Thin layer of silica for direct bonding

12 months of postdoctorat in LSI (IP Paris), collaboration with LETI (CEA) and AIST (Japan)

Densified silica is found in certain fibre optic sensors used in harsh environments, in the form of Bragg gratings. Thin layers of silica obtained by sputtering show characteristics very close to the dense equilibrium phase of silica obtained under "metamict" irradiation, with a density of 2.26 [1-2]. These thin films are constituents of high added-value materials in microelectronics and optics (telescope mirrors for detecting gravitational waves) or are used as barrier layers in so-called "technological" glasses. In microelectronics, direct bonding technology offers many advantages for the production of stacked structures, and has given rise to numerous innovations. At LETI, SiO2 thin films can be synthesized in two main ways: by deposition or by oxidation of the Si. Both methods result in different film structures and properties. Of these, it is known that layers made by thermal oxidation are denser with a low OH content, while those obtained by deposition are more hygroscopic. Water is a key element in direct bonding, but too much of it can be harmful. Among the parameters that promote bonding, the hydrolisation of SiO_2 asperities is one of the main mechanisms. However, the stresses induced in the silica seem to limit the penetration of water. Even if we are able to estimate the residual stress induced in a layer, we do not clearly know the relationship between stress, densification and impact on bonding properties.

The aim of the project will be to characterize the glass structure and properties of the thin layer in particular the densification aspects of silica depending on the synthesized way and to evaluate the changes after electron and ion irradiation.

[1] N. Ollier, M. Lancry, C. Martinet, V. Martinez, S. Le Floch, D. R. Neuville (2019) Relaxation study of pre-densified silica glasses under 2.5 MeV electron irradiation scientific reports 9:1227

[2] Imène Reghioua , Matthieu Lancry , Olivier Cavani, Sylvie Le Floch , Daniel R. Neuville and Nadège Ollier (2019) Unique silica polymorph obtained under electron irradiation Applied Physics Letters 115, 251101 https://doi.org/10.1063/1.5127836

Main aspects developed during the project:

Characterization of thin layer before and after electron and ion irradiation: structure by nano FTIR and nanoRaman (SMIS line SOLEIL synchrotron) and microRaman

Measurements of refractive index by ellipsometry (collab. IP)

Additionnal measurements in collaboration with Japan : Positron Annihilation Spectroscopy and Neutron diffusion

Instituts

LSI (DRF) and LETI (DRT) are two units of CEA respectively located in Palaiseau and Grenoble.

The LSI (Irradiated Solids Laboratory) is a joint research unit of the CEA, the CNRS and the Ecole polytechnique located in Ecole polytechnique (Palaiseau). The mission of Irradiated Solids Laboratory is the study of fundamental properties of the solid state and its various interactions with radiation (photons, electrons, ions), in the multiple goals. N. Ollier's team has been investigating the mechanisms of silica densification (under fs laser, high pressure and electron irradiation) for several years [ref 1-5] and is also studying the relaxation of densified silica under irradiation. This is of particular interest for probing the high- and low-density states involved in silica polyamorphism. Our studies also stand out for their original use of irradiation which, by relaxing the system, enables us to probe the different states of silica, in particular the so-called metamict phase.

Many laboratories around the world use direct bonding in applications such as microelectronics, microelectromechanics and optoelectronics. However, very few laboratories study the fundamental mechanisms of direct bonding. Even if we can mention the University of Tokyo, AIST, IMEC and, in France LC2N but DRT, is one of the main ones.

[3] M. Mobasher, M. Lancry, J. Lu, D. Neuville, L. Bellot-Gurlet, N. Ollier *Thermal relaxation of silica phases densified under electron irradiation*, Journal of Non-Crystalline Solids 597 (2022) 121917

[4] Shchedrina N., Ollier N., Mobasher M., Lancry M. *Investigating Densification Processes of Amorphous Silica Phases through Activation Energy Distribution* Journal of Non-Crystalline Solids 617 (2023) 122491

[5] Shchedrina N, Nemeth G, Borondics F, Ollier N., Lancry M. *Nano-FTIR spectroscopic analysis revealing densification mechanisms in fs-laser induced nanogratings* Nanoscale Advances (2024) DOI: 10.1039/d4na00409d

Profile

Knowledge on IR and Raman spectroscopies and glass will be appreciated

PhD in physics, chemistry or material science

Contact

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Please send your CV including your publications and a cover letter

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12 months post doc

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