Characterization of the Barrier and Electrochemical Properties of CVD Graphene on Metallic Substrates

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Growth of graphene using the CVD method (so-called CVD graphene) on mono- and polycrystalline copper surfaces give the possibility to obtain large-area graphene coatings [1]. The CVD graphene can be also transferred onto other metallic or non-metallic substrates. The results of many investigations indicate that graphene can provide a barrier substantially reduce the corrosion rate (e.g.[2,3]), however, the tightness of real graphene coating is a fundamental feature of barrier protection [1-4]. The experimental investigations of barrier properties of graphene layers included the development of methodical bases for characterization of obtained layers in the following working conditions: (i) as a barrier protection against corrosion and protection against processes leading to the loss of solderability (mainly the oxidation processes); (ii) as a barrier to the formation of intermetallic phases; (iii) as a part of the coupling which allows to bond graphene materials with other components. The μ-Raman Spectroscopy (μ-RS) is very sensitive on the properties of graphene layers and this method enables the possibility to characterise the following properties: (i) number of layers of graphene coating; (ii) type and density of defects, (iii) deformation/stresses in graphene coating and (iv) doping charge etc. Simultaneously, this method permits the determination of corrosion products and their changes during the corrosion process, as also increase of intermetallic phases in some conditions during formation processes in soldered joint. The relatively large areas of sample can be analysed on the base of a set of spectra from the small areas (about 1 μm^2 in used experimental conditions). This allows the formulation of statistical description, and a graphical representation of the distribution of heterogeneity of graphene layers in micro-areas simultaneously with the description of corrosion products during the corrosion process. The surface topography and roughness of the different substrate were examined using atomic force microscopy (AFM, tapping mode). The examinations of the barrier properties in soldering processes were done using tin and tin-zinc alloys on the copper substrate covered by CVD graphene. The processes of the electrodeposition of Cu, Sn and Sn-Zn layers from citrate solutions on graphene/copper substrate were investigated and optimal parameters were determined. The barrier properties of selected layers CVD graphene/Zn alloys were also examined by μ-Raman Spectroscopy, X-ray diffractometry and cross-section microscopy analysis (SEM/EDS). The obtained results indicate a strong influence of defects in CVD graphene materials (types, density), an important role of substrate preparation (topography, roughness, oxidation) and corrosion products as well as an influence of electrodeposition conditions on the barrier properties of graphene layers. The damages of graphene coatings by improper electrodeposition conditions were analysed by μ-Raman Spectroscopy.
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