Environmental Real Time Imaging with 200kV FE Aberration-corrected Analytical Scanning Transmission Electron Microscope (ESTEM) System with an Open Window Gas Injection

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Catalyst or fuel cells, observation of the behavior is necessary to understand the degradation process in real environment (*in-situ*) with transmission electron microscope (TEM). On the other hand, we have reported evaluation of environmental real time scanning transmission electron microscope (STEM) imaging with a probe-forming aberration corrector equipped analytical 200 kV cold field emission (CFE) TEM (Hitachi HF5000) [1][2][3].

The base microscope is capable of TEM, STEM imaging with bright field (BF), annular dark field (DF) detectors, and secondary electron (SE) imaging. The probe-forming aberration corrector with automated correction of up to third order aberrations allows users to obtain aberration-free STEM illumination optics with minimized effort.

For *in-situ* operation, we have modified a vacuum system suitable for high gas pressure configuration with differential pumping apertures (orifices) and additional turbo molecular pump (TMP) to improve the evacuation capability in order to maintain the gun pressure low enough to operate CFE[1][4] (Figure 1 (a)). This microscope enables to record three scanning image signal simultaneously SE, BF and DF-STEM in TV scan rate. This FE-TEM has a capable of switching standard TEM/STEM analytical condition and in-situ operation mode. This microscope provides user friendliness operation through the dedicated control GUI for the in-situ mode control for the environmental STEM and TEM vacuum operation as well as gas injection both needle gas pipe and gas injection filament heating holder. Because this TEM has a wider scanning dynamic range capability, it allows to operate a magnification of x20 which is corresponding to 1,100 μm x 1,100 μm field of view SE image (Figure 1(b)). We studied atomic resolution simultaneously acquired DF-STEM and SE images of Au particle on CeO_2 support with open window MEMS heating holder so that E-T (Everhart-Thornley) detector above the specimen is able to detect SE signal (Figure 1 (c)). SE, which provides surface topographic information may derive degradation and/or activation of catalysts [5]. This wide magnification range moreover opens possibility of variety of information.
In the presentation we will show newly developed back-scattering electron filter for E-T detector equipped with this Cs-corrected TEM/STEM.

References:
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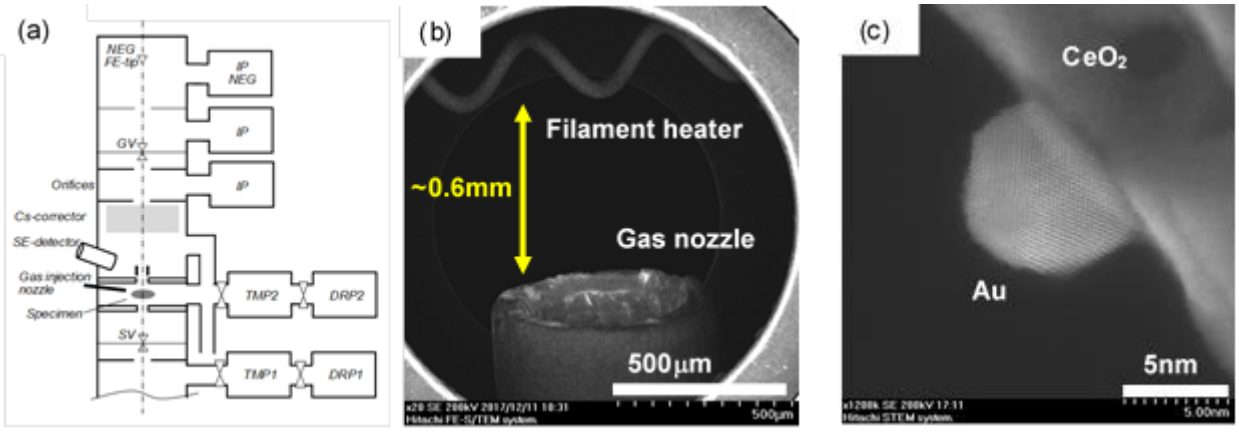

Figure 1 (a) Schematic diagram of differential pumping system open window type environmental TEM/STEM HF5000, (b) Large FOV SE image of gas injection filament heating holder (magnification of 20) in the gap of the TEM pole piece, and (c) Atomic resolution SE image of Au/CeO_2 catalyst on MEMS heating holder.