

Foams as a Pathway to Energy from Inertial Fusion (FoPIFE): overview of recent results
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Reaching high gain-high repetition rate ignition using current high-power lasers will necessitate important technological advances, not only on the laser side but in terms of the target and first wall design. Nano-or micro-structured (foam) materials (see figure 1) exhibit unique properties, by how they absorb laser energy and behave during the target implosion, which could make them one of the game changing technologies that fusion energy requires. The FOPIFE consortium gathers twelve Europeans laboratories in France, Italy, Greece, Poland, Germany, Czech Republic and Spain.

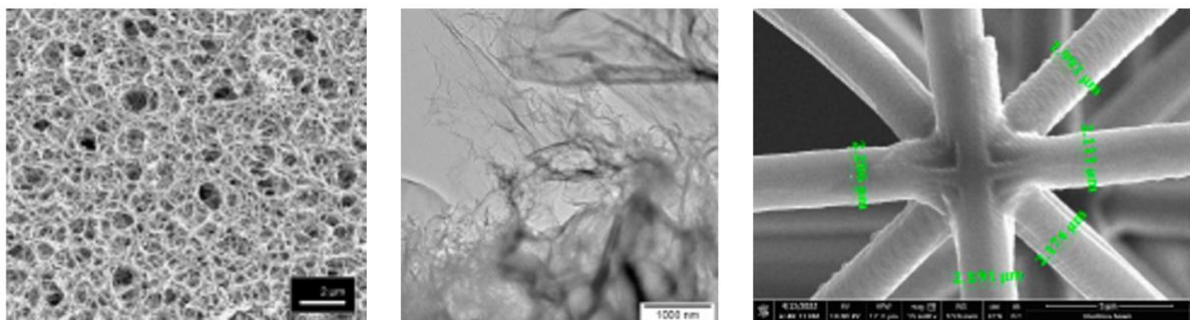


Figure 1 : Chemical synthesis of foam from liquid gels (left), Carbon nanotube and graphene target fabrication technology (center), Additive manufacturing of foams (right)

Our understanding of the basic properties of such materials under laser irradiation is still fragmented and incomplete. The FOPIFE consortium aims at filling these knowledge gaps by improving the theoretical framework, developing high performance numerical models and by gathering key experimental data in fusion-relevant conditions.

The research it is conducting is primarily focused on state-of-the-art theoretical and numerical studies, with supporting benchmarking experiments on existing European and American facilities with three key objectives:

- studying fundamental material properties of dry and wetted foams
- design an ignition scale target for high gain using foam targets
- studying the use of advanced nanostructured materials, in particular the nanostructured tungsten, for coating the first wall and blanket of the reactor chamber and other key components.

In this presentation, new results on foams studies will be presented along these three axis. First, a significant effort has been carried out to understand the physics of foam homogenization, this question being crucial as it sets the initial plasma state. Experiments have been carried out on the Phelix laser at GSI (Germany) and on a XFEL at SACLA (Japan) first to study the time it takes to a porous medium to become homogeneous and secondly to investigate the impact of foam structure on the propagation of a strong shock generated by a high energy laser. Results from these two experimental campaigns will be presented.

In parallel of these experimental campaigns, the consortium is developing a theoretical / simulation framework that will be used in ICF design codes. Large discrepancies between radiation hydrodynamic and experimental data have been observed when looking at the propagation of an ionization front in an under-dense foam. Consistently experiments have shown slower ionization front velocity than predicted by Rad-hydro codes using simple under-dense description of the foams. Within this project, reduced models based on Particle In Cell simulations have been implemented in rad-hydro code presenting better agreement with experimental data.

In addition, rad-hydro code such as FLASH, have been used to model the impact of foam structure on strong shock propagation.

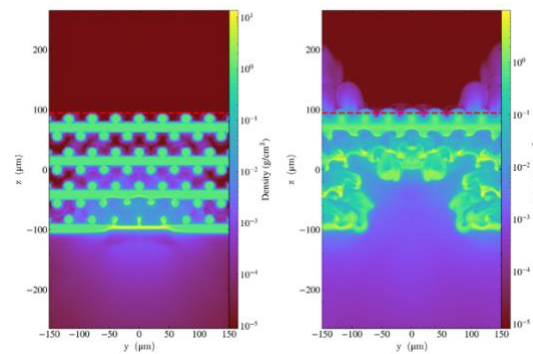


Figure 2: Flash simulation of an high energy laser interacting with a foam medium at two different time (early on the left, late on the right)

Results of these new codes development will be presented as well as results of point design studies of a foam target for high gain ignition.

In the context of material study, experiments have been carried out on the FFLEX laser in Japan to develop a high flux neutron source relevant to first wall material studies. High flux of neutron can be generated by a beam of high energy laser generated protons irradiating a neutron convertor (LiF for example). Foams are envisioned as a way to increase to proton/neutron flux to meet the requirements of a test bed facility for first wall materials. Results showing an increase of a factor of 10 of proton production using foam targets will be presented.

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