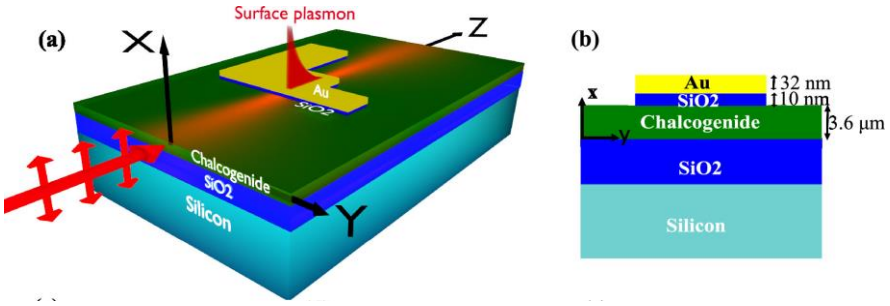
Hybrid Nonlinear-plasmonic devices for Integrated Quantum Technologies

Position: PhD Thesis
Duration & Funding: Fully funded PhD position (3 years), starting October 2026.
Supervisor/ Co supervisor: Dr. Tintu Kuriakose, Prof. Mathieu Chauvet, Prof. Marc Vallet.
Department: Department of coherent Optics and microwave Photonics (DOP), Institut Foton, Campus de Beaulieu, 35042 Rennes, France.
Application Deadline: 30 June 2026- 12 :00 (Europe/Paris). Applications may close earlier if a suitable candidate is identified.
Key words: Nonlinear optics, Plasmonics, Kerr-soliton, Semiconductor waveguides, Quantum optics

Project Description

Light-matter interaction at the nanoscale is central to next-generation photonic and quantum technologies[1]. As digital infrastructure expands and quantum systems move toward practical use, there is growing demand for compact, energy-efficient photonic devices that can precisely control light. Integrated photonics addresses this need by enabling miniaturized optical circuits for information processing, communication, and sensing[2].

Strong optical confinement at the nanoscale enhances nonlinear optical processes. Plasmonic structures are particularly promising because they confine light below the diffraction limit through coupling between electromagnetic fields and collective electron oscillations in metals. When combined with nonlinear materials, this confinement can greatly increase interaction efficiency and enable low-power photonic functions for integrated quantum systems[3].



(a) 3D artistic view of a hybrid nonlinear-plasmonic waveguide. (b) corresponding plasmonic cross-section[4]

However, plasmonic systems suffer from high losses and fabrication challenges. Hybrid architectures (see Fig. a & b) combining plasmonic confinement with low-loss nonlinear materials, such as chalcogenide glasses and III–V semiconductors, offer a promising solution.

The PhD project proposes the design, fabrication, and experimental study of hybrid metal-semiconductor waveguides to enhance nonlinear optical responses while maintaining manageable losses[4,5]. A key goal is achieving stable plasmon-soliton waves, where Kerr nonlinearity balances diffraction and dispersion, enabling compact all-optical switching and signal processing. Although

predicted theoretically[6], stable propagation remains difficult due to limited nonlinear index changes and intrinsic plasmonic losses.

The project will therefore optimize materials, waveguide geometries, and nanophotonic designs to improve nonlinear interactions and reduce losses, aiming to develop efficient hybrid nanophotonic platforms operating at telecommunication wavelengths for advanced classical and quantum photonic applications.

Research environment and partnership

The Institut FOTON[7] (UMR 6082) is a CNRS research unit affiliated with the University of Rennes. It comprises three departments: Coherent Optics and Microwave Photonics (DOP) and Optoelectronics, Heteroepitaxy, and Materials (OHM) in Rennes, and Photonic Systems (SP) in Lannion. The candidate will join the DOP department, collaborating with researchers, engineers, and technicians on nonlinear nanophotonics and integrated photonics.

The project will leverage international and national collaborations, including Femto-ST (Besançon, France), the Fresnel Institute (Marseille, France), ISCR (Rennes, France) and the University of Oxford (UK), providing a rich multidisciplinary and collaborative research environment, along with the possibility of collaborative visits to partner institutions when needed.

About the PhD candidate

The candidate must hold a master's degree or an engineering degree in a photonics-related field, including nonlinear optics, quantum optics and skills in experimental optics and programming. Knowledge of plasmonics, and integrated photonics is an advantage. The student should be interested in experimental research, capable of numerical simulations and data analysis, and willing to participate in cleanroom nanofabrication occasionally. Autonomy, creativity, critical thinking, teamwork, and fluency in spoken and written English are essential (min. B2 level).

Application – complementary information

Applications should be submitted by email, along with the required documents to Dr. Tintu Kuriakose at tintu.kuriakose@univ-rennes.fr (+33 2 23 23 66 05). For further information, please use the same contact details.

Applications should contain:

- A detailed CV
- A cover letter
- Mark lists (at university level) & publications (if applicable)
- Contact of, or letter from, two past lecturers/scientific advisors for reference.

[1]Leuthold et al., *Nat. Photonics*, 4, 2010.
[2]Silverstone et al., *IEEE J. Sel. Top. Quantum Electron.*, 22, 390–402, 2016.
[3]Kauranen et al., *Nat. Photonics*, 6, 737–748, 2012.
[4]Kuriakose et al., *ACS Photonics*, 7, 2562–2570, 2020.
[5]Kuriakose et al., *Opt. Commun.*, 403, 352–357, 2017.
[6]Oulton et al., *Nat. Photonics*, 2, 496–500, 2008.
[7] https://www.institut-foton.eu