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A new laser heating setup for the measurement of noble gases diffusion in nuclear materials

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The noble gases helium, krypton and xenon are generated or implanted in many materials employed in or developed for fission or fusion nuclear reactors (e.g. UO2, neutron absorbers, high-level waste matrices, etc.). Taking the example of the usual fission nuclear fuel UO2, the in-pile generation of noble gases is greatly responsible for the unfavorable microstructure and thermal properties evolutions of the fuel. However the underlying mechanisms governing the behavior of these gaseous elements in UO2 are so far not entirely understood and are almost unknown for the GenIV fuel candidates. Consequently, the diffusion mechanisms and kinetics of noble gases in nuclear materials are paramount to determine for a comprehensive range of experimental parameters. These are however often quite complex to access experimentally, especially when looking to low concentrations to avoid the formation of gas bubbles or defect aggregates.
At our laboratory the quantification of noble gases diffusing out of materials is made possible down to as low as few 107 atoms thanks to advanced gas purification and mass spectrometry techniques. However our investigations were up until recently limited by the actual conventional vacuum furnace used for samples heating (maximum temperature of 1400℃, imprecise control of temperature, impossibility to control and impose oxygen partial pressure (pO2), etc.).
To overcome these limitations, a new heating line has recently been implemented. The latter is based on the use of a high-power laser beam able to quasi-instantaneously and homogeneously heat the samples to controlled temperatures in the range of 600 to 2200℃, with a limited heating of the sample holding components. Furthermore we are currently trying to implement a pO2 control system to be able to vary this crucial parameter.
The proposed poster aims to present the features of this new experimental line and the unique new possibilities of investigation brought by this new setup. A recent example study will also be presented: helium diffusion mechanisms and kinetics in B4C.

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