

Recent Developments in *In Situ* Heating and Gas Reaction Studies of Catalytic Materials Via STEM Imaging in an Aberration-corrected Electron Microscope

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The ability to study the behavior of catalytic materials at atomic resolution and at elevated temperatures and/or under reaction environments is currently provided in a few laboratories equipped with aberration-corrected TEM or STEM instruments. Heating experiments can be conducted in a facile manner with sample stability limited only by the microscope stage performance utilizing MEMS-based heating technologies such as provided by Protochips AduroTM devices [1]. Such capabilities have been demonstrated in a number of studies; examples of Au/FeOx and Pd/alumina catalyst studies [2-4] will be discussed. Heating capabilities have recently been extended from single-tilt to double-tilt by the development of a new holder that still permits resolution at instrument specification (i.e. sub-Ångström), while allowing sample areas to be brought into precise alignment as required for best imaging of crystal lattices in high-angle annular dark-field mode. The use of Aduro devices for gas reaction studies via an environmental cell holder (E-cell) is being developed. The capability to image at atomic resolution through a double-window cell at pressures up to 20T has been demonstrated, and the design and initial performance of a new "Gen 3" prototype E-cell will be described [5].

[1] L. F. Allard, et al., *Micros Res & Tech*, **72**(3): 208 - 215 (2009).

[2] L. F. Allard, et al., *J Electron Micros*, **58**(3): 199-212 (2009).

[3] B. Lim, et al., *Nano Research* **3**: 180–188 (2010).

[4] J. Y. Howe, et al., *Micros & Microanal*, **16**(Suppl 2): 312-313 (2010).

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