2016 Jülich – OCPC – Programme
for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project: Aptamer-Nanoparticle Si Nanowire FET Biosensor

Jülich's institute: Peter Grünberg Institute (PGI-8): Bioelectronics

Project leader: Priv.-Doz.Dr. Svetlana Vitusevich

Web-address: http://www.fz-juelich.de/pgi/pgi-8/EN/AboutUs/OrganizationAndResearchGroups/ElectronicSensing/_node.html

Description of the project (max. 1 page)[1]**: see overleaf**

Description of existing or sought Chinese collaboration partner institute (max. half page)**:**
The Post-Doc project combines the advantages of existing collaboration with Shanghai Institute of Microsystem and Information Technology (SIMIT), started in 2006 with topic (1) focused on development of techniques for nanoparticle-assisted improved diagnostic of diseases and topic (2) - development of new materials and structures aiming at a deep understanding of interfacing mechanisms between biological objects such as cells together with novel approaches for biosensor developments on the basis of Si nanowire (NW) field-effect transistor (FET) structures, recently supported by Innovation Award 2015 (see in News at http://www.fz-juelich.de/pgi/pgi-8/EN/Home/_node.html). In particular, two main questions in the project have to be targeted: shortening of binding time (magnetic nanoparticles of topic (1) can be used to speed-up the binding process) and improved signal (methods of improved interfacing of topic (2)) have to be further developed and implemented in new approaches on the basis of Si NW FETs utilizing novel interfacing materials such as aptamers. The aptamers are promising due to their unique properties in replacing the antibodies which are currently used to bind target molecules. It should be noted that the global market for biosensors and the use of biosensors in the areas of healthcare, environmental, industrial, security and defense is expected to grow drastically over the next years, the market and valorization potential of the technology on the basis of high-sensitive high-speed silicon nanowire FET structures is very promising. It is known that SIMIT has huge experience in nanowire biosensor activity. Therefore, we are very interested to strengthen of ties with SIMIT or to establish new collaborations with institutes in China on elaboration of NW FET biosensors.

[1] Please add overleaf

Required qualification of the post-doc:

- PhD in Microelectronics, bioelectronics or electrical engineering
- Experience in semiconductor device and surface functionalization technologies
- Additional skills in microfluidic chip fabrication and biosensor characterization

PART B

Documents to be provided by the post-doc: see attachments

- Detailed description of the interest in joining the project (motivation letter)
- Curriculum vitae, copies of degrees
- List of publications
- 2 letters of recommendation

PART C

Additional requirements to be fulfilled by the post-doc:

- Max. age of 33 years
- PhD degree not older than 5 years
- Very good command of the English language
- Strong ability to work independently and in a team

Description of the project
Aptamer-Nanoparticle Si Nanowire FET Biosensor

As statistics shows chronic heart failure is relevant in view of the demographic trend in the world. 21 million adults in the US and EU are estimated to be living with heart failure. This number unfortunately rises. The diagnostic has to be done within the first two hours at very first stage of the acute myocardial infarction (AMI), when only several molecules of Troponin (Tn), the heart disease indicators, are released. The elevation of C-reactive protein (CRP) has also been recently linked to be a marker of the inflammation of arteries and heart disease. Therefore, high-speed, reliable and ultra-sensitive detectors of such molecules as Tn and CRP have to be developed. This will allow applying medical treatment in time and decrease the probability of mortality. The essential feature of nanowire (NW), as a part of field-effect transistor (FET) structures, is increased surface-to-volume ratio enabling development of ultra-sensitive chemical and biological sensors. Further improvement of such techniques is required not only for development of stable materials tolerant to chemical reactions on the surface, but also for different methods of signal recording using FET technology. The interface phenomena between silicon NW channel and molecules has not been investigated thoroughly at the moment not only from the point of view of the signal transfer from molecule, but also of interface processes between the molecules, traps in dielectric layer and the nanowire channel depending on gate coupling effects. One of the important aspects in such devices is the investigating of exchange processes between channel carriers and a single trap in different transport regimes. Recently we have shown, that understanding the transport regimes and gate coupling effect as well as novel parameters such as capture time to single trap can be used for sensitivity enhancement of biosensors. Such new parameters and approaches will enable direct monitoring and control of the molecular interactions, therefore the most attention in the project will be attracted to development of these techniques for biosensor applications. An effective control of interface phenomena will enable a better engineering of nanostructures and developing biosensor devices. We expect that binding time of molecules can be decreased using magnetic nanoparticles. Aptamers developed for troponin and CRP allow not only sensitivity, but also selectivity improvement for cardiac marker detection. Direct attachment of target molecules on predefined sites at the top of dielectric layer will allow studying unique properties of molecular object down to single molecule level. The nanowire shape with predefined places for molecular attachments is not the only factor affecting the quality of the signal. The oxide passivation layer of the nanowire is of critical importance as well. For stable, sensitive, reproducible measurements it should be thin enough to provide high capacitive coupling between molecules in solution and the NW channel. In addition, it has to be stable and provide the reliable binding with studied molecules. The signal from molecule can be improved by binding to the specially predefined places using advanced technologies as well as specially modified places with nanoparticles. Moreover the question of the nanowire surface passivation and functionalization should be solved. Therefore, the goal of this work is to optimize the above discussed nanostructure configurations to improve and understand interface with cardiac molecules to get maximum signal response from the molecules in the conductive channel of Si NW FET biosensor. The innovation technology is very promising for development of cardiac Point-of-Care (POC) Diagnostic. Recently opened Helmholtz Nanoelectronic Facility (HNF) will be available for the candidate to implement the novel approaches and to develop test biosensor structures. Therefore, I strongly recommend supporting the application for two years Post Doc project and certify that my laboratory and office space will be provided in our Institute at Forschungszentrum Jülich.