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## **Femtosecond laser inscription of near-IR laser-gain medium based on laser-induced hydride donor/acceptor complexes**

*F. Alassani, G. Raffy, M. Carpentier, J. Harb, V. Jubera, A. Del Guerzo, L. Canioni, T. Cardinal, Y. Petit*

### Abstract: (200-300 words)

Femtosecond laser inscription has demonstrated these last years its unique potential to achieve material modifications and non-conventional manufacturing of advanced photonic components and devices, giving access to numerous industrial transfers. This includes the all-optical approaches to develop integrated monolithic laser sources, which is of high interest for sensing applications. Our approach is to investigate the benefits of photosensitizing glasses with noble metals such as silver ions to produce the needed functionalities to create integrated lasers. We already reported that laser-induced photochemistry of silver can lead to a specific type of refractive index modification, referred to as Type-A modification (“A” for Argentum) supported by the creation of molecular silver clusters, allowing for the creation of innovative waveguides and promising waveguide Bragg gratings.

In the present work, we co-doped our silver-containing photosensitive glasses with luminescent Ytterbium ions. We demonstrate the resilience of the silver photochemistry despite the presence of the Ytterbium ions. We also report on efficient energy transfers from silver clusters to Ytterbium ions, allowing for the background-free 3D-localized near-IR emission co-located with the laser-induced silver clusters, despite the random and homogeneous distribution of the near-IR emitters. We produced an adapted waveguide that allowed for the efficient injection of a UV pump beam, which was further seeded with a near-IR beam. This led to the indirect laser pumping of the Ytterbium ions by means of energy transfers and their subsequent stimulated emission. We observe up to 25% photon conversion efficiency from UV to near-IR, demonstrating significant Ytterbium inversion population beyond the optically-induced transparency at the emission of 1030 nm. These results depict the achievement of laser-induced creation of a localized hybrid laser gain medium involving silver clusters and Ytterbium ions as donor/acceptor pairs. Further work is in process to demonstrate integrated laser behavior.

### Summary (100 word)

Femtosecond laser inscription is a unique approach to achieve non-conventional manufacturing of integrated photonic devices such as laser waveguides. Our approach relies on sensitized glasses containing both silver and Ytterbium ions. Laser inscription allows for the 3D-localized production of highly luminescent molecular silver clusters that support waveguiding architectures. We demonstrate efficient energy transfers from silver clusters to Ytterbium, allowing for background-free 3D-localized near-IR emission. Near-IR laser amplification under indirect pumping is demonstrated, depicting the localized creation of a hybrid laser gain medium involving silver clusters and Ytterbium ions as donor/acceptor pairs. Further work targets to demonstrate integrated laser behavior.

## **Biblio**

Assoc. Prof. Yannick Petit has investigated linear and nonlinear optics in low-symmetry crystals and in micro-structured periodically-poled ferroelectric crystal. He also investigated ultrafast terawatt-level highly-nonlinear propagation under filamentation regime for atmospheric applications such as laser-induced phase transitions. He currently focuses his interest in femtosecond laser processing of photosensitised glasses to achieve 3D-localized optical contrast to develop multiscale photonic architectures. This led recently to the demonstration of original waveguiding structures for efficient sensing applications under evanescent coupling as well as the creation of both integrated and volume Bragg gratings.