Understanding and Tuning Catalytic Materials Using Nanocrystal Precursors

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Catalytic processes are central to the goal of a sustainable future. A promising approach in developing catalytic materials is represented by the design of catalytic sites based on the knowledge of reaction mechanisms and structure-property relationships and aided by computation, and in the precise synthesis of these sites at the atomic and molecular level. The materials-pressure gap, however, still hinder the full realization of this strategy. Nanocrystal precursors, with tunable active sites and compositions, can help bridge this gap. The goal of this talk is to show how this approach can provide not only fundamental understanding of catalytic reactions, but also represent a way to precisely engineer catalytic sites to produce efficient catalysts that are active, stable and selective for several important catalytic transformations. Advances in the synthesis of these materials will be presented, in order to better understand the mechanism of colloidal nanocrystal formation, to control their structure and composition at the nanometer level. Examples of the use of these building blocks as supported systems or in combination with hybrid organic materials will be shown, both to understand trends in methane and CO_2 activation, and in the preparation of optimized catalytic systems combining multiple active phases. In all these examples, important efforts to obtain precious structure-property relationships will be highlighted, with this knowledge used to prepare more efficient catalysts for sustainable production of fuels and chemicals.

Matteo Cargnello received his Ph.D. in Nanotechnology in 2012 at the University of Trieste (Italy) under the supervision of Prof. Paolo Fornasiero, and he was then a post-doctoral scholar in the Chemistry Department at the University of Pennsylvania (Philadelphia) with Prof. Christopher B. Murray before joining the Faculty at Stanford in January 2015. He is currently Assistant Professor of Chemical Engineering and, by courtesy, of Materials Science and Engineering and Terman Faculty Fellow at Stanford University, Stanford, CA.

Dr. Cargnello is the recipient of several awards including the ENI Award Debut in Research 2013, the European Federation of Catalysis Societies Award as best European Ph.D. thesis in catalysis in 2013, the Young Scientist Prize at the 16th International Congress on Catalysis in 2016, the Junior award from the European Rare Earth and Actinide Society in 2018, and the Sloan Fellowship in 2018. General goals of the research in the Cargnello group pertain to solving energy and environmental challenges. In the Cargnello group, uniform and tailored nanocrystals and nanostructures are synthesized, studied and used for energy and environmental applications through catalytic processes, with emphasis on how to precisely control nanoarchitectures to understand and exploit interactions between well-defined building blocks.