Internship subject

Laboratory: Centre for Nanoscience and Nanotechnology
Address: University Paris Saclay, CNRS
10 Boulevard Thomas Gobert, 91120 Palaiseau - France

Contact: Laurent Vivien
Phone number: +33 (0)1 70 27 05 30
email: laurent.vivien@c2n.upsaclay.fr
https://minaphot.c2n.universite-paris-saclay.fr/en/

Rare earth doped crystalline oxides for on-chip light amplification

Near-infrared (near-IR) integrated photonic devices in silicon-based platforms have been studied over the last decades for applications such as on-chip optical communications and sensing. Driven by the need of more power efficient photonic systems, the hybrid integration of functional oxides has become an attractive route to explore new physical phenomena. In this regard, Yttria-Stabilized Zirconia (YSZ) stands as an interesting material for its structural, chemical and optical properties. We recently demonstrated YSZ waveguides with propagation losses of 2 dB/cm at a wavelength of 1380 nm [1] and promising optical Kerr effect [2]. We have recently explored the introduction of active rare-earth dopants into YSZ waveguides to demonstrate on-chip optical amplifiers from 1300nm to 1550nm [3,4]. For that purpose, erbium (Er^{3+}) ions have been first studied due to their strong luminescence properties within the C-band of telecommunications. In this internship, the candidate will actively participate to the demonstrations of linear and nonlinear optical properties as well as the luminescence behaviors under several optical pump configurations of Er-doped YSZ multilayer stacks around $\lambda = 1.54$ µm, grown by pulsed laser deposition (PLD) technique. The alternation of YSZ thin films and sub-nanometric layers of Er has enabled us to have control of the Er-Er inter-distance in the growth direction, hence being able to strongly decrease the luminescence quenching caused by up-conversion processes. The student will study different layer configurations to understand the optical mechanisms involved in such hybrid waveguides. Moreover, the optical properties of Er-doped YSZ thin films grown on silicon nitride strip photonic waveguides under resonant pumping will be explored and tested. The candidate will be fully involved in the optical simulations, the fabrication and the characterization using integrated optical benches.

The research activity will include:

- **Theoretical study and optical simulations** (using commercial and home-made software) to evaluate the key metrics for tuning the optical properties of the waveguide modes including mode dispersion

- **Experimental characterizations** of integrated devices using photoluminescence set-up and linear and nonlinear optical integrated benches

VALUED QUALITIES IN THE STUDENT

- Curiosity for novel research experiences and fields.
- Creativity and pro-activity in the search for innovative solutions and approaches.
- Attractivity in experiments and simulations.
- Capability to communicate and share results in a multidisciplinary and multi-nationality environment.

This project can be continued and expanded within the frame of a PhD.

[1] G. Marcaud, S. Matzen, C. Alonso-Ramos, X. Le Roux, M. Berciano, T. Maroutian, G. Agnus, P. Aubert, L. Largeau, V. Pillard, .l Serna, D. Benedikovic, C. Pendenque, E. Cassan, D. Marris-Morini, P. Lecoeur, and L. Vivien, "High-quality crystalline yttria-stabilized-zirconia thin layer for photonic applications," Physical Review Materials 2(3) (2018) https://hal.archives-ouvertes.fr/hal-01801073

[2] G. Marcaud, S. Serna, K. Panaghiotis, C. Alonso-Ramos, X. Le Roux, M. Berciano, T. Maroutian, G. Agnus, P. Aubert, A. Jollivet, A. Ruiz-Caridad, L. Largeau, N. Isac, E. Cassan, S. Matzen, N. Dubreuil, M. Rérat, P. Lecoeur, and L. Vivien, "Third-order nonlinear optical susceptibility of crystalline oxide yttria-stabilized zirconia," Photonics Research 8(2), pp. 110 – 120, (2020) https://hal.archives-ouvertes.fr/hal-02389837

[3] A. Ruiz-Caridad, G. Marcaud, J.M. Ramirez, E. Durán-Valdeiglesias, C. Lafforgue, J. Zhang, L. Largeau, T. Maroutian, S. Matzen, C. Alonso-Ramos, S. Collin, G. Agnus, S. Guerber, C. Baudot, F. Boeuf, S. Monfray, S. Crémer, V. Vakarin, E. Cassan, D. Marris-Morini, P. Lecoeur, and L. Vivien, "Erbium-doped yttria-stabilised zirconia thin films grown by pulsed laser deposition for photonic applications," Thin Solid Films, Volume 639, Article number: 1377062, January 2020.https://hal.inria.fr/hal-02415781/

[4] A. Ruiz-Caridad, G. Marcaud, J.M. Ramirez, L. Largeau, T. Maroutian, S. Matzen, S. Collin, C. Alonso-Ramos, G. Agnus, S. Guerber, C. Baudot, F. Boeuf, V. Vakarin, E. Duran-Valdeiglesias, E. Cassan, D. Marris-Morini, P. Lecoeur, and L. Vivien, "Erbium-doped Yttria-stabilized Zirconia thin layers for photonic applications," IEEE Journal of Quantum Electronics, Volume 56, Issue 2, Article Sequence Number: 7000107, April 2020.https://hal.archives-ouvertes.fr/hal-02932964

This project can be continued and expanded within the frame of a PhD.