**Electronic Support Information:**

***In situ* ptychography of heterogeneous catalysts using hard X-rays:**

**high resolution imaging at ambient pressure and elevated temperature**

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This electronic support information gives additional technical details and information on the ptychographic reconstruction and the spatial resolution achieved in ptychography.

For the ptychographic reconstruction, we used a reconstruction scheme based on the (e)PIE algorithm presented by Maiden and Rodenburg ([Maiden & Rodenburg, 2009](#_ENREF_1)). In the reconstruction algorithm used here, we introduced additional degrees of freedom in terms of a background intensity map that can account for several parasitic scattering contributions to the diffraction patterns, e. g., from the sample environment and the scanning microscope itself. The scattering from the Kapton foil did not show a significant effect on the reconstructions, as the SAXS region was used in this experiment and Kapton does not show significant scattering in this range.

The scattering signal from thin samples is very faint compared to the direct beam. The reconstructed image is formed using a large number of diffraction patterns, i. e., 1681 for each ptychographic image in Figures 3, 4, and 5. One representative diffraction pattern for the ptychogram shown in Figure 4b) is presented in Figure S1.

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**Figure S1:** Diffraction pattern from the ptychographic scan reconstructed in Figure 4b). a) linear scale with maximal count rate of 7734, b) same diffraction pattern on logarithmic scale, showing single photons at larger diffraction angles.

One prerequisite for achieving a given resolution in ptychography is that the diffraction patterns contain scattering information in the corresponding *q* range. Figure S2 a) shows the X-ray diffraction averaged over all 1681 diffraction patterns. X-ray photons are scatteredup to the edge of the detector, as illustrated by the azimuthal average count rate shown in Figure S2 b). Clearly, there is a relatively strong scattering signal in *q* ranges corresponding to 30 and 20 nm spatial resolution.

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**Figure S2:** a) Integral over all diffraction patterns of the ptychographic scan. The black crossed lines at the bottom and right are areas between different tiles of the detector, where no X-rays are detected.In addition, there are a few black “dead” pixels scattered over the field of view. The two white circles indicate the *q* values that correspond to 30 and 20 nm, respectively. b) Azimuthal average of the count rate in a) as a function of momentum transfer *q*. The arrows indicate the average count rate for *q* values corresponding to 30 and 20 nm, respectively.

However, the high resolution expected from the scattering signal is not observed in the ptychographic reconstructions. To obtain an unbiased measure for the resolution in the ptychograms, the Fourier ring correlation method was applied to the ptychographic reconstructions (Van Heel & Schatz, 2005). Figure S3 shows the Fourier ring correlation for the ptychogram shown in Figure 4 b). It was calculated by splitting the ptychographic data set in two parts by taking either the odd or the even scan points for the ptychographic reconstruction. The Fourier components of the two resulting images were then correlated and summed over each ring corresponding to fixed *q* as detailed in (Van Heel & Schatz, 2005). The result is shown together with the 1-bit and 1/2-bit threshold in Figure S3. Van Heel and Schatz consider the 1/2-bit threshold as a good standard criterion for the spatial resolution (Van Heel & Schatz, 2005). Thus a spatial resolution slightly better than 40 nm can be assumed.

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**Figure S3:** Fourier ring correlation for the ptychogram shown in Figure 4b) (Van Heel &. Schatz, 2005).The one and one half-bit thresholds lead to a resolution limit of 38 to 45 nm.

The spatial resolution obtained in ptychography falls behind the expectations derived from the scattering count rates in the diffraction patterns. This can for example be explained by deviations from the ptychographic model: e. g., the diffraction intensities are not fully explained by the coherent diffraction of the illuminating beam by the sample. In this case, the reconstruction is not fully consistent, introducing artifacts in the reconstruction. We have tried to correct for such a parasitic scattering contribution by extending the reconstruction algorithm and thus reducing artifacts, however, the signal-to-background ratio seems to limit the resolution to 40 nm in this case.

A comparison with the SEM images is only possible for the first and last temperature step. However, as the SEM contrast shows surface features, only, and does not show thickness variations of the material, it cannot be compared directly to the contrast in the ptychograms that is proportional to the projected density. In particular, the features in Figure 5e) document thickness variations that cannot be seen in Figure 5f) that shows the surface of the sample, only. Note that in Figure 5e) the scanned field of view is denoted by the dashed rectangle. The reconstruction outside this rectangle is usually noisy and prone to artifacts.

Reference:

Maiden, A.M.&Rodenburg, J.M. (2009). An improved ptychographical phase retrieval algorithm for diffractive imaging. Ultramicroscopy **109**(10), 1256-1262.

Van Heel, M. & Schatz, M. (2005). Fourier shell correlation threshold criteria. J Struct Biol **151** (3), 250-   
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