Low pressure and atmospheric pressure plasma interactions with molten metals and liquid droplets for materials processing

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ABSTRACT

Several grand challenges in energy storage and conversion need the discovery functional materials that many agree will be composed of complex compositions and nanoscale materials such as nanowires. In this regard, plasma based materials processing has been shown to be promising for combinatorial techniques and scalable processing. For example, our group has shown that gentle plasma excitation of gas phase will allow the use of non-catalytic, low melting metals for catalyzing nanowire growth. Furthermore, the use of plasma oxidation of liquid precursors allows for creation of metastable complex oxide particles with compositional control. A number of examples will be discussed in which the above two techniques are currently being used for accelerating the development of a variety of catalysts including electrocatalysts and materials for storage applications.

This talk will highlight our efforts to understand the role of plasmas under two categories: (a) the synergistic effects hydrogen and nitrogen plasma interactions with molten metals; and (b) the oxygen plasma-liquid droplet interactions. To gain insights into these mechanisms we have studied the interaction of hydrogen and nitrogen plasmas with low melting point metals, primarily with gallium. Absorption/desorption experiments as well as theoretical-computational calculations were performed. Experiments have shown an increment of adsorbed gaseous species into the molten metal in the presence of plasmas; furthermore, Density Functional Theory (DFT) calculations suggest a strong interaction between atomic hydrogen and molten gallium that is described as a high absorption on the surface, rapid diffusion and a steady state concentration of the gas inside the bulk. In the case of oxygen plasma-liquid droplet interactions for creating complex oxides, the role of solvated electrons and oxygen radicals will be discussed.

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