Thesis proposal

Photonic memristors

Context: Brain-inspired electronic computing network such as neuromorphic architecture greatly benefited from the implementation of a new class of discrete low-power components that are memristors. 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.). 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 integrated chips (PIC). However, data handling by on-chip routes requires integrated functionalities and faces an immense technological challenge to downsize components. One of the essential elements of a PIC is the light source. Integrated solutions require complex monolithic assemblies of semi-conductor materials and have typical footprint in excess of hundreds of μm^2. Emerging alternatives are now being proposed with the development of extremely small sources resting on radically different emission mechanisms than those found in more technologically-mature semi-conductor heterostructures. 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. From this analysis, it is clear that there is an urgent need for proposing novel compact interface components with dual functionalities that are able to bring new performing capabilities to these yet-to-be-merged electron and photon computing technologies. Our preliminary results markedly demonstrated that the memristive change of state initiated by the motion of a few atoms may be accompanied by light emission[1]. **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 proposal will thus explore the correlation between transport and photon emission that are both triggered by the same atomic dance with the objectives to explore, understand, and control concurrent light emission mechanisms triggered by the electrical operation of a memristive nano-junction.**

Facilities: The research will be conducted in Dijon (FR) at ICB's photonic department and will be supervised by Dr. Alexandre Bouhelier. The candidate will work in a lively environment composed of four permanent researchers supervising 4 to 5 PhD students and a couple of postdocs. The candidate will have full access to the characterization tool including confocal microscopy retrofitted for simultaneous optical and electrical investigations. The laboratory hosts the technological platform ARCEN Carnot. The

[1] B. Cheng, Light & Science App. 11, 78 (2022), https://doi.org/10.48550/arXiv.2212.02320

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platform operates a user nanofabrication facility in a clean-room environment including electron-beam lithography, thin film depositions and ion etching apparatus. The candidate will receive an exhaustive training on the nanofabrication line. Such know-how is nowadays a valuable asset for prospecting jobs in academia and in nanotechnology related industries.

Requirements: The candidate will have a Master in Physics, Nanosciences or Optics. She/he will have a marked taste for experimental science and technology, be oriented toward a problem-solving attitude, have good sense of organization and priorities, and should demonstrate proficiency in oral and written English. The application must contain contact information of two reference tutors or mentors, an extensive CV and a strong motivation letter.

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