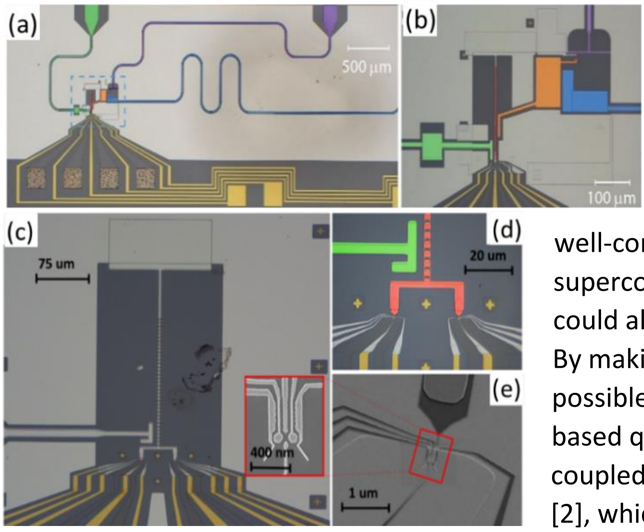
PhD positions in Hybrid Cavity Quantum Electrodynamics with semiconductor QDs and Josephson Junctions Quantum Metamaterials

The group of Pasquale Scarlino (starting at EPFL in October 2020) will explore **hybrid quantum electronics**, combining **semiconductors and superconductors** to build and measure novel devices architectures.



Topic description: Superconducting electronic circuits and semiconductor quantum dots have very similar requirements for their successful implementation as quantum information technology, which presents the potential to address common challenges via hybrid systems. Creating a well-controlled interface between semiconductor- and superconductor-based quantum information technologies could allow to harness the best of both device architectures. By making use of this hybrid technology, it has been recently possible to realize a device integrating a quantum dot (QD) based qubit with a **superconducting transmon qubit** [1], both coupled to a tunable **high impedance SQUID array resonator** [2], which acts as a **quantum bus** [see Figs.(a,b)]. Circuit QED approach is also of primary importance as a means for **scaling semiconductor quantum dots**-based architecture, as represented in Figs.(c-e) reporting a device for microwave photon-mediated interaction between two depletion DQDs (separated about 45 um) defined in a GaAs/AlGaAs 2DEG [3].

The project: The research position aims at exploring concepts of hybrid-circuit QED with GaAs, Si and Ge based QDs charge/spin qubits strongly coupled to high impedance microwave resonators made from **Josephson junction arrays** or **high kinetic inductance** thin superconductor films. The majority of circuit Cavity QED experiments realized so far couples cavity photons to two-level systems enabling both the development of powerful quantum computing architectures and a fundamental study of the light-matter interaction. By coupling cavity photons to more complex hybrid mesoscopic systems it could be possible to explore light/matter hybridization in a class of solid state systems which are new in the context of Cavity QED [4].

Major responsibilities: As a PhD student, the focus of your work will be nanofabrication, quantum transport and circuit QED experiments in low-dimensional hybrid nanodevices, to build devices for quantum information processing with semiconductor quantum dots (hosted in a GaAs, Si and Ge two-dimensional electron/hole gas and nanowires), superconducting qubits and resonators. During the project, you will also interact and exchange ideas with external academic collaborators and will present your results in international conferences.

Qualifications: Candidates are required to have a master's degree with a focus on quantum physics and, ideally, a solid background in quantum information processing with superconducting circuits and/or semiconductor qubits. The successful candidate is curious to learn new experimental techniques and is eager to expand his/her current expertise in microwave engineering, signal processing, nano- and micro-fabrication, low-temperature and semiconductor physics. Programming experience in Python, Mathematica, Matlab and instrumentation control experience (e.g. QCoDes) are beneficial.

For questions or additional information, please contact:

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References:

[1] P. Scarlino, et al., *Nature Communications* **10**, 3011 (2019).

[2] A. Stockklauser, P. Scarlino, et al., *Phys. Rev. X* **7**, 011030 (2017).

[3] D. J. van Woerkom, P. Scarlino, et al., *Phys. Rev. X* **8**, 041018 (2018).

[4] G. Burkard, et al., *Nature Reviews Physics* **2**, 129–140 (2020).