Master thesis/Internship proposal

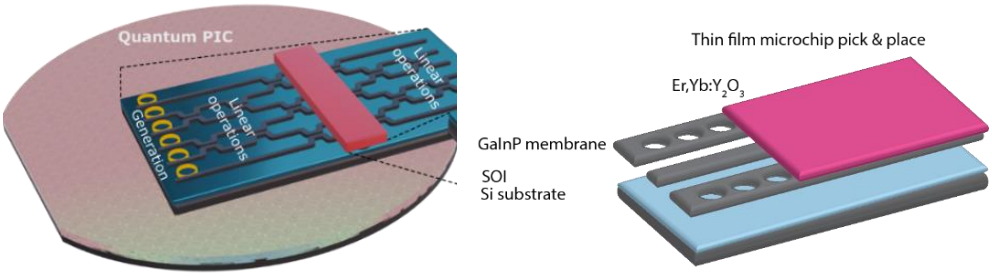
Quantum photonics with crystalline nanomaterials

Laboratory :

Université PSL - Chimie ParisTech, Institut de Recherche de Chimie Paris (IRCP),
Crystals and Quantum State Dynamics group (CQSD)
11 Rue Pierre et Marie Curie, 75005 Paris

The project :

The goal of the project is to realise a hybrid nanophotonics interface [1] with rare-earth ion-doped nanomaterials [2]. Rare-earth (RE) ion-doped oxide crystals constitute a promising solid-state platform for quantum information applications. Indeed, their 4f optical transitions, covering a broad spectral range from visible to infrared spectra, provide atomic-like properties with long optical coherence times up to 4.4~ms (Er^{3+}:YSO) and spin hyperfine coherence times from seconds (Er^{3+}:YSO) to hours (Eu^{3+}:YSO). These unique properties make them very promising for optical quantum memories, quantum transducers, and single-photon sources.



Current CQSD group activities aim to realise on-chip hardware interfacing nanophotonic semiconductor platforms and RE ions doped nanomaterials [2]. To achieve this, we interface Er^{3+} and Yb^{3+} doped oxide thin films with programmable photonic integrated circuits (PIC) based on GaInP on Si, which is well-known for integrated nonlinear photonics applications. The approach enhances the interaction between light and RE ions, thereby compensating for their low oscillator strengths, a crucial advantage for developing integrated quantum memories and operating with single ions [3,4].

The project concerns the fabrication and further optimisation of the quality of rare-earth ion-doped nanomaterials and the study of their optical and spin properties in a cryogenic environment. It will also involve the characterisation of nanophotonic structures compatible with hybrid interface with rare-earth ion nanomaterials.

[1] J.-H. Kim, S. Aghaeimeibodi, J. Carolan, D. Englund, and E. Waks, Optica **7**, 291 (2020).
[2] T. Zhong and P. Goldner, Nanophotonics **8**, 2003 (2019).
[3] Z. Wang, L. Balembois, M. Rančić, E. Billaud, M. Le Dantec, A. Ferrier, P. Goldner, S. Bertaina, T. Chanelière, D. Esteve, D. Vion, P. Bertet, and E. Flurin, Nature **619**, 276 (2023).
[4] C. Deshmukh, E. Beattie, B. Casabone, S. Grandi, D. Serrano, A. Ferrier, P. Goldner, D. Hunger, and H. de Riedmatten, Optica **10**, 1339 (2023).

Who are we looking for? :

The candidate is expected to have:
- Background in optics, solid-state physics, or optoelectronics, including experimental skills
- Basic knowledge of quantum physics and quantum information

- Interest in experimental work and nanoscience
- Ability to work independently and in daily collaboration with the international research team

About us :

Institut de Recherche de Chimie Paris (IRCP) is one of the leading CNRS chemistry laboratories in the Paris region. The group "Crystals and Quantum State Dynamics" (cqsd.fr) is internationally recognized for developing rare-earth ion doped materials for applications in quantum technologies. Our team has extensive experience in the design, growth, and characterization of bulk, thin films and nanoscale crystals, as well as diamond films containing colour centres for applications in photonics and quantum sensing.
We offer creative and stimulating working conditions in a dynamic and international research environment, with access to a wide range of cutting-edge experimental techniques including high resolution coherent spectroscopy, structural analysis and nanofabrication facilities.

Project responsible :

Please send applications to Alexey TIRANOV (alexey.tiranov@chimieparistech.psl.eu)