KMC-1: A High Resolution Beamline for HIKE-PES

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Introduction

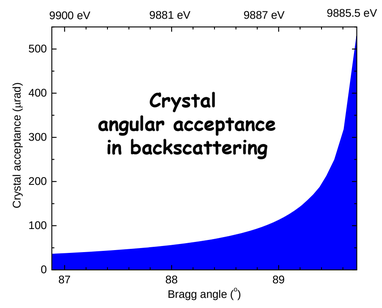
- Electron spectrometers are available nowadays with ultra-high resolution down to 20 meV@10 keV kinetic energies. Hard x-ray photoemission at high kinetic energy (HAX-PES or HIKE) is an ideal tool to look deeply into bulk material (>5 nm) and to study (buried) interface layers
- For this technique hard x-rays with similar ultra-high energy resolution at highest flux are required

Bragg equation $n\lambda = 2d \sin\theta$

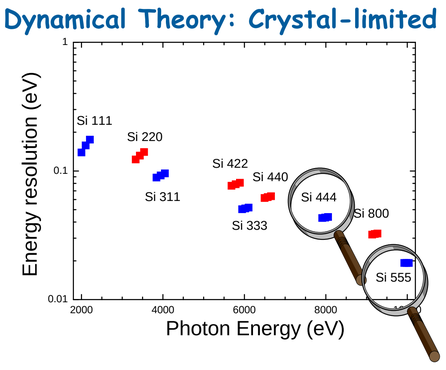
$\Delta E = E\,\Delta\theta / \tan\theta$

$\Delta\theta = ((\Delta\theta_c)^2 + \psi^2 + (\phi^2 \tan\theta/8)^2)^{1/2}$

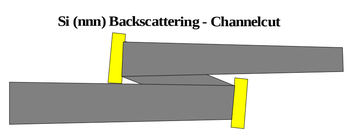
Rocking curve width — Darwin width — Beam divergence (mer., sag.)

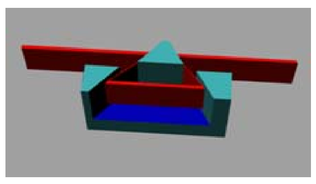


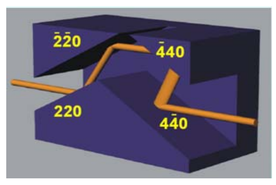
Dynamical Theory: Crystal-limited Resolution



suggested in-line 2-bounce or 4-bounce High resolution schemes





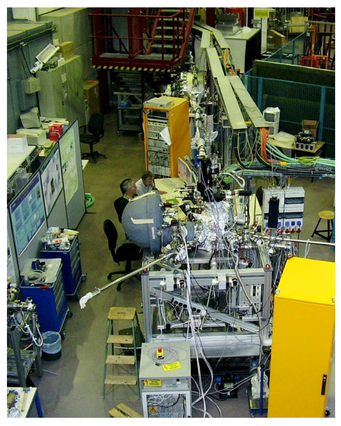


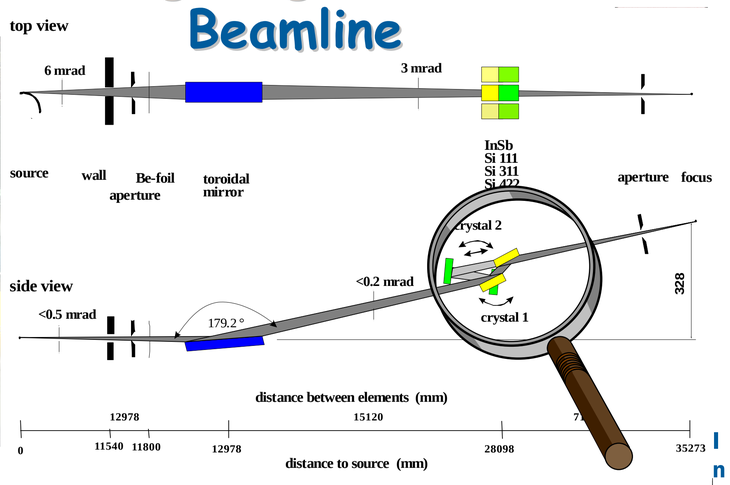
asymmetric (60°) diffractions
Si (620,-620,-533,533)
Θ_B=68.59 and 63.89 deg
E= 8.03996 keV,
ΔE= 14.685 meV
(courtesy D. Korytar)

