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Engineering ordered porous structure with direct additive-manufacturing approach for solar thermochemical fuel production

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Solar-driven thermochemical fuel processing has shown potential for efficient large-scale solar fuel production due to its broadband solar absorption and favorable thermodynamics and kinetics at high operating temperatures. The porous media is one of the crucial components in the fuel production reactor, which directly converts concentrated solar radiation into heat, enhances heat and mass transport, and provides reactive sites for redox reactions. The coupled multiphysical phenomena involved in a typical reactor require an in-depth understanding of optical propagation, heat and mass transfer, as well as thermochemical reactions in a comprehensive manner. Moreover, these transport and reactive phenomena are closely related to the morphology of the porous reactant. Hence, it opens a pathway for optimizing the reactor with tuned porous structures.

In this study, we introduced the 3D-ordered structures, i.e, TPMS structures, whose morphology can be precisely controlled by their well-defined mathematical expressions. By introducing local anisotropy, we aim at achieving uniform solar absorption as well as temperature distributions to minimize the thermal and chemical stresses in the porous structure for a longer lifetime. The designed porous structures were fabricated by an advanced stereolithography-based ceramic 3D printing method. The fabricated structures were then tested in a dedicated environment chamber operating under a high-flux solar simulator at SUSTech. The local temperature and oxygen sensors were used for probing temperature and partial pressure of oxygen along the sample length which was then linked to optical and reaction phenomena via our high-fidelity modeling framework. This study will offer a verified method for optimizing porous structures for performant solar thermochemical fuel generation.

Participation

In-Person

References

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