工学系WINGS産学協創教育推進基金

第402回GMSI公開セミナー／第147回WINGSセミナー

From nanocarbon plasmonics to near-field imaging: Multifaceted physics of low-dimensional materials

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Date: Monday, October 16, 2023 14:00-15:30
Venue: Faculty of Engineering Bldg. 2, Room 31A

Abstract:

In this talk I will give a try to cover several major themes of my research in the past couple of decades.
The talk will start with touching upon the van-der-Waals/quantum forces in NEMS devices: in 2002 I proposed that these new terms are needed in classical MEMS theory. vdW/Casimir force, never studied in the past, was incorporated in MEMS theory and a new model was developed applicable for simulation of nanoscale devices. Since then, this model has been accepted by a wide community of researchers and allowed to understand the scaling laws for NEMS and physical limitations for their operation. I will continue with the electrostatics of 1D devices: the concept of nanotube quantum capacitance will be introduced which is required for modelling of 1D-transistors, diodes, heterostructures, compound materials, etc. I will continue with the theory of bandstructure engineering in 1D-materials via symmetry breaking, either with the electric field, of surface potential or DNA wrapping.
Another concept we introduced, remote polariton scattering in low-dimensional materials, led to formulation of a new theory of polar surface scattering and, ultimately, to discovering a novel channel for heat exchange in nanotube based materials and devices – quantum heat tunneling. This concept is important for solving the heat dissipation problem for next generation electronic devices.
I will briefly review several most recent theoretical and experimental results on nanoscale optical characterization for 1D and 2D-materials. Several vignettes on near-field microscopy will be presented: imaging of doped and twisted graphene, chemical bond modification is damaged glass surface, hBN shells in heteronanotubes and vdW vertical heterostructures. A few topics in Raman microscopy and multidimensional (correlated) imaging will be reported next. If time will allow, I will touch on nano-biophysics of DNA-wrapped nanotubes and their interaction with neural stem cells and methods of multiplexed biosensing with 2D-materials.

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