MECHANICAL ENGINEERING

The Department of Mechanical Engineering presents:

The Ph.D. Dissertation Defense of

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Synthesis of Graphene Layers from Metal-Carbon Melts: Nucleation and Growth Kinetics

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Professor Reza Abbaschian, Chairperson

A new method for growth of large-area graphene, which can lead to a scalable low-cost high-throughput production technology, was demonstrated. The method is based on growing of graphene films on the surface of metal-carbon melts and involves dissolving carbon in a molten metal at a specified temperature and then allowing the dissolved carbon to nucleate and grow on top of the melt at a lower temperature. The synthesized graphene layers were subjected to detailed microscopic and Raman spectroscopic characterizations. The deconvolution of the Raman 2D band was used to accurately determine the number of atomic planes in the resulting graphene layers and access their quality. The results indicated that the technology can provide bulk graphite films, few-layer graphene as well as high-quality single layer graphene on metals. It was also shown that upon cooling of supersaturated metal-carbon melts; graphite would also grow inside the melt either with flake or sphere morphology, depending on the solidification rate and degree of supersaturation. At small solidification rates, graphite crystals are normally bounded by faceted low index basal and prismatic planes which grow by lateral movement of ledges produced by 2D-nucleation or dislocations. At higher growth rates, however, both interfaces become kinetically rough, and growth becomes limited by diffusion of carbon to the growing interface. The roughening transition from faceted to non-faceted was found to depend on the driving force and nature of growing plane. Due to high number of C-C dangling bonds in prismatic face, its roughening transition occurs at smaller driving forces. At intermediate rates, the prismatic interfaces become rough and grow faster while the basal plane is still faceted, leading to formation of flake graphite. At higher growth rates, both interfaces grow with a relatively similar rate leading to initiation of graphite sphere formation, which later grows by a multi-stage growth mechanism. An analytical model was developed to describe the size and morphology of graphite as a function of solidification parameters.