Comparison Between the μXPS Endstation and the PHI Quantum 2000

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Comparison between analytical instruments allow relative cost/benefit analysis and guides one in optimizing both instruments. We have engaged in comparative studies of the PHI Quantum 2000 (Q2000) and the μXPS endstation at the ALS. Both machines are scanned probe imaging XPS systems (the Q2000 scans the X-ray beam and μXPS scans the sample). Further, the electron analyzer in both facilities are of very similar design.

The design goal of μXPS was to get the greater (resolution)x(intensity) product obtainable using a synchrotron radiation X-ray source. μXPS has higher resolution (1-2μ) at a power level roughly commensurate with the flux delivered by the Quantum 2000 at 100μ resolution (table 1). The synchrotron source allows for variation of the photon energy - making photon energy dependent phenomena (NEXAFS, for example) accessible contrast/analytical tools. The disadvantage of the synchrotron source is the greater difficulty in accessing the facility and variation of the flux with time and energy. μXPS is still being improved (recently the flux was improved 50% from the reported values - design goals are 2-4x more flux and 1μ resolution), but the following results reported here are useful as an interim baseline.

Energy resolution in μXPS is limited by the monochromator and the analyzer - we have similar resolution to the Q2000 at 500eV photon energy. The utility of this resolution for complex systems typical of industrial and environmental samples will be determined by the ability to deal with sample charging and heterogeneity. A small spot makes charge neutralization more difficult but makes it more likely that the sampled volume is homogeneous.

Scattered light determines the signal to noise of spectra of minority species in small regions. The μXPS optics are more demanding than the Q2000, and the scattered light results are worse. This issue may be addressed with improved optics and/or through software.

Instrument productivity (throughput) are influenced by other factors than flux and resolution - the ease of sample introduction, data analysis, and software overheads all play a part. The Q2000 has a highly developed user interface, and is a model to us of user friendliness. The overhead values in the figure are typical results obtained by skilled workers on μXPS and the Q2000 with average samples. This table indicates areas in need of improvement on μXPS: the longer overhead for imaging is being addressed by specialized hardware, the long time necessary to find regions of interest is being addressed by prefiducialization of the samples, and the handling overhead can be minimized by loading multiple sample cassettes at one time.

Stability of the instrument can be broken into issues common to both XPS devices and those specific to μXPS. Samples are positioned in μXPS by a mechanical stage. We installed a laser interferometer and will incorporate it into the control loop to improve scan accuracy. The stability of the μXPS source must be monitored by using reference channels in the data acquisition, and the reference incorporated into the data analysis.

Comparison of μXPS and PHI Quantum 2000

	μXPS	Quantum 2000
Signal Intensity	Sputtered Ag ~33pA @ 1.5μm spot size ~65kc/s 3d 5/2 (850eV hν, 300mA) (80,40)μm slits, 23.5eV pass energy	Sputtered Ag ~50pA @ 100μm spot size 90kc/s 3d 5/2 (1487 hν) 23.5eV pass energy
Spectral Resolution	Sputtered Ag 500eV hν 0.67 eV 870eV hν 1.03 eV 1250eV hν 1.68 eV (80,40)μm slits, 23.5eV pass energy	Sputtered Ag 1486.6eV hν 0.64eV 23.5eV pass energy
Spatial Resolution	1x1.5μm	8μm
Scattered Light	~15%	~10% @ 2 x FWHM ~2% @ 5 x FWHM
Handling Overhead	15-30 minutes (dependent on sample vacuum characteristics)	10-15 minutes (dependent as μXPS)
Localization Overhead	15-30 minutes (dependent on size and visibility of features)	20-30 minutes (dependent as μXPS)
Spectral Overhead	6 minutes for 100x100 image spectra as Q2000	seconds for imaging ~1-2 minutes/spectra
Data Reduction	~10 minutes (conversion and analysis time)	5-10 minutes
Spatial Reproducibility	0.2-1μm with an image 1μm with an experiment <10μm linearity over 40x40mm sample	5-10μm
Spectral Reproducibility	Low (due to varying beam current, damage, etc.) - to be improved	Medium (due to sample damage and source drift)

Table 1

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REFERENCES

1. E. Principe, R. W. Odom, Z. Hussain, and, H. Padmore, Proceedings of the 1998 MRS Spring Meeting, San Francisco, CA (submitted).

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