Colloquium Thermo- and Fluid Dynamics

Harnessing sunlight to drive thermochemical cycles utilizing redox-active mixed ionic-electronic conducting materials for CO2/H2O splitting, thermochemical energy storage, and air separation

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Effectively utilizing sunlight is integral for driving the transition from fossil fuels to renewable energy technologies. Research endeavors focused on coupling concentrated solar thermal technologies to thermochemical processes and cycles are offering new, promising pathways towards effectively capturing and storing sunlight to accelerate the transition. Two-step solar thermochemical cycles based on metal oxide reduction/oxidation (redox) reactions aimed at H2O and CO2-splitting, solar thermochemical storage, and air separation are particularly interesting. The first cycle step is the thermal reduction of the metal oxide to a lower valence metal oxide or a metal and O2 driven by concentrated solar irradiation. Three different oxidation pathways are considered in the second step: (1) oxidation with H2O and/or CO2 to produce H2 and/or CO, (2) oxidation with O2 at elevated temperatures to release sensible and chemical heat for electricity generation, and (3) oxidation with O2 in air to produce N2. Redox-active mixed ionic electronic conducting (MIEC) materials are promising materials that are being investigated for integration into different solar thermochemical cycles due to attractive properties, including tunability via cation selection and substitution for different operating conditions, reactions in the absence of crystal structure changes, and thermal stability over a large range of temperatures. The net result is rapid kinetics from the facile conduction of electrons and O2- ions through the sublattice at elevated temperatures, creating charge imbalances that result in O2- vacancy formations in the sublattice. The state-of-the-art in redox-active MIEC materials will be examined for the different solar thermochemical cycles along with future perspectives.

Dr. Peter Loutzenhiser is a Professor and a Woodruff Faculty Fellow in the Woodruff School of Mechanical Engineering at the Georgia Institute of Technology (GIT). He joined the faculty of GIT in May 2012 and is pursuing research in the area of Solar Thermochemistry and Technology, and he has directed research in this area funded by the U.S Department of Energy and NASA. He was the recipient of the ASME Solar Energy Division's prestigious Yellott Award in 2018, and he was elected Fellow of the ASME in 2023. He also serves as Associated Editor for Solar Energy and the International Journal of Heat and Mass Transfer and is on the editorial board of Materials. Dr. Loutzenhiser received his PhD in Mechanical Engineering from Iowa State University in May 2006. Research for his PhD was performed at the Swiss Federal Laboratories for Materials Testing and Research (EMPA) and focused on Building Physics. Dr. Loutzenhiser was a post-doctoral researcher at the Paul Scherrer Institute, applying his extensive solar experience to the field of Solar Thermochemistry. He continued his research at the ETH Zurich in Solar Thermochemistry where he was a Lecturer and Research Associate prior to moving to GIT.

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Place: ETH Zurich, ML H 44
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