Overcoming historical challenges in carbon nanotubes and nanoribbons to enable their application in transistors and photovoltaics

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Carbon nanotubes and graphene-related materials are among the best charge transport materials ever discovered. The transformative potential of these materials in electronics and optoelectronics has already been demonstrated, on a single nanostructure level. However, implementing these exceptional materials in scaled, large-area, high-performance applications involving many nanostructures has been much more difficult. My work addresses challenges – in controlling the growth, processing, ordering, and heterogeneity of carbon nanomaterials and in understanding phenomena beyond the scale of single nanostructures – that must be overcome to exploit these materials in (opto)electronics technology.

Along these lines, I will present on 3 inter-related areas: (1) *Achieving highly monodisperse semiconducting carbon nanotubes without problematic metallic nanotubes and depositing these nanotubes into useful, organized arrays and assemblies*. We have recently pioneered a scalable approach for depositing aligned arrays of ultrahigh purity semiconducting nanotubes called floating evaporative self-assembly (FESA) that has allowed us to create the highest performance carbon nanotube field effect transistors (FETs) ever demonstrated, using on-conductance and on/off ratio as key metrics. (2) *Unlocking the potential of carbon nanotubes as light absorbers in macroscopic, thin film photovoltaic photodetectors and solar cells*. We have discovered how to efficiently harvest photons from thin films of nanotubes by driving the dissociation of photogenerated excitons using donor/acceptor heterojunctions. The efficiency of these devices is determined by the flow of energy in these films that we have temporally resolved and understood using a particularly broadband form of two-dimensional white light ultrafast spectroscopy. (3) *Creating graphene nanoribbons with smooth edges via a combination of top-down and bottom-up methods that can be extended to the large scales necessary for technology*. We have recently discovered a new CVD-based synthesis for high aspect ratio, self-aligned armchair nanoribbons that are < 10 nm in width but 100's of nanometers in length, with smooth edges.

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