PhD thesis

Title of the project: Memristive Atomic light source

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Laboratory : ICB

Summary: This project ambitions to develop a new family of atomic-scale electro-optical nonlinear devices for future generation of cognitive neutral computing network. The planet-wide explosion of data trafficking and transmission bandwidth have forced the electronic sector to initiate technological revolutions beyond the von Neumann architecture bottleneck. For instance, data centers are now essential infrastructures for controlling and routing information, and new computing paradigms such as artificial intelligence or neuromorphic computing are massively deployed to tackle problems with an ever-increasing complexity. In this context, brain-inspired electronic computing network greatly benefited from the implementation of a new class of discrete low-power components that are memristors. **A memristor is a nonlinear analog memory device which undergoes resistive switching from a high resistance state (HRS) to a low resistance state (LRS) upon electrical activation**. Memristors can be volatile with a state that spontaneously decays back to HRS after removal of the activation, or volatile where the programmed state is stable even in absence of an electrical stimulus. In its most advanced implementation, memristive switching is triggered by a reversable structural change of the device occurring at atomic scale (ion migration, reduction, nucleation, etc.). Memristor are therefore amongst the smallest solid-state electronic component realized and are optimally suited for a large-scale integration essential in the deployment of scalable and flexible neuronal architectures. In parallel to the migration of the microelectronic industry to the nano-scale, an alternative technological thrust has emerged for massively increasing the volume of information and its processing bandwidth by utilizing photonic chips. **Data handling by on-chip routes requires integrated functionalities and faces an immense technological challenge to downsize components.** While realizing compact photonic devices at the nanoscale is unquestionably a technological achievement, they are still far from bringing a complete and robust processing solution. Instead, it is now accepted that a hybrid approach mixing the advantages of electronic and photonics on the same circuit design is an expected short-term evolution. In this fertile ground, at the crossroads between generic high-tech approaches, the thesis aims at augmenting the functionalities of memristors. The preliminary results obtained by PRISM in collaboration with ETH Zurich (Swizterland) and HK-USTC (China), markedly demonstrated that the memristive change of state initiated by the motion of a few atoms may be accompanied by light emission. **Hence, this unique behavior offers the possibility to realize a double function within the same atomic-size device**: an electronic switch combined with an extremely compact source of photons. The **project aims at exploring, understanding, and controlling concurrent light emission mechanisms triggered by the electrical operation of a memristive junction.**

Devices will be fabricated using the technological facility available at ARCEN and will be characterized with the microscopy center of SMARTLIGHT. The candidate will be fully trained at utilizing the resources of these two platforms and will therefore acquire a complete set of hard skills which can be promoted for an industrial occupancy as well as for an academic position.

The candidate will be in close connection to the supervisor on a day-to-day basis. A wider interaction with group and the platform crews is expected. Since the preliminary data were obtained within an international collaboration, the candidate will evolve in lively community, communicating with the partners on a monthly basis. Short visits to the partners are expected.

Type of project (theory / experiment): Experiment.

Required knowledge: Good understanding of nanoelectronics and photonics. It is essential to be familiar with small-signal recovery equipment and associated measurement protocols. An experience of nanofabrication (e-beam lithography, thin-film deposition) is a plus. The candidate should have a strong taste for experiment, shows independency and be oriented to a problem-solving attitude. Good writing skills and communication ability is essential.