Materials Science & Engineering Seminar Series

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Revealing the Scaling Properties of Matter Through Low-Dimensional Crystals

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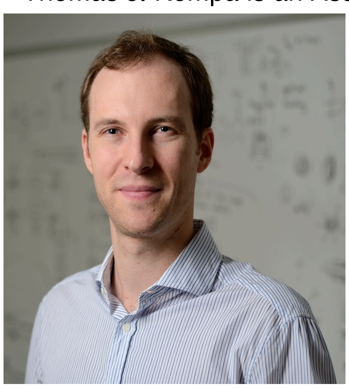
ABSTRACT:
The physical properties of matter change dramatically as atoms assemble into extended solids. Low-dimensional crystals could be used to reveal the intricate evolution of material properties across extremes of scale. However, overcoming profound challenges to progress will require methods for systematic and precise control over the size, shape, and structure of these crystals. To this end, we have developed strategies for controlled crystallization of low-dimensional materials and have identified that even subtle tuning of their dimensionality and morphology yields substantial property changes. Notably, we can manipulate precisely the dimensionality of transition-metal dichalcogenide crystals by growing these model 2D materials on specially functionalized surfaces. The resulting 1D crystals emit light whose energy and profile show an unexpected progression as a function of crystal size. Expanding the scope of our methodologies, we also demonstrate the synthesis of 2D metal-organic frameworks. A reversible 1D-to-2D phase switching can be induced in these molecular frameworks with concomitant and substantial change in electronic transport. Our efforts underscore the importance of rational synthesis in the design of low-dimensional materials that link material lengthscales and advance the fields of optics, electronics, energy conversion, and quantum sensing.

BIOGRAPHY:
Thomas J. Kempa is an Assistant Professor of Chemistry and of Materials Science and Engineering at



Johns Hopkins University. He holds a bachelor's degree in chemistry from Boston College (2004) and spent 2 years as a post-graduate student at Imperial College London courtesy of a Marshall Scholarship. After returning to the United States, Tom pursued graduate studies in chemistry under the direction of Prof. Charles Lieber at Harvard University where he focused on the discovery and development of nanoscale materials for next-generation solar cells and photonic devices. After receiving his PhD in 2012, Tom conducted postdoctoral studies in the laboratory of Prof. Daniel Nocera, first at MIT and then at Harvard, and focused on harnessing electrochemical and hydrodynamic phenomena to form complex patterns of inorganic nanostructures. Over the course of his graduate and post-doctoral studies, Tom has received the MRS Graduate Student Award, the Dudley Herschbach Teaching Award, and the 2013 IUPAC Young Chemist Prize.

Professor Kempa's research group develops new methods to prepare and study low-dimensional (low-D) inorganic crystals from nanoparticles (0D) to few-atom thick sheets (2D) whose exceptional properties render them intriguing platforms for optoelectronic, energy conversion, and quantum science studies. His group's expertise spans the areas of physical, inorganic, and materials chemistry. Professor Kempa is the recipient of numerous awards including an NSF CAREER Award, a Toshiba Distinguished Young Investigator Award, a Dreyfus Foundation Fellowship in Environmental Chemistry, and a Hopkins Discovery Award

Doherty Hall 2210, 11:30AM
Friday, February 28, 2020