INVITED LECTURE

Synthesis, structure and properties of MXene: The 2-D material beyond Graphene

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ABSTRACT

The ability to isolate and grow two-dimensional (2D) materials has generated considerable excitement and fascination in scientific community because of the endless possibility of tuning their functional properties. The isolation of graphene in 2004 from graphite was a defining moment for the development of two dimensional (2D) materials. In recent years, various other non-graphene 2D materials and heterostructures have been developed to provide specific electrical, thermal, physical or mechanical properties and functionalities. By combining various 2D materials, unique combinations of properties that were unimaginable in bulk materials can be achieved. Recently, after its discovery in 2011, a novel kind of non-graphene 2D layered material named MXene, has received increasing attention and rapid expansion of interest because of its potential applicability in a variety of fields such as energy storage including super capacitors, lithium-ion batteries, oxygen evolution reaction, heavy metal adsorption, electromagnetic interference shielding, water purification, electrocatalysis and medicine etc. For more than a decade, graphene has been touted as the key material to making better microchips, batteries, antennas and many other devices. But ensuring production in bulk quantities without losing quality has been a significant challenge of using this atom-thin building material for the technology of the future. According to recent report, it is no longer a problem with MXenes that has significantly higher electrical conductivity compared to graphene. MXene is synthesized by selective etching of MAX phases, a family of early transition metal carbides, nitrides or carbonitrides. In this paper, we describe the synthesis methods, structure and properties of Ti_3C_2 MXene. The process of preparing Ti_3SiC_2 MAX phase and subsequent etching and delamination to obtain Ti_3C_2 Mxene are elucidated. We also explain the effects of synthesis parameters on the size and quality of MAX phase and suggest the optimal processes for the desired application. Phase pure Titanium silicon carbide (Ti_3SiC_2) was synthesized following solid-state sintering method. The MAX phase pellet synthesized at 1400^{o}C was porous in nature and 30% or more voluminous compared to the green pellets. Use of slightly excess silicon powder precursor than stoichiometry promotes formation of high-pure Ti_3SiC_2 MAX phase. Particle size of the Ti precursor played a key role in the formation of phase pure Ti_3SiC_2. With the help of x-ray diffraction and Rietvielt analysis, the percentage composition of the as grown materials were calculated. Electrical and optical properties of the as-grown products were also studied and the observed results are corroborated with their respective structures. Coating of MXene was made on copper substrate by Electrophoretic deposition (EPD) at an applied voltage of 100V for deposition time range of 30s to 120s to obtain desired coating thickness.

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