Report on the outcomes of a Short-Term Scientific Mission[1]

Action number: CA20129 - MultIChem

Grantee name: Egor Evlyukhin (IESL-FORTH)

Details of the STSM

Title: Establishing a High-Pressure Platform for Investigating Radiation-Driven Processes under Extreme Conditions at IESL-FORTH

Start and end date: 19/01/2025 to 02/02/2025

Description of the work carried out during the STSM

The primary objective of my STSM at Sorbonne Paris North University was to prepare the high-pressure (HP) equipment for integration into the IESL-FORTH's new HP research platform. This involved working closely with Dr. Andreas Zerr at the Laboratoire des Sciences des Procédés et des Matériaux (LSPM), CNRS, UPR3407, where I successfully prepared the diamond anvil cell (DAC) and 45 gaskets, critical tools for generating extreme pressures on small sample areas. Of these gaskets, 30 had holes with diameters of 120 µm and 15 with holes of 150 µm, and they are essential components for conducting HP experiments.

Upon arrival in Paris, I met with Dr. Zerr to discuss the specifics of the DAC and gasket preparation processes and to familiarize myself with the equipment and protocols in place at LSPM. The first task involved assembling the DAC, which required precise alignment of the diamond anvils and gasket preparation. As part of this process, the diamond anvils were glued to tungsten carbide seats using a light-curing composite. Initially, I had planned to use epoxy glue, which requires approximately 12 hours to solidify. However, to improve efficiency, we chose a light-curing composite instead, as it fully polymerizes in just a few minutes. Once cured, the seats were installed into the DAC, with particular attention paid to aligning the diamond culets (the flat, 400 µm in diameter polished faces of the diamond anvils) to ensure they faced each other precisely. This alignment is crucial for enabling even pressure distribution on the sample material. After the DAC was assembled, I proceeded with the gasket preparation. The gaskets, made from stainless steel and 250 µm thick, were indented to create a cavity. This step required careful control to achieve the desired indentation depth of 50-60 µm. Using an Electrical Discharge Machining (EDM) system, I drilled holes into the pre-indented areas of the gaskets

[1] This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the GH for payment of the Grant.

that would hold the sample under pressure (see Fig.1). The diameter of the holes varied, with 30 gaskets drilled to 120 μm and 15 to 150 μm, depending on the experimental requirements. Each gasket preparation took approximately 1.5 hours, and by the end of my STSM, I had completed 45 gaskets. Throughout the process, I followed strict protocols to ensure the precise indentation and hole dimensions of each gasket, which were critical for maintaining the integrity of the HP experiments. By the end of my stay, the fully equipped DAC, along with the prepared gaskets, were ready to be transported back to IESL-FORTH, where it will be integrated into our HP research platform.

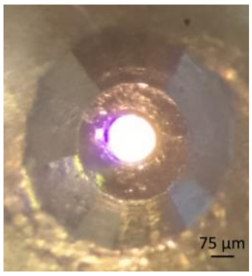

Fig.1. Pre-indented gasket with drilled hole in the middle.

In parallel to the gasket preparation, I also gained valuable hands-on experience with advanced HP experimentation techniques, including the use of the DAC for material compression and *in situ* monitoring using various spectroscopic methods. The work completed during this STSM has laid a solid foundation for future experiments at IESL-FORTH, directly contributing to the establishment of the new HP research facility.

Description of the STSM main achievements and planned follow-up activities

The STSM at Sorbonne Paris North University, conducted in collaboration with Dr. Andreas Zerr at the Laboratoire des Sciences des Procédés et des Matériaux (LSPM), CNRS, UPR3407, successfully achieved its primary objective: the preparation of HP equipment, specifically the DAC and 45 precision gaskets, for integration into IESL-FORTH's emerging HP research platform.
The preparation of the DAC and gaskets was a highly technical process requiring precision and attention to detail due to the micron-sized diamond culets and the required sample openings. This component of the STSM directly supports future investigations into radiation-driven processes, including the fabrication of laser-induced periodic surface structures (LIPSS) and the laser-induced synthesis of biocompatible polymeric materials under high pressure. The successful completion of these tasks ensures that the necessary tools are in place for future experiments and lays a solid foundation for the HP research platform at IESL-FORTH.
One of the main achievements of the STSM was gaining expertise in advanced techniques and protocols used in Dr. Zerr's lab, which will be instrumental for their future adaptation at IESL-FORTH. This knowledge transfer is critical for the long-term development of the HP research facility, as it enhances the technical expertise of IESL-FORTH's researchers while also strengthening the collaboration between the two institutions.
The research conducted during this STSM directly contributes to several objectives outlined in the COST Action MultIChem, specifically related to the advancement of irradiation-driven chemical (IDC) processes at extreme conditions. The future experiments on the fabrication of LIPSS at HP, the synthesis of pristine polymers and nanocomposites, and the study of X-ray-matter interaction mechanisms under extreme conditions will provide valuable data for understanding material transformations in radiation-driven processes. This contributes to the development of new technological protocols, essential for multiscale modeling of IDC processes and data generation for the comprehensive IDC databank.
Planned follow-up activities include conducting at least 45 *in situ* optical experiments at IESL-FORTH using the DAC and newly prepared gaskets. These experiments will investigate material transformations and surface modifications at HPs, directly contributing to future publications focused on LIPSS fabrication and radiation-induced synthesis of materials. The obtained results will be published in scientific journals with appropriate acknowledgment of the COST Action MultIChem.
Moreover, the success of this STSM lays the groundwork for securing additional funding to expand HP research at IESL-FORTH. The next step is to obtain experimental results that will demonstrate the potential of HP techniques and help convince the FORTH board of directors to invest in additional HP equipment, such as EDM machinery, with an estimated budget of €18,000–20,000. This investment will enable the establishment of a fully operational HP research facility capable of supporting a wide range of high-pressure experiments in photonics, nanoelectronics, and biocompatible material synthesis.
In the longer term, the newly established HP facility will be made available to external users, including members of the COST Action MultIChem. This open-access approach will encourage further

collaborations, promote the exchange of scientific knowledge across institutions and disciplines, and facilitate advanced research on light-matter interactions under extreme conditions.