Hollow nanoparticles: applications in nuclear fusion power plants

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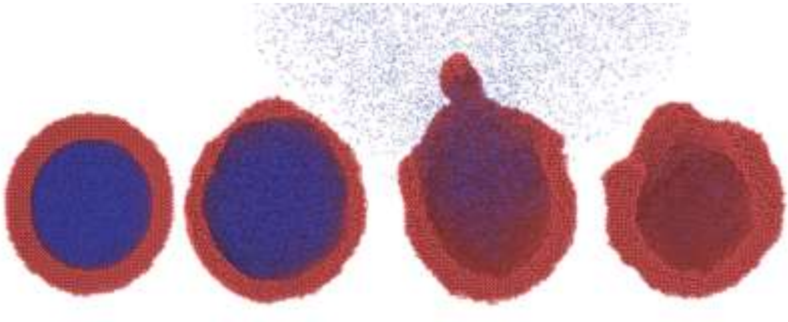
In the last years, hollow nanoparticles have been studied due to their astonishing properties. In particular, their high resistance to elevated temperatures and pressures and their distinctive optical properties. Fabrication is an issue for many materials due to the natural trend of the nanoparticles to the most stable configuration, the solid sphere. In this talk, a brief description about fabrication methods by means of laser pulses will be given to focus next on the application of hollow tungsten nanoparticles in future nuclear fusion power plants. The first wall of these plants is still an open problem in many concepts due to the poor behaviour of the existing plasma facing materials under the expected detrimental irradiation conditions. A special concern is related to the retention of light species, in particular hydrogen and helium. Our studies on tungsten hollow nanoparticles under different irradiation scenarios by means of classical molecular dynamics determined that these particles can resist temperatures up to 3000 K and huge internal pressures (>5 GPa at 3000 K) before rupture. In addition, a self-healing mechanism leads to the formation of an opening, through which gas atoms are able to escape. The opening disappears as the pressure drops, restoring the original particle. By means of object kinetic Monte Carlo simulations we found an additional self-healing mechanism for defect annihilation. We will discuss our multiscale methodology and the results obtained for different fusion scenarios. We will show the promising behaviour of hollow tungsten nanoparticles in some scenarios, which opens a new path to solve a long-standing problem in the field of fusion technology.

References

P. Diaz-Rodriguez, F. Munoz, J. Rogan, I. Martin-Bragado, J.M. Perlado, O.Y. Peña Rodríguez, A. Rivera, F. Valencia, Highly porous tungsten for plasma facing applications in nuclear fusion power plants: a computational analysis of hollow nanoparticles, Nucl. Fusion. 60 (2020) 096017. https://doi.org/10.1088/1741-4326/aba092.

Figures



Molecular dynamics simulations of a hollow tungsten nanosphere explosion highly pressurized at 3000 K. Red = W atoms, Blue = Helium atoms.