Energy-filtered PEEM with *nanoESCA* : principles, capabilities and application to work-function imaging with high sensitivity and lateral resolution

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The importance of energy-filtering in PEEM-based imaging methods has been shown in recent years with the availability of powerful instruments [1, 2]. However, conventional energy-filtering suffers from the spherical aberration (α^2-term) of the single hemispherical analyzer that blurs the image at low pass energies. A new instrument, the *nanoESCA*, combines a fully electrostatic PEEM column and a double hemispherical analyzer as energy filter that corrects these spherical aberrations [3]. The energy filter can then be operated at low pass energies (and therefore, high transmission) without detrimental effects on the spatial resolution. It also largely retains the time structure of the electron signal, which is important for future time-resolved studies. The first instrument of this kind has recently been installed at the Nanocharacterization Center of CEA in Grenoble. It allows to perform optimized energy-filtered PEEM using various excitation sources : UV, VUV, soft x-rays using synchrotron radiation for high resolution XPEEM and x-rays from a focused monochromated AlK_{α} source for XPEEM at lower spatial resolution. Demonstrated (but not ultimate) spatial edge resolutions with energy-filtering are 80 and 120 nm in XPEEM with soft x-rays excitation of threshold and core-level electrons respectively [3], and 40 nm in UV-PEEM [4]. After a first section that will present the instrument and its capabilities as summarized above, we will focus on results on PEEM imaging of polycrystalline copper using work-function contrast. We will first show how energy-filtering allows spectromicroscopic information from UV excitation with a direct relation between local work function changes (due to different grain orientations) and the corresponding energy distribution of the emitted electrons [4]; particularly, the local photoemitted intensity does not seem to follow the Fowler law. Second, from a data set of energy-filtered VUV-PEEM images, a treatment using Principal Component Analysis allows to generate meaningful nanospectra over typical areas of 50x50 nm^2 that are used to estimate, within an uncertainty of 20 meV, the local work function from proper analysis [4] of the secondary electron emission onset. Thus, a work function image can be reliably reconstructed. Besides three zones previously identified arising from <111> (Φ =4.77 eV), <110> (Φ=4.54 eV), and <100>-oriented grains (Φ =4.62 eV), a faint, additional zone appears (Φ=4.69 eV). These results are important for the local analysis of defects in materials.

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