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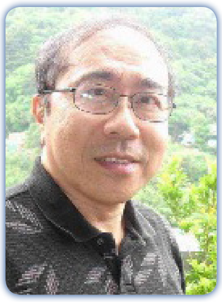

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## Applications of four-dimensional electron microscopy in studies of dynamics and structures of nanomaterials

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 Ultrafast Scanning Fast Electron Microscopy (USEM) 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 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 Ultrafast Transmission Electron Microscopy (UTEM), 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 $TiO_2$ 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 lase 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.

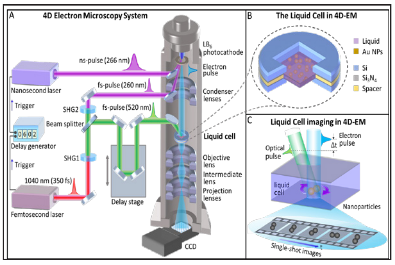


**Figure-1:** Schematic diagram for 4D UEM used in investigation of photoinduced lano-bubbled driven rotation and translation of single gold nanoparticle.

### Recent Publications

1. Fu X W, Chen B, Tang J, Zewail A H (2017) Photoinduced nanobubble-driven superfast diffusion of nanoparticles imaged by 4D electron microscopy. *Science Advances*; 3: e1701160.
2. Chen B, Fu X W, Tang J, et al. (2017) Dynamics and control of gold-encapped gallium arsenide nanowires imaged by 4D electron microscopy. *PNAS*; 114: 12876.

### Biography

Jau Tang is a Distinguished Professor in the Institute of Technological Sciences at Wuhan University in China. His research areas include nanoscience, 4D electron microscopy, ultrafast phenomena, single-molecule spectroscopy, phase transitions, plasma hydrodynamics, optoelectronics, synthetic diamond growth, photochemistry and electron transfer reactions. He has received his PhD degree from UC Berkeley (1981) and has worked at Argonne National Lab, Bell Labs, Caltech prior to Wuhan University.

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