School of Molecular Sciences
Arizona State University

SMS Fall Seminar P&T

Friday Sept 2 | 2:30pm | Biodesign Auditorium

Expanding the Compositional and Microstructural Space of Transition Metal-based Carbides and (Carbo)Nitrides as 3D and 2D Functional Materials

In the world of molecular chemistry, powerful "synthesis-by-design" strategies lead to an ever-growing collection of organic compounds, biomolecules and polymers. In contrast, inorganic solid-state chemistry is typically bound by thermodynamics that determines which phase/structure is the most stable as well as slow kinetics (slow mass transport in solids) that leads to the necessity of very high reaction temperatures and times for phase transformations to occur. As a result, certain solid-state target compounds may seem out of reach. However, technological innovations are driven by the synthesis and exploration of novel materials pushing solid-state and materials chemists to develop advanced synthetic protocols to access new, or improved, functional materials.

My group has accepted this challenge focusing on the syntheses of new types (in terms of chemical composition and shape/morphology) compounds that belong to the family of layered 3D and 2D carbides and (carbo)nitrides, the so-called MAX phases and MXenes. Both are chemically highly diverse – new members are being added frequently – and promise useful properties for a wide array of potential applications, for example in consumer electronics, construction materials and biomedicine. To fully understand the structure, microstructure and properties, we collaborate with a number of theoreticians and experimentalists specializing in different aspects, such as low-temperature physics, and polymer and surface chemistry.

MAX phases consist of an early-to-mid transition metal (M), a main group element, mostly from groups 13 and 14 (A) and carbon and/or nitrogen (X) and are an intriguing class of materials – particularly in terms of their mechanical properties – as they combine characteristics of metals and ceramics. Furthermore, they serve as bulk layered precursors for the relatively young family of 2D MXenes, that can be synthesized by selective removal of the A element, typically Al, through chemical etching, typically with aqueous hydrofluoric acid. They can be fully delaminated into atomically thin sheets stabilized by surface functional groups (mostly -F and -OH).

In my talk, I will highlight a few key successes of my team in the synthesis of new versions of MAX phases and MXenes including, for example, new shapes (e.g. microwires, -spheres) of ternary carbides, hitherto unknown carbonitrides as well as hybrid MXene-polymer structures that exhibit switchable properties.

Christina S. Birkel, PhD

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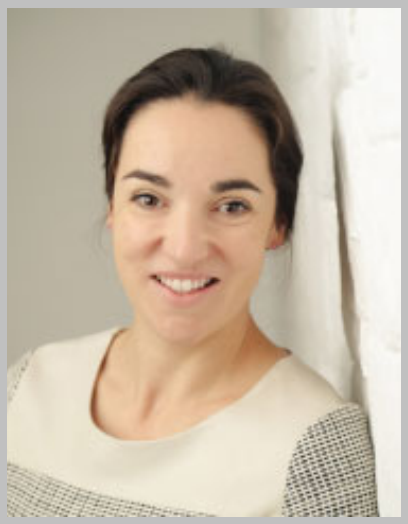
School of Molecular Sciences



Christina Birkel joined the faculty of the School of Molecular Sciences in 2019. Prior to her appointment as an assistant professor at ASU, she held an Athene Young Investigator (junior research group leader) position at the Technische Universität (TU) Darmstadt, Germany (2013-2018). During that time, she also completed her Habilitation in the Department of Chemistry at TU Darmstadt. Before her independent career, she was a postdoctoral researcher in the groups of Prof. Galen Stucky and Prof. Ram Seshadri at the University of California, Santa Barbara (UCSB, 2011-2013). At UCSB, she focused on the development of non-conventional solid-state synthesis methods to prepare (mostly intermetallic and oxide) energy (e.g. thermoelectric and phosphor) materials. She received her doctorate (Dr. rer. nat., summa cum laude) in late 2010 with a double-degree from the University of Mainz, Germany and Seoul National University, South Korea working with Prof. Wolfgang Tremel and Prof. Kookheon Char. Her graduate work involved the wet-chemical synthesis of chalcogenide nanoparticles for thermoelectric applications.

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