HT BSE detector and EBAC electronics for ESEM

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Observation of microscopic surface dynamics in SEM plays an essential role in the study of functional materials, however instrumentation requirements for such experiments are very challenging because of the combination of High Temperature (HT) and environmental conditions. For example, characterization of collective atomic motion in CVD graphene growth requires temperatures of up to 1,000 °C and injections of gases [1,2]. FEG ESEM instruments provide a good platform for such experiments, however common SEM detectors are not compatible with such demanding requirements. This work presents a novel BackScattered Electron (BSE) detector, as well as novel Electron Beam Absorbed Current (EBAC) electronics developed specially for high temperatures and reactive atmospheres.

Standard BSE detectors are not HT compatible because of their sensitivity to infrared light emitted by heated samples, which masks the signal induced by BSE. A suitable light-blind alternative is provided by replacing the sensing elements from diodes to conductive absorption pads, and thus switching from induced to Absorbed Electron Detection (AED). The inherent diode amplification is thus lost, and the electronics must be optimized for much lower signals, which results in a slower minimum dwell time in the range of a few us/pixel. This is sufficient for HT experiments, a thus a double-sided ceramic board was designed to provide the absorption pads and AED electronics, respectively.

A quadrant detector geometry was readily designed and manufactured, showing sufficient performance for operation under normal electron beam currents. The segmented HT BSE detector also provides the necessary simultaneous signals for quantitative topographic reconstruction [3], and thus the hot surfaces can be inspected in a 3D for the first time. A by-product of the AED electronics is excellent sensitivity to very low energy electrons, in principle down to a few eV, much exceeding the performance of room-temperature BSE detectors in this regard.

A second ESEM limitation arises from dynamic insertion of gasses, which alters the cascade process used by the Large Field Detector (LFD). It thus become unclear if a change of LFD signal originates from changes in the sample, or changes in the imaging gas. A suitable alternative is EBAC, as it provides signal independent from gas composition and pressure, and it can also use the thermocouple already connected to the sample. A combined temperature and EBAC measurements *in situ* board was thus designed and manufactured, showing spatial resolution similar to that of in-lens detectors at room temperature, whilst independent of working distance and acceleration voltage.

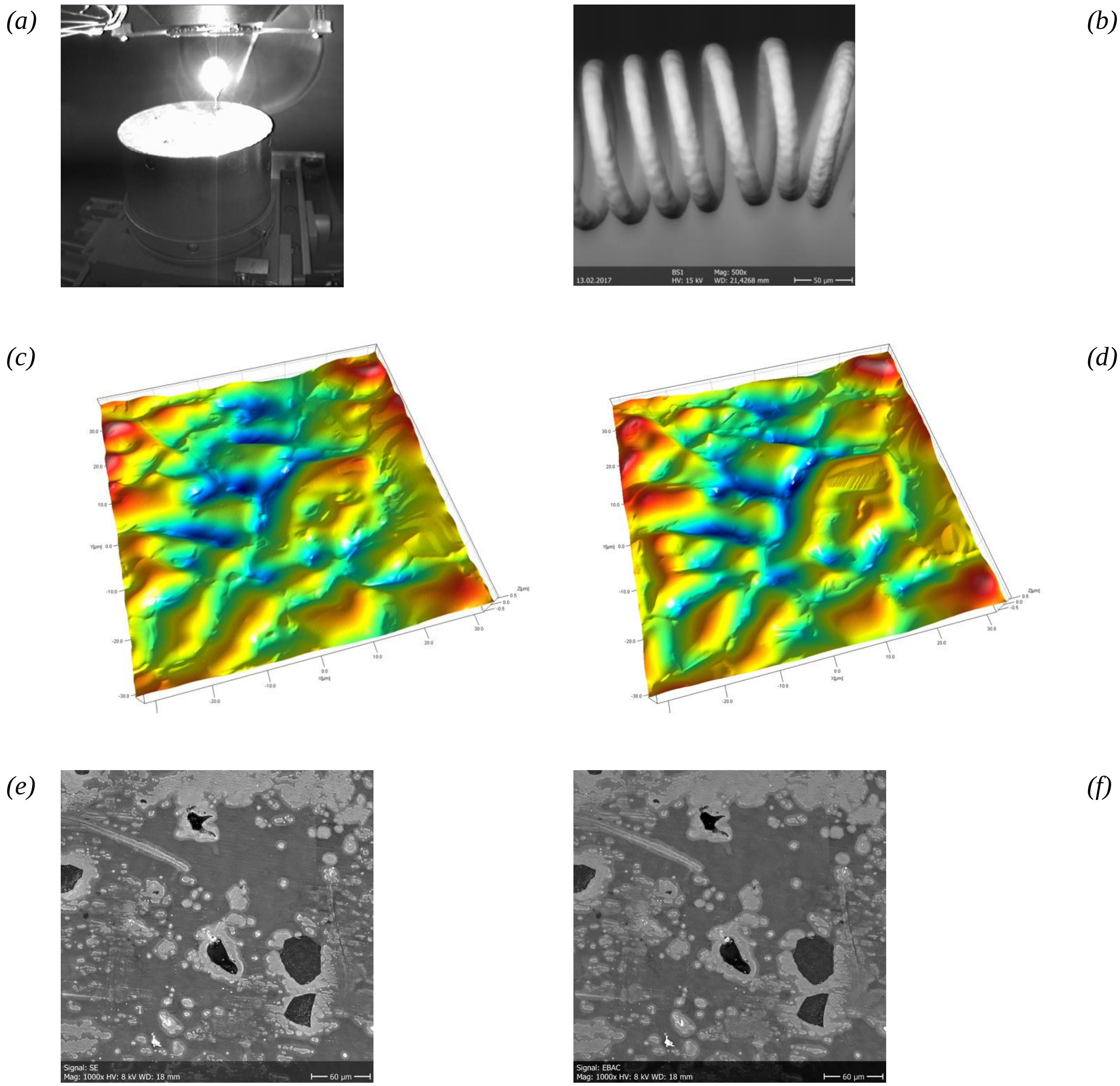

Figure 1. *IR chamberscope view of heated W filament* ***(a)*** *and corresponding HT BSE image* ***(b)****. Extracts from a time series topographic reconstruction of Cu catalyst during hydrogen oxidation* ***(c, d)****. Large field detector* ***(e)*** *and Electron Beam Absorbed* ***(f)*** *images of graphene on Pt at 400 °C.*

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