UNIVERSITY OF CALIFORNIA UCRIVERSIDE | Mechanical Engineering

The Department of Mechanical Engineering Presents

Prof. Timothy S. Fisher

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Title: Zero-carbon energy and nanomaterials at scale: Solar-thermal synthesis of graphitic carbon and hydrogen via methane decomposition

Abstract: Current industrial processes for power, fuel, and commodity production are responsible for massive, ongoing CO_2 emissions that adversely affect the stability of Earth's climate with potentially disastrous consequences. Increased use of hydrogen as a fuel and chemical building block promises to reduce CO_2 emissions in critical sectors, but modern hydrogen production technologies also involve high greenhouse gas emissions. Specifically, steam methane reforming (SMR) typically relies on fossil-fuel combustion to derive heat and constitutes 95% of current hydrogen production which yields substantial CO_2 emissions. The entirety of the combustion heating would be avoided by utilizing a portion of the bountiful 75,000 terawatts of solar power reaching Earth's surface. This talk considers a process in which concentrated radiation from a simulated solar source converts methane to high-value graphitic carbon and hydrogen gas. Methane flows within a photo-thermal reactor through the pores of a thin substrate irradiated by several thousand suns at the focal peak. The methane decomposes primarily into hydrogen while depositing highly graphitic carbon that grows conformally over ligaments in the porous substrate. The direct heating of the porous substrate serves to capture the solid carbon into a readily captured and useful form while maintaining active deposition site density with persistent catalytic activity. Results indicate a strong temperature dependence with high decomposition with concentration factors and temperatures above 1000 suns and 1300 K, respectively. Even with a large flow area through regions of lower concentration and temperature, methane conversion and hydrogen yields of approx. 70% are achieved, and nearly 60% of the inlet carbon is captured in graphitic form.

About the Speaker: Timothy S. Fisher (PhD in Mechanical Engineering, 1998, Cornell) was born in Aurora, IL USA. He joined UCLA's Department of Mechanical & Aerospace Engineering in 2017 after 15 years in Purdue's School of Mechanical Engineering, and several previous years at Vanderbilt University. In 2018 he was named Department Chair and received the John P. and Claudia H. Schauerman Endowed Chair in Engineering at UCLA, as well as the ASME Heat Transfer Memorial Award. From 2009 to 2012, he served as a Research Scientist at the Air Force Research Laboratory's newly formed Thermal Sciences and Materials Branch of the Materials and Manufacturing Directorate (WPAFB, OH). He also has a long-standing affiliation with the Jawaharlal Nehru Center for Advanced Scientific Research in Bengaluru, India. His research has included studies of nanoscale heat transfer, electronics cooling, carbon nanomaterial synthesis, coupled electro-thermal effects in semiconductor and electron emission devices, energy conversion and storage materials and devices, microfluidic devices, biosensing, and related computational methods ranging from atomistic to continuum scales. He has advised more than 30 doctoral advisees to completion, and in 2012 he received the McDonald Mentoring Award from ASME. He is active in professional service through a variety of responsibilities and is a former Co-Editor of the journal Energy Conversion & Management and Specialty Chief Editor for Thermal and Mass Transport of the journal Frontiers in Mechanical Engineering.

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