



Fonctions Optiques pour les
Technologies de l'Information

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PhD open position at Institut FOTON

Elaboration of InP and related nanostructures on Si for solar hydrogen production and quantum photonics

A 36-month duration PhD will start at « Institut FOTON », on the development and processing of InP and related materials and nanostructures on Si photo-electrochemical cells for solar hydrogen production and quantum photonics.

PhD starting : 1st October 2024

Duration : 36 months

PhD director : Nicolas Bertru **PhD co-supervisors** : Charles Cornet, Fauzia Jabeen.

Funding : CDO Grant from Univ Rennes

Involved Institut FOTON groups : OHM (Optoelectronics, Heteroepitaxy and Materials) research group at INSA Rennes

Keywords : III-V/Si materials, Photo-electrochemical cells, Quantum Dots (QDs), Telecom wavelength, Single Photon Sources / detectors.

PhD context

For years, InP was considered as a semiconductor of choice for light emitting applications (lasers, LEDs) and solar harvesting devices (photovoltaic solar cells), and was associated to excellent optical properties, but also to a high production cost. On the contrary, silicon is a well-known cost-efficient and earth abundant semiconductor. Monolithic integration of InP-based materials on Si thus offers the promise to reach high efficiency, low cost and reduced earth impact optical devices. The direct crystal growth of InP on Si is however subjected to various materials issues and generation of structural defects. In this work, the elaboration of InP/Si-based materials and nanostructures will be considered for applications in :

- 1- Solar hydrogen production. Indeed, the production and storage of clean, renewable, and low-cost energy is one of the challenges facing XXIst century science. The photo-electrolysis of water promises the direct conversion of solar energy into hydrogen,



which can be reused to produce heat or electricity on demand. Preliminary results obtained at the Laboratory suggest that InP/Si heterostructures have a great potential to be used as photoelectrodes in photoelectrochemical cells for water splitting applications.

- 2- Quantum photonics. Like energy demands, fast and secure information transfer is the need of the hour. Developing emitters, detectors, and related quantum optical methodologies that operate in the lowest attenuation window (C-band) is essential for realizing future optical quantum technologies, due to the availability of low optical losses in optical fibers and space communication channels. Ideally, one would like to obtain sources emitting at 1.55 μm spectral window, so it could be built into the currently functioning telecommunication network, as this wavelength aligns with the C-band for silicon fibers. So far, III-V-based emitters are reported only on the InP substrate, with few reports on the GaAs substrate. The III-V systems are the first choice due to their compatibility with existing networks. The realization of such sources emitting in the C-band directly on the Si substrate will open a novel area of research.

In this context, the OHM research team at “Institut FOTON” (located at INSA Rennes), which has recognized expertise at the highest international level in the mastery and understanding of solar cells and III-V on Si semiconductor materials, developed over last year’s propose Phosphide based and related materials integration on the low-cost silicon substrate with promising high yields of photo-electrodes and single photon sources/detectors.

The purpose of the thesis is to develop high quality nanostructured InP/Si templates by molecular beam epitaxy and evaluate their potential for solar hydrogen production and quantum photonics.

About the PhD candidate

The candidate will have to justify a master's or engineering degree, proving, if possible, a basis in semiconductor physics, and in solid-state physics or chemistry. The applicant should have a strong interest in experimental work.

Fluency in English is required (written and spoken).

Partnership

The project will benefit from all the already existing national and international collaborations for the elaboration and characterization of materials and devices. This includes state-of-the-art atomic scale structural characterizations and advanced photonic characterizations.

About “Institut FOTON” laboratory

The FOTON Institute is a research unit of the French National Centre for Scientific Research (CNRS) associated to University of Rennes and the National Institute for Applied Sciences (INSA) of Rennes. FOTON is composed of three research teams: the “Optoelectronics, Heteroepitaxy and Materials” team, the “laser Dynamics, microwave photonics, Polarimetry, terahertz, imaging” team located in Rennes, and the “Photonic Systems” team located in Lannion. The two cities are located approximately 170 km apart, in the province of Brittany, Western France. The OHM research team has an established reputation in the area of advanced materials for photonics, photovoltaics or energy conversion applications. The doctoral student will work in particular within the technological platform NanoRennes, resulting from the gathering of clean rooms of the FOTON institute and the IETR. NanoRennes

is a member of the Renatech+ network. The successful candidate will carry out research in Rennes, France. More information about FOTON can be found at: <http://foton.cnrs.fr>

Additional information - Contact

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How to apply

All applicants have to bring the following documents:

- Motivation letter
- Detailed curriculum vitae (CV)
- Educational grades and marks (at university level)
- Publication list if applicable
- Recommendation letters or people to contact for recommendation.

Candidates from any countries are welcome.