Colloquium Notice

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Controlling light down to the single-photon level with integrated quantum photonic devices

Light-matter interactions allow adding functionalities to photonic on-chip devices, thus enabling developments in classical and quantum light sources, energy harvesters and sensors. These advances have been facilitated by precise control in growth and fabrication techniques that have opened new pathways to the design and realization of semiconductor devices where light emission, trapping and guidance can be efficiently controlled at the nanoscale.

In this context, I will show the implementation of semiconductor quantum dots in nano-photonic devices that can create simultaneously bright and pure, triggered single-photon sources [1], critical for quantum information technology. I will then present photonic geometries for controlling light propagation and brightness in broadband, scalable devices, based on plasmonic nanostructures [2].

Hybrid systems can allow overcoming limitations due to specific material properties and I will show how hybrid III-V/Silicon devices can be a platform for low-loss quantum light propagation [3]. I will also present a technique based on the transfer of semiconductor membranes embedding quantum emitters onto different host materials [4], for hybrid quantum photonic applications [5].

Finally, I will discuss novel photonic designs based on bio-inspired aperiodic [6] and disordered photonic crystals [7], showing efficient light confinement and optical sensing, and I will present our recent work on quantum biology, focused on the investigation of photosynthetic light harvesters on a chip.

References:

[1] L. Sapienza et al., Nanoscale optical positioning of single quantum dots for bright and pure single-photon emission, Nature Communications 6, 7833 (2015).

[2] O.J. Trojak, S.I. Park, J.D. Song, L. Sapienza, Metallic nanorings for broadband, enhanced extraction of light from solid-state emitters, Applied Physics Letters 111, 021109 (2017).

[3] M. Davanco, J. Liu, L. Sapienza et al., Heterogeneous integration for on-chip quantum photonic circuits with single quantum dot devices, Nature Communications 8, 889 (2017).

[4] C. Haws, B. Guha, E. Perez, M. Davanco, J.D. Song, K. Srinivasan, L. Sapienza, Thermal release tape-assisted semiconductor membrane transfer process for hybrid photonic devices embedding quantum emitters, Materials for Quantum Technology 2, 025003 (2022).

[5] C. Haws, E. Perez, M. Davanco, J.D. Song, K. Srinivasan, L. Sapienza, Broadband, efficient extraction of quantum light by a photonic device comprised of a metallic nano-ring and a gold back reflector, Applied Physics Letters 120, 081103 (2022).

[6] O.J. Trojak, S. Gorsky, F. Sgrignuoli, F.A. Pinheiro, S.-I. Park, J.D. Song, L. Dal Negro, L. Sapienza, Cavity quantum electro-dynamics with solid-state emitters in aperiodic nano-

photonic spiral devices, Applied Physics Letters 117, 124006 (2020)
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Short Bio:
Luca Sapienza is an Associate Professor in Quantum Engineering at the University of Cambridge (United Kingdom), where he is leading the Integrated Quantum Photonics research group,whose activities focus on the fundamental understanding of quantum optics effects on a chip, the development of quantum and nano-photonic devices integrating single-photon emitters, and the study of quantum effects in bio-molecules.
He graduated summa cum laude from the University of Padua (Italy) and obtained his PhD with highest honours from the University Paris-Diderot (France).
He has held visiting positions at the National Institute of Standards and Technology (USA) and at the Ecole Normale Superieure de Paris (France). He is the Chair of the Semiconductor Physics group of the Institute of Physics, Editor of Materials for Quantum Technology, Fellow and Deputy Dean at Christ's College Cambridge.

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