MSE SEMINAR

February 3, 2017
113 McBryde Hall
3:30 – 4:30 PM
Refreshments at 3:00 PM

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"Materials Thermodynamics – An Engineering Tool for Green Materials Manufacturing"

Abstract

Thermodynamics has long been a tool for the discovery of materials and their fabrication processes. This presentation will focus on how thermodynamics has been used to design hydrothermal methods to replace conventional high temperature processes. Since the late 80s, we have been building an inorganic solids databank that is the heart of the thermodynamic simulation engine. Methods for compiling a reliable databank will be presented, including methodologies for thermodynamic property estimation. We have used phase diagrams generated by these computations for identifying materials systems that can be synthesized by hydrothermal methods. Thermodynamic modeling has great utility in the design of processes for powders, films, and monoliths. Using thermochemical computations, we invented a process called reactive hydrothermal liquid phase densification (rHLPD) to create densified monolithic materials. This process is ideal for the processing of net-size & -shape composites that include a wide range of materials chemistries never explored before. For example, cementitious material can be prepared by carbonation of mineral grade wollastonite ($CaSiO_3$) with an energy investment as little as 0.3 GJ/t and a negative carbon footprint of ~-11%, while Portland cement requires about 5 GJ/t with a positive carbon footprint of ~+90%. This thermodynamic modeling approach has led to several new processes for carbonate cement and concrete production. Version 1.0 for carbonate cement concrete reduces CO_2 emissions up to 70% and energy consumption by up to 30%. New technology currently under development could produce some of the first carbon-neutral materials manufactured only with renewable energy. World-wide adoption of Version 1.0 could reduce anthropogenic CO_2 emissions by at least 3% if not much more, which would be the largest amount for any single materials manufacturing technology in history. In addition, this technology has evolved to include composites that include a wide variety of metals, polymers and ceramics. Polymer-ceramic composites can be prepared at ultra-low cost, yet offer atypical thermal-mechanical behavior that could enable significant light-weighting of land, marine and air-based vehicles to reduce their emissions by a few percent as well.

Biosketch

Richard Riman is a Distinguished Professor in the Department of Materials Science and Engineering at Rutgers University. His current research focuses on the discovery and development of sustainable materials manufacturing methods in a wide range of fields of use. He holds a B.S. degree in Ceramic Engineering from Rutgers and a Ph.D. from MIT in Materials Science and Engineering. He has authored more than 200 publications, 100 patent applications and patents and delivered over 500 presentations. Early in his career, he received research recognition awards from the National Institute of Health National Science Foundation, Office of Naval Research, Alcoa, DuPont. and Johnson & Johnson and R&D 100. His research has assisted over 100 established companies and enabled the founding of 4 manufacturing companies, namely Ceramaré Corporation, Solidia Technologies, Inc., Rare Earth Separations, Inc., and RRTC, Inc.. His work has been entitled him membership in the National Academy of Inventors, NJ Inventor's Hall of Fame, World Academy of Ceramics and as an American Ceramic Society fellow.