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Colloidal Crystals for Photonic Detection of Fluid Phenomena in Nanoporous Systems

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Photonic colloidal crystals, also referred to as *artificial opals*, are well-known systems that, relying on their photonic properties, have wide applicability in many fields such as photonics, sensing, light harvesting, etc. Recently, latest knowledge on their ability to adsorb and confine fluids, and correspondingly transduce to photonic response [1-3] allowed to envisage new perspectives for artificial opals as labs-on-a-chip for the investigation of liquid-solid interplay in porous microsystems [4-5]. In particular, simple spectroscopy that monitors in situ the photonic bandgap of an opal allows to study phenomena such as vapor adsorption and condensation, wetting, imbibition and confined flow within the nanoporous network formed by the constituting submicron spheres. Opals offer a number of benefits compared to other porous materials or nanofluidic devices. Beside the easy and versatile fabrication in different scales with diverse materials and post-manufacture treatments, the main advantage of artificial opals resides on the photonic nature of the output, which ensures high sensitivity and immediate response time, while no further sensors or imaging devices are required. Eventually, the correlation of the bandgap performance with the state of the fluid in the opal can allow visualizing the fluid via software conversion.

In this talk I will gather recent achievements that prove the potential of opals as novel micromodels for investigation of fluids in nanoporous media. On the one hand, water condensation in the opal network under saturated vapor conditions was studied near the dew point. The outstanding optical response of the opal, even visible for the naked eye, allowed the investigation of features such as pore filling, coalescence of capillary bridges and macroscopic water transport. Shifted phase changes were inferred from the observed hysteretic behaviors. On the other hand, the opal response to selective pore filling allows straightforward evaluation of the pore size distribution, as demonstrated in a hierarchically porous carbon opal [6]. Finally, as a particularly interesting application of the photonic performance of opals, light diffusion is used to reveal nanoscopic inhomogeneities of the fluid/gas phases within the ordered spheres arrangement. Specifically, the unfavorable wetting on hydrophobic surfaces (such as those in polymer opals) may lead to irregular water clustering and, thus, to diffusive processes that can be easily monitored via light losses. Additionally, the mean free path of light in the wet opal can be obtained, which can be correlated with the morphology and connectivity of both liquid and gas phases.

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