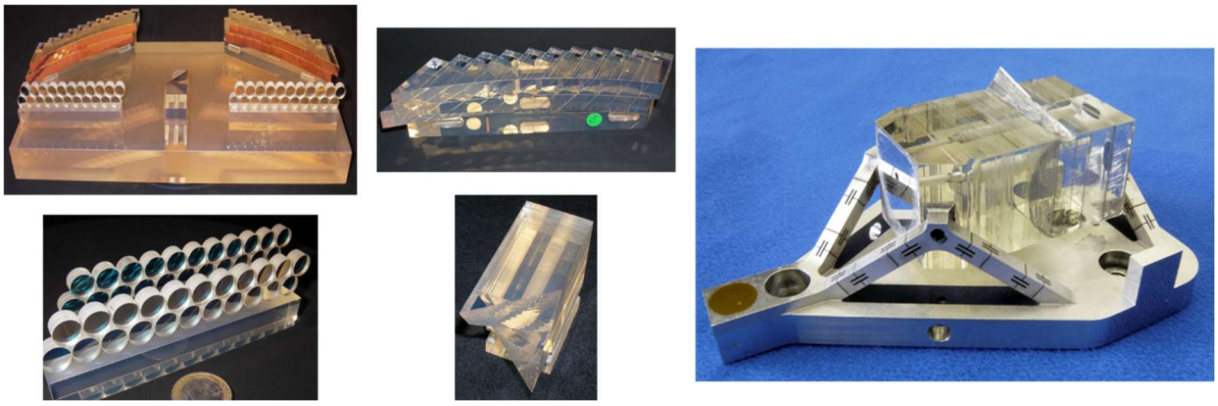
Mechanisms of direct bonding reinforcement by plasma

Context

This project proposes to improve the adhesion technique to improve the adhesion of optical grade silica assemblies. This involves understanding the impact of substrate preparation, polishing techniques, as well as plasma surface preparation which can improve the adhesion process and then adhesion, microelectronics techniques, in order to increase the mechanical strength of hybrid structures.



The development of a multiscale model (from atom to structure), thanks to the multidisciplinary expertise (optics, physics, mechanics, materials) of the consortium, to open the way to fundamental research and a methodology applicable to common optical materials. Under certain conditions, the methodology could also be applied to metallic assemblies.

The consortium was formed within a working group of the Optical and Photonic Business Network (ROP), supported by the CNRS MITI. It includes the Laboratoire de Mécanique et Acoustique de Marseille (LMA UMR 7031 CNRS-AMU, project leader), the Laboratoire de Physique des Lasers (LPL UMR 7538 CNRS-USPN), the Institut Néel (UPR 2940 CNRS-UGA), the Centre de Nanosciences et de Nanotechnologies (C2N UMR 9001 CNRS-UPS), the Laboratoire Charles Fabry (LCF UMR 8501 CNRS-IOGS) and the CEA LETI. It has been financed at the operational and equipment level by a PEPS CNRS and an 18-month R&T CNES starting in June 2023.

Activities

The project proposes to work on three main objectives:

- The first objective concerns the multidisciplinary understanding of the physics of spontaneous adhesion based on experimental tests in the laboratory, such as the fine characterisation of surfaces in order to understand the different states or textures of the surfaces (material(s), flatness, roughness, dangling bonds) as a function of the process parameters (surface cleaning, surface activation, plasmas, etc.), making it possible to establish

a physical link between these observations and the bonding energies measured experimentally.

- The current procedure uses a thermal energy input to strengthen the molecular bonds at the interface (temperature + annealing time) as a direct consequence of the creation of covalent bonds at the interface. The second objective concerns the exploration of so-called "isothermal" procedures based on energy input by radiation (ionising, plasma, etc.). By exploring the performance of these procedures for bonding mainly Silica type materials and to explore if there is time the adhesion of other materials (Oxide, Fluoride type) while evaluating the surface requirements (roughness, flatness...).

- The third objective concerns the mechanical and optical characterisation of adhered assemblies in order to evaluate the mechanical strength as a function of the process parameters and the presence of defects. Initiation and propagation tests to evaluate in detail the performance of adhesions obtained using our processes.

Description or nature of the obstacles to be surmounted

Deepen our knowledge of the physico-thermo-chemical mechanisms of molecular adhesion on different materials such as silica, silicon, oxides and fluorides. To explore the quantitative effect of surface preparation and plasma treatments on the number of dangling bonds available for adhesion, and on the possibility of creating covalent bonds during annealing reinforcement. The mechanical strength of the adhesion thus obtained will be quantified. This identification of the mechanisms may open the way to new bonding procedures and/or the creation of new hybrid interfaces.

Expected skills

PhD in mechanics and/or materials, solid mechanics, experimental activities,

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