the potential challenges related to unwanted nucleation of graphene and its adverse effects on graphene synthesis by LPCVD. On ASTM A36 steel samples, the CVD process had the following methodology: mechanical polishing, ultrasonic cleaning, heating, annealing, growth with various times using a liquid precursor, and cooling conducted under vacuum conditions. The samples were characterized using different techniques. First, scanning electron microscopy (SEM) was used to study the graphene domains. To complement the SEM results, a qualitative and semi-quantitative chemical analysis of the samples before and after CVD graphene synthesis was performed on a low-vacuum analytical scanning electron microscope, using the X-ray energy dispersive spectroscopy (EDS) technique. The SEM images suggest that the graphene layers are homogeneous. In the EDS technique, an increase in the normalized mass of the carbon element was observed from 2% to about 79%, while the iron element, which in total constituted more than 96% of the substrate, was reduced to 19%. The X-ray diffraction (XRD) analysis showed that there were no displacements in the diffraction angle that could characterize an increase in the average interplanar distance of the crystal and possible defects. To evaluate the number of graphene layers and the intensity of intrinsic defects in the graphene network, Raman spectroscopy and mapping tests were performed using a micro-Raman spectrometer, equipped with a charged-coupled device (CCD) detector and a solid-state laser (wavelength 473 nm). In the Raman measurements, it is possible to detect in the high-resolution (HR) spectra typical graphene films with low disorder, as evidenced by the full width at half-maximum of the 2D band (FWHM) and absence of the D band, as well as the symmetry of the line shape indicating highly ordered crystalline samples. In addition, the mapping shows the average I2D/IG intensity ratio behavior for each measured sample. These features indicate a low concentration of point defects in graphene in all the probed regions. The morphology of the steel surface, together with all the operating conditions of the CVD phases, show visible effects on the quality of the synthesized graphene. Therefore, it is of the utmost importance to understand the potential events and operating parameters in each phase that could influence the growth mechanism and, consequently, the quality of the graphene produced.