Precision Synthesis of Quantum Material Building Blocks

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Abstract:

Quantum materials are poised to transform the development of next-generation sensors, analytical instruments, information processing systems, and energy conversion platforms. Realizing these lofty goals will require low-dimensional crystals whose size, shape, structure, and composition can be tailored to atomic levels of precision. Chemistry will play a vital role in creating these crystalline building blocks of quantum matter. In this vein, the Kempa group has focused on the precision synthesis of 2-dimensional (2D) materials to harness quantum phenomena. Our work with 2D atomic lattices and 2D molecular frameworks has revealed that even subtle manipulations of the dimensionality and morphology of these materials yield substantial property changes. Notably, we can dramatically manipulate the structure of 2D transition-metal dichalcogenides by growing them on chemically tailored surfaces. The resulting nanoribbons emit light whose energy and profile show an unusual progression with crystal size. Seeking to expand the 2D materials landscape, we have also prepared and examined new 2D molecular frameworks. Reversible phase switching can be induced in these frameworks with concomitant modulation of electronic transport. Our efforts underscore the importance of rational synthesis in building low-dimensional materials that enable new discoveries and advance the fields of optics, electronics, energy conversion, and quantum sensing.

Biographical Information (Long):

Thomas J. Kempa is an Assistant Professor of Chemistry and of Materials Science and Engineering (by courtesy) at Johns Hopkins University. Tom received a bachelor's degree in chemistry from Boston College in 2004 and was also awarded a Marshall Scholarship, which he used to pursue two years of post-graduate study at Imperial College London. 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 a DARPA Young Faculty Award, an NSF CAREER Award, a Toshiba Distinguished Young Investigator Award, a Dreyfus Foundation Fellowship in Environmental Chemistry, and two Hopkins Discovery Awards. He was also named an Emerging Investigator by the *Journal of Materials Chemistry A* and was recently selected by *Matter* as one of 35 early career PIs leading breakthroughs in materials science.

Biographical Information (Short):

Thomas J. Kempa is an Assistant Professor of Chemistry and of Materials Science and Engineering (by courtesy) at Johns Hopkins University. After receiving a bachelor's degree in chemistry from Boston College (2004) and after being awarded a Marshall Scholarship, Tom completed two years of post-graduate study at Imperial College London. Returning to the United States, he began graduate studies under the direction of Prof. Charles Lieber at Harvard University and earned his PhD in 2012. Thereafter, Tom conducted postdoctoral studies in the laboratory of Prof. Daniel Nocera, first at MIT and then Harvard. 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. Professor Kempa is the recipient of numerous awards including a DARPA Young Faculty Award, an NSF CAREER Award, a Toshiba Distinguished Young Investigator Award, a Dreyfus Foundation Fellowship in Environmental Chemistry, and two Hopkins Discovery Awards. He was also named an Emerging Investigator by the *Journal of Materials Chemistry A* and was recently selected by *Matter* as one of 35 early career PIs leading breakthroughs in materials science.