PhD subject - Sujet de thèse (2022-25)

Title: **Glass-metal femtosecond laser welding**

Titre : **Soudure verre-métal par laser femtoseconde**

PhD supervisor/ directeur de thèse : Pr. S. Lecler, F. Antoni sylvain.lecler@insa-strasbourg.fr

Co-supervisors: G. Chabrol, T. Engel

Host Unit/ Unité d'accueil : ICube Laboratory (D-ESSP Department)
IPP team (Photonics Instrumentation and Processes)

Affiliate institution: INSA of Strasbourg

Collaboration(s) (if applicable): IREPA LASER, IPR

Attachment to a program (if applicable): ANR Project Glass-Welding

Summary:

Glasses are highly resistant materials used in a wide range of **key applications** from glass-ceramic plates to MEOMS encapsulation. Their assembly is usually done by bonding or by thermal processes (anodic discharge, brazing, etc.). However, for some applications these techniques have restrictive limits. Polymer adhesives do not withstand high temperatures and thermal processes are not suitable for making precise welds on small dimensions. When two thermally welded materials are dissimilar, a difference in thermal expansion is often a cause of failure.

In this context, **welding by femtosecond pulse lasers**, depositing just the required energy at the good place, without adding material is **very promising green technology** [1-2]. The project aims to develop a laser welding process for glass-to-glass and glass-to-metal that is compatible with current industrial requirements: precise, fast, robust, inter-material distance up to 10 µm, tight, without microcracks, with high tensile strength and capable of withstanding high temperatures up to 700 K or a large number of thermal cycles.

The PhD student will contribute to a better theoretical understanding of the underlying multi-scale physical phenomena and to the development of a more efficient laser process. Pulsed laser with **high repetition rates** [3] and **light patterning** will be considered to better **control thermal accumulation**, reduce the required energy, minimize the residual stresses, and maximize the mechanical strength of the weld seam. A multiphysic model will be implemented and compared to in situ and post experimental characterization. A new femtosecond laser welding station will be developed.

The PhD work is in the context of the **Glass-Welding ANR project**. The process will be tested at **IREPA LASER** and **Institute of Physic of Rennes** will contribute to high accurate post processing characterizations of the welding.

Skills in photonic, laser process and light-matter interaction will be appreciated. The student will develop theoretical and experimental expertise in the high potential field of femtosecond laser processes.

References:

[1] M. Gstalter, G. Chabrol, A. Bahouka, L. Serreau, J-L. Heitz, G. Taupier, K-D. Dorkenoo, J-L. Rehspringer, S. Lecler, Stress induced birefringence control in femtosecond laser glass welding, Appl. Phy. A 123 (714), (2017).

[2] M. Gstalter, G. Chabrol, A. Bahouka, K-D. Dorkenoo, J-L. Rehspringer, and S. Lecler, Long focal length high repetition rate femtosecond laser glass welding, Applied Optics, 58(32), p.8858, (2019).

[3] G. Bonamis, K. Mishchik, E. Audouard, C. Hönninger, et al., Use of bursts up to GHz repetition rate for femtosecond ablation efficiency increase, Journal or Laser Applications **31**, 022205 (2019).