

## Exploiting Microreactors for Correlative Studies of Working Catalysts With Electrons And X-Rays

Eric Stach<sup>1</sup>, Alexandre Foucher<sup>1</sup>, Nicholas Marcella<sup>2</sup>, Anna Plonka<sup>3</sup>, Ryan Tapper<sup>4</sup> and Anatoly Frenkel<sup>5</sup>

<sup>1</sup>University of Pennsylvania, Philadelphia, Pennsylvania, United States, <sup>2</sup>Stony Brook University, United States, <sup>3</sup>Stony Brook University, New York, United States, <sup>4</sup>Brookhaven National Laboratory, Upton, New York, United States, <sup>5</sup>Stony Brook University, Stony Brook, New York, United States

The development of “closed cell” atmospheric electron microscopy methods have had a substantial impact on the characterization of materials in reactive gaseous environments and increased our understanding of how morphological and chemical changes occur in nanostructured heterogeneous catalysts.[1] These closed-cell microreactors allow the provision of multiple gas streams and temperatures in excess of 1000°C to be applied to the catalysts, concomitant with atomic-resolution imaging and spectroscopy.

In recent years, our group has extended the utility of this microreactor approach to include the incorporation of a range of excitations beyond electrons, including the provision of micro-focused x-rays [2] and infrared radiation.[3]. These studies have demonstrated the ability to understand dynamic changes that can occur in nanoparticle systems during oxidation and reduction [2], to explore how surface speciation affects catalytic activity [3], and determining the structure and associated chemistry of the active phase in bimetallic systems [4].

In this presentation, I will review the entire suite of available correlative techniques and their application to specific problems in heterogeneous catalysis. Particular emphasis will be placed on the latest developments concerning (1) the use of electron energy loss spectroscopy, especially results obtained from the K2-IS detector incorporated into Penn’s NEOARM instrument and (2) the development of electron pair distribution function analysis. These two capabilities fill in the final gaps in the overall characterization suite, adding spectroscopic information from light elements and providing sophisticated diffraction analyses.[5]. By providing imaging, spectroscopy and diffraction with x-ray, photons and electrons it becomes possible to describe the structural and chemical features of both catalyst and support over a wide range of descriptors, allowing a deeper understanding of the complex interrelationships that control their reactivity and selectivity.

### References

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- [6] This work was supported as part of the IMASC, an Energy Frontier Research Center funded by the U.S. Department of Energy, Office of Science, Basic Energy Sciences under Award # DE-SC0012573. This research used the XFM Beamline at the National Synchrotron Light Source II, a U.S. Department of Energy (DOE) Office of Science User Facility operated for the DOE Office of Science by Brookhaven National Laboratory under Contract No. DE-SC0012704. This work was carried out in part at the Singh Center for Nanotechnology at the University

of Pennsylvania which is supported by the National Science Foundation (NSF) National Nanotechnology Coordinated Infrastructure Program grant NNCI-1542153. Additional support to the Nanoscale Characterization Facility at the Singh Center by the University of Pennsylvania Materials Research Science and Engineering Center (MRSEC) supported by the National Science Foundation (DMR-1720530) is acknowledged.