HEIBRIDS
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Admission Round 2019

Project Title	**Array of tunable single photon emitters for photonic reservoir computing and quantum computing**
Project leads / supervisors	Prof. Dr. Catherine Dubordieu (HZB, Helmholtz) Prof. Dr. Stefan Reitzenstein (TU, ECDF)

Project description

In the 4-year timeframe PhD, we aim at going an important step further in photonic reservoir computing (RC) circuit and design, by building and testing new innovative hardware concepts that are needed to realize a highly performant fully integrated photonic RC chip. In the mid- and long-term perspective (3-10 years from now) our project aims to explore the quantum regime of neuro-inspired photonic computing by using single photons as information carriers once the required quantum hardware has been established. For this purpose, we will develop an array of single photon emitters made of site-controlled III-V semiconductor quantum dots (QDs), with spectral control of each individual dot using functional oxides. With the current state-of-the-art expertise, QDs have a spectral dispersion of typically Dl ˜ 40 nm. This spectral inhomogeneity shall be mapped and compensated for each QD via local oxide induced strain-tuning. In order to enable a sufficiently large coupling of the QDs in RC schemes we will aim at achieving a spectral dispersion of < 0.1 nm for an array of 5 x 5 QDs, which has not been yet demonstrated. Our goal is also to experimentally explore, during the last phase of the PhD, learning tasks using the reservoir computing photonic device targeting e.g. voice recognition. This task will be performed in close cooperation with the external partner D. Brunner at FEMTOST in Besançon and partners of the Berlin area. We are in contact e.g. with Prof. K. Obermayer, TU Berlin - Institute of Software Engineering and Theoretical Computer Science - who is an expert in neural information processing. Prof. Obermayer will advise us with respect to efficient neuronal algorithms to be implemented in the suitably designed nanophotonic hardware. The heterogeneous monolithic integration of III-V and metal oxides will be achieved by combining the expertise of the PI's groups. Quantum dots are among the most promising technologies for realizing a quantum computer[1], surpassing other technologies such as ion traps, superconductors and linear optics in terms of physical speed, logical speed and footprint of th qubit (including the qubit's associated control and infrastructure). As also shown, QDs represent a technology to appear in a long-term timeline; it is precisely our goal to address the research needed so that new hardware concepts can emerge and be exploited with this technology for quantum computing.

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