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Incorporation of graphene and other carbon nanostructures in metals via electrocharging assisted process*

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Carbon in the form of graphene sheets and graphene nanoribbons (GNR) was incorporated in 99.99% Ag, 99.99% Cu and Al 6061 and Al 7075 alloys by electrocharging assisted process. This process consists of the application of a high DC current to a mixture of the liquid metal and particles of activated carbon. The current is believed to produce ionization of the carbon particles followed by polymerization in such a way that graphene sheets and nanoribbonsform within the metal. The new materials, called covetics, are very stable as the carbon remains in the metal even after remelting and resolidification. The graphene structures bond to the metal atoms and develop epitaxial structures with the metal lattice upon crystallization.We have varied the current applied during the reaction and measured the voltage between the crucible and the electrode. The voltage across the sample fluctuates as an indication that the reaction is taking place and slowly decreases as the carbon distribution becomes more uniform. Samples are compared for different currents and initial carbon content. We have used Raman scattering, x-ray photoelectron spectroscopy, X-ray diffraction, scanning electron microscopy and transmission electron microscopy for characterization of samples prepared with different current and for different carbon content. Raman scattering using 532 nm excitation laser shows that the graphitic regions have *sp2* character with high intensity of the G and D peaks at ~1,580 and 1,354 cm^{-1} which are characteristic of graphitic structures having defects. The graphitic structures form a network throughout the sample that is believed to enhance the properties of the material. The domain size of the graphene nanoribbons are in the range of 10-30 nm as measured by Raman, TEM, and electron energy loss spectroscopy. Simulations from density functional theory predict bonding between carbon and silver (or Al) at vacancies and edges of the graphene-like ribbons. First principles calculations of the dynamic matrix of Ag and Al covetics predict a phonon density of states with Raman active modes corresponding to bonding between C and Ag/Al and which agree with our Raman scattering results that show weak modes in the region of 500 to 1,000 cm^{-1}. Al 6061 and Al 7075 with 5% C show higherultimate tensile strength compared to the pure alloys. Cu covetic films with 4 wt% C show higher transmittance to light and higher resistance to oxidation than pure copper films.

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Biography:

Lourdes Salamanca-Riba is a Professor in the Materials Science and Engineering Department at the University of Maryland. Her research is in the areas of nanomaterials, self-assembly in semiconductor nanostructures, hybrid photovoltaics, solid oxide fuel cells and carbon nanostructures in metals called covetics. Her research focus is on the synthesis and characterization of materials using transmission electron microscopy. She has a BS degree in Physics from the Universidad AutónomaMetropolitana in Mexico City and a PhD degree also in Physics from MIT. She was a Senior Research Scientist at the GM Research Laboratory in Warren, MI prior to becoming a faculty member at the University of Maryland. Professor Salamanca-Riba has over 140 publications and is a member of the Materials Research Society, American Physical Society and the Microscopy Society of America.