Electronic Control at the Nanoscale: Towards Solid Interfaces with Enhanced Electronic and Optoelectronic Functionalities

Electronics and optoelectronics technologies rely on the control of electric charge at the interfaces between active materials of solid-state devices. The behaviour of electric charge in these systems depends on the energy level alignment and spatial extent of interfacial electronic states. This is dictated by quantum mechanical phenomena unfolding at the nanoscale and depends strongly on the atomic-scale morphology of these interfaces. Controlling such atomic-scale structure and local electronic properties yields therefore potential for developing enhanced nanoelectronics, light-harvesting, light-emitting and photocatalytic technologies.

In the first part of my talk, I will show how supramolecular chemistry on surfaces – where organic molecules and atoms are used as building units for the assembly of well-defined nanostructures – offer compelling avenues for designing materials with atomic-scale precision and tailored electronic properties. I will focus on 1D and 2D organic and metal-organic nanostructures, resulting from on-surface non-covalent and metal-ligand interactions between \( \pi \)-conjugated molecules and transition metal adatoms.

In the second part, I will review the feasibility of generating and controlling electric current in semiconductors and insulators with few-cycle optical waveforms, within a single cycle of light, and on a timescale of 1 femtosecond. I will also discuss experiments dealing with ultrafast photo-induced electron dynamics in photoactive supramolecular nano-assemblies on surfaces.