A 2 years postdoctoral position is opened at CEA/INAC (Grenoble, France) on the theory and modelling of the electronic and transport properties of single impurities in nanowire and MOS devices.

The effect of single dopants on the electrical properties of short-channel devices is a major preoccupation of the microelectronics community. The fluctuations of the number and position of the dopants diffused from the source and drain contacts for example is one of the largest source of variability in ultimate MOS transistors. In addition, the electronic and transport properties of each individual dopant is expected to be dependent on its environment (dielectrics, neighbouring impurities, etc...). The low temperature $I(V)$ characteristics of such transistors actually display well defined Coulomb blockade diamonds below the threshold voltage (Fig. 1), which are the fingerprints of the tunnelling through one up to a few dopants in the channel [1]. These outstanding experiments provide, in particular, a direct measure of the energy level structure of the neutral and charged impurities. While the data clearly show that the electronic properties of dopants are very different in such complex environments, a comprehensive analysis is still missing. Meanwhile, further experiments are carried out at CEA/INAC to make innovative devices (such as latch switches) based on single-electron (Coulomb correlated) transport through systems of few impurities.

![Figure 1: Silicon-on-insulator transistors used for single-impurity spectroscopy (left: top view; middle: cross section of the channel), and Coulomb diamonds measured at low temperatures just below the threshold voltage of such devices (right). The diamonds display complex features associated with the tunnelling of electrons through one or a few impurities in the channel. Adapted from Ref. [1].](image)

The laboratory of atomistic simulation (L_Sim) of CEA/INAC and the CNRS/IEMN have a recognized expertise in the modelling of the electronic and transport properties of dopant impurities [2-5] using atomistic tight-binding methods. The aims of this postdoctoral position, opened at L_Sim, are:

- To model the electronic structure of neutral and charged dopants in realistic device geometries (including contacts, gate oxides and metals, ...), in order to understand the experimental data and the physics of impurities in complex dielectric environments. Accurate (possibly self-consistent) tight-binding models will be used for that purpose, supplemented with original approaches for the calculation of the dielectric response of the system. The possibility to use the electronic structure of the impurities as a probe of their position in the device will be investigated, in close connection with the experiments and with the variability issue in microelectronics.

- To model the transport through few impurity devices in the Coulomb blockade regime, in order to assess the feasibility of such devices, and to help their design and characterization. This work takes place in the context of a national project, which will give the candidate the opportunity to interact with the experimental group of CEA/INAC [1], and to collaborate with other French theory labs, in particular CNRS/IEMN (Lille) and CNRS/IM2NP (Marseille).

The candidate should send her/his CV to Yann-Michel Niquet (yniquet@cea.fr), with a list of publications, a motivation letter with a summary of past accomplishments, and contact details of two persons for references (or recommendation letters).
References:

[1] Single-donor ionization energies in a nanoscale CMOS channel,  
M. Pierre, R. Wacquez, X. Jehl, M. Sanquer, M. Vinet and O. Cueto,  
Nature Nanotechnology 5, 133 (2010).

[2] Ionization energy of donor and acceptor impurities in semiconductor nanowires: Importance of dielectric confinement,  

[3] Screening and polaronic effects induced by a metallic gate and a surrounding oxide on donor and acceptor impurities in silicon nanowires,  

[4] Ab initio calculation of the binding energy of impurities in semiconductors: Application to Si nanowires,  

[5] Impurity scattering in gated silicon nanowires,  
M. P. Persson, H. Mera, Y. M. Niquet, C. Delerue and M. Diarra,  

Additional informations about L_Sim:  
http://inac.cea.fr/sp2m/L_Sim/  
http://inac.cea.fr/sp2m/L_Sim/Qui/YMNiquet/

More about Grenoble and its surroundings:  
THEORY & MODELLING of the TRANSPORT PROPERTIES of NANOWIRES.

A 2 years postdoctoral position is opened at CEA/INAC (Grenoble, France) on the theory and modelling of the transport properties of ultimate nanowires (1D NW) as well as Fully Depleted Silicon-On-Insulator (2D FDSOI) devices with non-equilibrium Green's functions methods.

The characteristic dimensions of upcoming MOS transistors are entering the sub 20 nm range where quantum corrections due to confinement and tunnelling for example become increasingly important. In addition, new materials and nanostructures, such as nanowires and molecular films, are progressively being introduced in micro-electronics devices. This calls for the development of next generation modelling tools for the design and understanding of these devices, that are able to cope with complex systems and to deal with atomic scale features. In this respect, the Non-Equilibrium Green's Functions (NEGF) method appears as one of the most versatile approach to quantum transport. It can account for both elastic (surface roughness, impurities, ...) and inelastic (phonons) scattering in a consistent framework. Combined with $k.p$ and atomistic tight-binding methods for the electronic structure, it can address problems at various scales, from ultimate < 5 nm nanowires to thin-film SOI devices (see Fig. 1).

![Figure 1](image1.png)

**Figure 1, left and middle :** A FDSOI device (with a 8.5 nm thick silicon channel) and an array of nanowires fabricated and characterized at CEA/LETI. **Right :** The transmission through a gate-all-around silicon nanowire with one phosphorous impurity at different locations, computed with an atomistic (tight-binding) non-equilibrium Green's functions solver [1].

The laboratory of atomistic simulation (L_Sim) is actively developing NEGF tools and has a recognized expertise in the modelling of nanowires [1-3] and graphene [4-5] for example, as well as in the theory of the electronic structure of materials and the theory of transport [6, 7]. The aims of this postdoctoral position are:

- To contribute to the development of these tools, and in particular to join the ongoing efforts on the advanced modeling of the electron-phonon interaction in an atomistic framework.
- To use both $k.p$ and tight-binding NEGF solvers to explore the physics of transport in nanostructures (mostly nanowires and thin films), such as the interaction between elastic and inelastic scattering (prevalence of ballisticity and weak/strong localization effects, dissipation, etc...).
- To simulate the $I(V)$ characteristics of realistic nanowire and FDSOI devices, in close connection with characterizations made at CEA-LETI, in order to improve the understanding of the experimental data and to help the design of these devices.

The present project takes place in the framework of a national project, involving 4 academic theory teams (CEA/INAC, CNRS/IEMN, CNRS/IM2NP, IMEP/LAHC), ST microelectronics and CEA-LETI. This will give the candidate the opportunity to interact with other theory groups, and to have access to experimental data on state-of-the-art devices.

The candidate should send her/his CV to Yann-Michel Niquet (yniquet@cea.fr), with a list of publications, a motivation letter with a summary of past accomplishments, and contact details of two persons for references (or recommendation letters).
References:


Additional informations about L_Sim:
http://inac.cea.fr/sp2m/L_Sim/
http://inac.cea.fr/sp2m/L_Sim/Qui/YMNiquet/

More about Grenoble and its surroundings: