Low-pressure ammonia Thermocatalyst prepared by exsolution of trimetallic heterostructures

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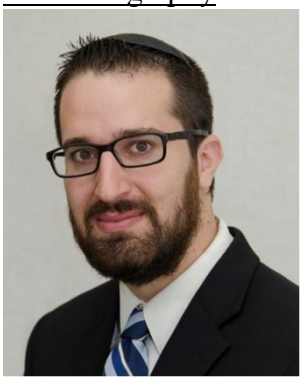
Abstract
Ammonia synthesis is typically done by the Haber-Bosch process and is a chemical critical for sustainable agriculture. It is additionally gaining significant interest in the energy sector as a chemical hydrogen carrier. The Haber-Bosch process is an energy-intensive and polluting method for making ammonia; therefore, there is great interest in developing catalysts for thermochemical production of ammonia at comparatively lower pressures and temperatures. This effort has been blocked by a lack of active catalysts which can simultaneously activate nitrogen bond scission, relieve the effects of hydrogen poisoning, and maintain nanoscale stability for extended periods of time. Here, we report the exsolution of heterogeneously structured tri-metallic Ru-Cu-Fe nanoparticles from lanthanum ferrate backbones. By exploiting the immiscibility regions in the Ru-Cu-Fe phase diagrams, nanoscale catalytic heterostructures from these three metals were formed, and found to catalyze thermochemical ammonia synthesis at atmospheric pressure (0.1 MPa) at 7.54 mmol/gcat/h/wt% Ru. Copper, which is not active for ammonia synthesis, was shown to be a promoter by preventing agglomeration, producing additional oxygen vacancies in the support which act as nitrogen activation sites. The immiscibility between the Cu and Ru-Fe was further shown to prevent agglomeration, whereby maintaining an ideal Ru particle size around 1.8 nm for up to 100h.

Short Biography



Brian Rosen is the Vice Dean for International Affairs in the Faculty of Engineering at Tel Aviv University, an Associate Professor the Department of Materials Science and Engineering, and the head of the Energy Materials Laboratory. The laboratory specializes in the design of novel ceramic catalyst for fuel cells (PEMFC, AFC, H_2/NH_3-SOFC), and synthetic fuel production (H_2, NH_3, syngas) via thermochemical and electrochemical routes. The Rosen lab investigates \ways to modulate catalyst activity by tuning the metal-ceramic interface via multi-scale defect engineering, strain engineering, solid-state phase separations, and electronic structure modulation. Prof. Rosen was named as U.S. Department of Energy Office of Science Graduate Fellow in 2010. His work was the basis for a US-based startup company, Dioxide Materials (Boca Raton, FL) which develops industrial CO_2 electrolyzers and the Israeli startup Fonto Power (acquired by Solar Edge) which develops SOFC-Battery hybrid systems. Professor Rosen was given the Young Innovator Award in Nanocatalysis Research by the Springer journal Nano Research in 2021, and the Climate Solutions Breakthrough Research Prize in 2023.