Silicene – a two-dimensional silicon form – the material similar in crystal and band structure to graphene – is since relatively recently treated as its attractive alternative for spintronic applications ready to be integrated within the silicon electronics. In contrast to graphene, in silicene the spin-orbit coupling is strong and controllable by external fields. The spin-orbit coupling allows for manipulation of the confined electron spins by external electric fields, which makes the material attractive for quantum information processing on systems of confined spins. The perpendicular electric field opens the energy gap in silicene, which allows for electrostatic confinement of the carriers. Thus, silicene fulfils all the criteria that the graphene failed to meet in the context of the confined spin manipulation.

The free-standing silicene is unstable in air. Experimental studies of silicene deposited epitaxially on silver were performed. The properties of the silicene are strongly modified by the metallic substrate. Only in 2015 a technology that allows for the silicene transfer on the SiO_2 substrate was reported , for which the properties of the silicene are similar to the ones predicted for the free standing monolayer. The growth technique opens wide prospects for practical implementation of this new material starting from the field effect transistor operational in the room temperature. One should expect a prompt appearance of experimental studies on nanoribbons, quantum dots, quantum point contacts, electron interferometers etc. based on the novel growth technique.

The objective of the project is a design of electrically controlled devices for trapping the charge carriers (electrons and / or holes) and transformations of their spin, both in resonant conditions - for systems driven by electric fields varying periodically in time, and off resonance – in the effective magnetic field due to the spin-orbit coupling induced by motion of the electron wave packet in response to electric pulses.

The research within the frame of the proposed project will determine the possibility of using the electric-field controllable properties of silicene to carrier confinement, the initialization, manipulation and read-out of the spin degree of freedom of the trapped carriers. The results of the project should be useful for experimental research that was recently made possible

For a close relation of the confinement potential induced by electric field with the field-tunable properties of the material (gap, Rashba spin-orbit coupling) the Hamiltonian parameters are co-dependent and the study requires a complex modeling of the electrostatics of the device with the Schroedinger-Poisson approach. Moreover, the project will determine the electron structure of several confined carriers in a single and double quantum dot and study its dynamics driven by external AC electric fields with charge transitions (between the dots) as well with the spin and valley state transitions. The project will be based on a original numerical approaches of the group: the time-dependent configuration interaction approach and the Schroedinger-Poisson modeling The single-electron eigenstates will be determined with the atomistic tight-binding. They will be used in the configuration interaction method for determination of the few-particle systems. The dynamics of the system will be studied with a direct solution of the time-dependent Schroedinger equation with the time-dependent configuration interaction method that allows to keep an exact account for the electron-electron interaction, electron-electron correlation, as well as for the dynamical effects outside the two-level single-photon Rabi transitions.