From micro- to nanoelectronics: challenges from the quantum world

Modern microelectronics is one of the most successful technologies ever conceived by the humankind. According to Moore's law the speed of information processing by the state-of-the-art computers doubles approximately every 2 years. Such extraordinary growth is possible due to the progress in semiconductor manufacturing, which enables production of ever smaller circuitry, and thus makes possible to accommodate ever increasing number of basic electronic components (transistors, capacitances etc.) on the same area of a silicon chip.

While the current processor units are manufactured using the 65 nm technology, one expects that already in the 2020s the typical lateral dimensions of the circuitry elements will drop beyond the 10nm threshold. On these scales, however, the solid state electronics will be confronted with a completely new set of phenomena related to the primary quantum effects, such as energy level quantisation, single charge tunnelling and many others. Then the traditional CMOS logic structures will have to be realised taking these phenomena into account: the microelectronics will give way to the nanoelectronics.

During the last decade it turned out that the semiconductor technology is not the only option for the nanoelectronics. As has successfully been shown already in 1997, even single molecules can be contacted by metallic electrodes and show transistor-like action.
The molecule-based electronics has several important advantages in comparison to the conventional solid state chips and recently established itself as an independent research field.

The goal of the presentation is to give a comprehensive overview of most important theoretical advances in these two young and exciting research fields of nano and molecular electronics.