- manipulation of beam cross section
- monoenergetic
- but designeable for all energies
- potential for sub-meV resolution

High resolution → Collimated light and/or large Bragg angles

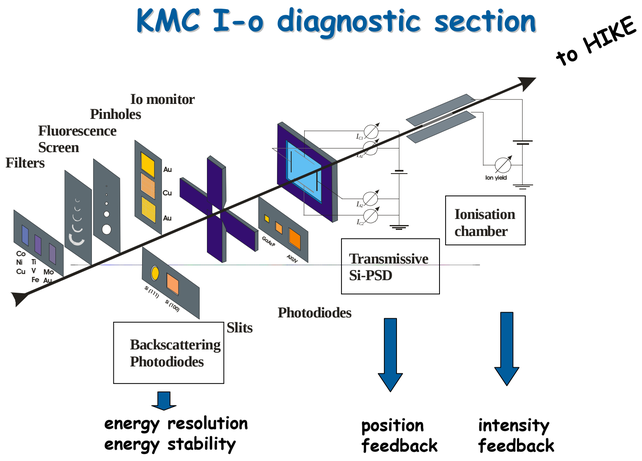
Bending Magnet KMC-1 Beamline



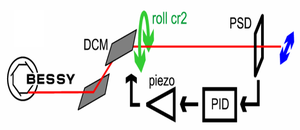


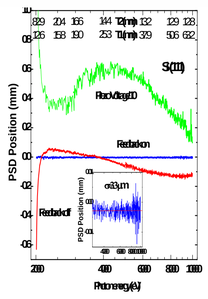
Bragg angular range 5° - 82°

KMC I-o diagnostic section



In-situ PSD for horizontal beam



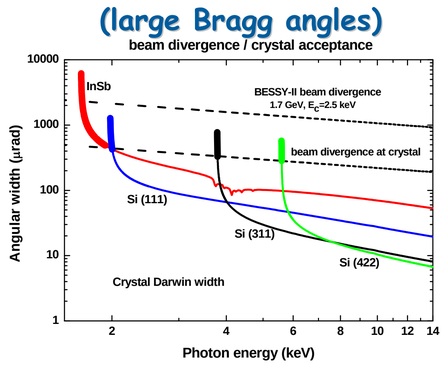


2 - 10 keV: one scan

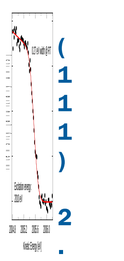
Beam Stability: 3 µm

Transmission 20-95 %

Crystal limited resolution at low energies (large Bragg angles)



HIKE on Au Fermi edge @2010 eV



HIKE on Au 4f: Depth profiling within one scan

ΔE=0.21±0.01 eV, 4 min. — ΔE=0.33±0.02 eV, 40 min. — ΔE=0.40±0.02 eV, 2 hours

The x-ray flux is in the range of 10^{11}-10^{12} photons/(sec)

Higher diffraction orders of Si (111): no postmonochromator necessary

The resolution becomes very high at certain photon energies

SCIENTA R4000 Electron Spectrometer

HIKE Performance Targets:

Electron spectrometer: (SCIENTA R4000)
High stability power supplies (~4x10^{-6})
New lens design, E_{kin}/E_{pass} > 500 (700)

Kinetic energy range: 0-10 keV
Resolution: ΔE = 40 meV, Epass = 50 eV
ΔE < 15 meV, Epass < 20 eV

Conclusion

- Ultra-high x-ray resolution is possible at synchrotrons employing backscattering crystals
- High kinetic energy PES is a non-destructive method to investigate buried layers and interfaces
- Depth profiling on real devices is possible
- Bending magnet beamlines at third generation facilities with medium energies

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