Special Program in Applied Mathematics and Applied Mechanics

Four-dimensional electron microscopy studies of nanomaterials and other recent research on cold plasma applications and growth of single diamond crystals

Prof. Jau Tang

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10:00 - 12:00
103, Mathematics Research Center Building (ori. New Math. Bldg.)

By combining high spatial and temporal resolution of 4D electron microscopy we have demonstrated its some applications in nanoscience and nanotechnology. We are able to investigate ultrafast dynamics and atomic scale spatial resolution of nanomaterials which might help soling important issues in energy, environment and health related issues in modern society. In our 2015 Science paper we have used USEM (ultrafast scanning fast electron microscopy) ultrafast dynamics of photo-induced electrons and holes induced by fs laser in p-n semiconductor junctions. We have observed ballistic dynamics and gating mechanism of the depletion zone for the hot charged carriers at short times, rather than the more familiar carrier diffusion. Moreover, we have also observed THz plasma waves at high laser fluence due to Coulomb forces among carriers. In our another Science paper in 2017 and a paper in Science Advances we have studied photo-induced rotational and translational motion of single gold nanoparticles Using UTEM (ultrafast transmission electron microscopy) we observed ballistic motion with friction, yet at longer time scales abnormal diffusion with extremely fast diffusion was observed. We have identified steam nanobubbles generated on the laser-heated gold nanoparticles are the driving force for such fast dynamics. We have also investigated the processes of nucleation from the liquid phase to final crystallization of TiO2 nanoparticles to elucidate the mechanism. Eutectic reactions of alloys from GaAs nanowires encapped by a gold tip were also studied to improve understanding of the laser heating and heat transfer processes during superstructure formation of the alloy. In another work of USEM of graphene monolayer, we have observed dynamic spatial

and temporal distributions of charged carrier, exhibiting a crater-shaped charge density map at high fluence and yet a Gaussian distribution at low fluence. We have attributed these phenomena to Auger-assisted charge recombination processes.

We have also worked recently on MPCVD (microwave plasma chemical vapor deposition) growth of diamond single crystals and are developing alternatives for improvement. In addition, we have also investigated air electric corona discharge and interactions with liquid and polymer-coated conducting substrates to develop some plasma applications.