Industrial approach to in-situ electron microscopy of heterogeneous catalysts

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Studying nanoparticles with atomic resolution by (scanning) transmission electron microscopy (S)TEM is being routinely carried out nowadays to reveal the structural and electronic properties of so called "fresh" and "post-mortem" catalyst materials. The crucial next step to aid our understanding of the reaction mechanism is to visualize and study catalyst particles in their catalytic active state which is usually at elevated temperatures and pressures in a liquid or gas environment.
Over the last decades ETEMs have enabled so called *operando* or *in-situ* studies during which materials can be investigated at elevated temperatures in various gas environments. The more recent commercial availability of closed liquid/gas *in-situ* cells based on MEMS technology has led to a significant step towards *in-situ* studies under more realistic conditions as the pressure range is now extended from several millibar to 1 bar.
In this contribution we are going to showcase experiments carried out with a DENSsolution Climate gas flow system used in JMs aberration corrected ARM200F electron microscope located within the electron Physical Sciences Image Center (ePSIC) within the Diamond Light Source synchrotron facility. Our contribution will aim to correlate changes in the particle structure to their activity under catalytically relevant conditions.
Johnson Matthey has together with the I14 DLS team developed a transfer system enabling us to bring the sample from the ARM directly to the nanoprobe beamline without a change of the gas environment.
This enables us to carry out complementary in-situ experiments within the ACTEM and a hard X-ray nanoprobe beamline.
In this contribution we will showcase the additional information that can be gained from combining these two approaches and demonstrate how this could be potentially used on a wide range of beamlines enabling an "identical location" in-situ study through the lengthscales and energy ranges.