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# Experimental characterization and numerical simulation of the effect of temperature on the thermal behavior of $\text{UO}_2$ ceramics with a filamentary porosity network

*Abstract for the Nuclear Materials Conference (NuMat2022)*

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The materials studied here are  $\text{UO}_2$  ceramics obtained by sintering, with a highly developed porosity network. This network is characterized by the presence of a fine and elongated porosity which is referred to as "filamentary" porosity after its shape. The latter is associated with open porosity. We also find at a lower scale a quasi-spherical and isolated porosity in the matrix. It is called "occluded" porosity and is assumed to correspond to the closed porosity. Both families of porosity have a strong influence on the thermal behavior of ceramics by degrading their thermal conductivity.

A double-scale model has been developed to evaluate the influence of these two families of porosity on the thermal behavior of ceramics. The effect of occluded porosity is approximated using an analytical model. The Maxwell upper bound gives a good estimate of the effective conductivity in this case which can be approximated by a homogeneous distribution of spherical pores embedded in the solid matrix. The effect of filamentary porosity is evaluated by full-field numerical simulations (FFT method) performed on synthetic microstructures [1] optimized so as to be representative of the real microstructures [2].

In order to validate the developed model, thermal diffusivity measurements have been performed under different conditions. As the conductivity of the gaseous environment is explicitly modelled (conductivity of the open porosity), simulated and experimental results of the thermal diffusivity of the ceramics have been first compared at  $50^\circ\text{C}$  in various gaseous environment (Vacuum, Air and Helium). At this temperature, the Knudsen effect is particularly studied. As the model represents explicitly the contradictory effect of an increasing temperature on the conductivity of the dense ceramic and the gas (conductivity of the porosity network including radiative effects), the simulated diffusivity of the ceramics then has been compared to experiments for temperatures up to  $500^\circ\text{C}$  in  $\text{Ar}/\text{H}_2$ .

## References

- [1] Meynard J, Ibrahim M, Monnier A, Bornert M, Castelier E, Duguay C, Garajeu M, and Masson R. Effective properties of an isotropic solid weakened by micro-cracks localized at inter-granular position. *Journal of Mechanics and Physics of Solids*, 2021.
- [2] Moutin L., Masson R., Bouineau V., Duguay C., Fayette L., Adenot F., and Bornert M. Conductivité thermique d'une céramique affectée par un réseau de fissures localisées aux joints de granulats : simulations 2d de l'effet d'une distribution bimodale de taille de granulats. *Abstract pour le 30<sup>e</sup> congrès français de thermique, Société Française de Thermique 2022*, 2022.