Nondispersive Hard X-ray K-B Focusing *Below 100 nm*

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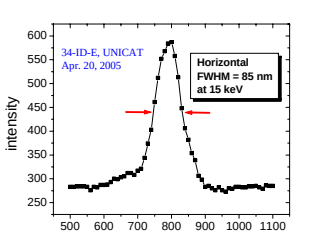
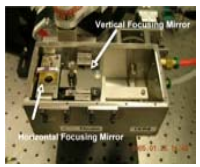
Introduction

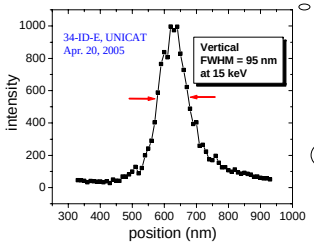
We describe x-ray total-external-reflection Kirkpatrick-Baez (K-B) mirrors with ultra-low figure errors to produce nondispersive x-ray focus below 100 nm. A doubly focused ***85 x 95 nm²*** hard x-ray nanobeam has been obtained on the UNICAT 34-ID beamline at the Advanced Photon Source.

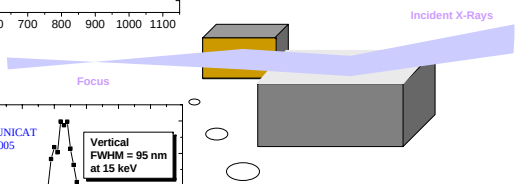
- The mirrors can be fabricated by differential polishing, or by differential deposition on ultra-smooth surfaces.
- The mirror optics are inherently achromatic and have a gain of ~10^5 with high reflectivity up to ~22 keV and low backgrounds.
- A special small-displacement monochromator allows rapid change between monochromatic and polychromatic beams.
- Achromatic hard x-ray nanobeam optics offer unique experimental opportunities for the characterization of structure and chemistry in nanomaterials. Crystalline phase, orientation, strain, and defect microstructure can be characterized ***without sample rotations***.





K-B Nanofocusing Mirror Box



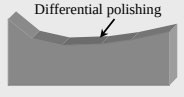


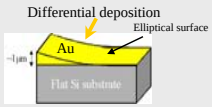
Goal: ~ 40 nm

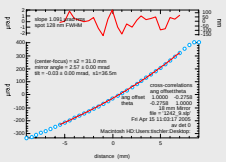
Mirror Fabrication and Metrology

The 40 mm long vertical primary focusing mirror was fabricated by a differential polishing method from the **Tinsley Laboratories Inc, CA**, while the 20 mm long horizontal secondary focusing mirror was produced at the **Advanced Photon Source** by differential deposition of a thin Au layer onto an ultra-flat Si substrate.

- Figures before and after deposition were characterized by long-trace profilometry (LTP).
- The optics are inherently more stable and more compact than dynamically bent mirror optics.





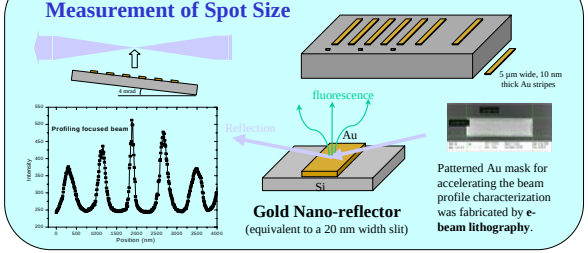


X-ray reflectivities of Pd coated Tinsley mirror and Au coated APS mirror at 3 mrad glancing angle.

Three methods proposed for making elliptical supermirrors and focuses achieved:

- Differential polishing
  - APS (95 nm)
  - Spring8 (90 nm x 180 nm)
- Differential deposition
  - APS (85 nm)
- Bending
  - ESRF (~ 80 nm)

Measurement of Spot Size



Gold Nano-reflector
(equivalent to a 20 nm width slit)

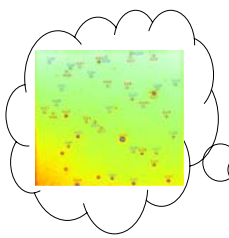
Patterned Au mask for accelerating the beam profile characterization was fabricated by **e-beam lithography**.

Alignment Accuracies and Limiting Factors

Focusing parameters:	Horizontal	Vertical
Glancing angle	3 mrad	3 mrad
Focal length	30 mm	60 mm
Beam convergence	1.3 mrad	0.8 mrad

Alignment accuracies required:
- Glancing angle: < 2μrad.
- Perpendicularity of two mirrors: < 1 mrad (0.06°).
- Mirror in-plane rotation: < 50 mrad (3°)

Limiting factors in achieving sub-100 nanosized beam:
- Sub-microradian mirror slope errors are essential.
- Diffraction limits: ~ 40 nm when utilizing entire mirror.



Polychromatic Laue micro/nano-diffraction

CCD

Focus (sample) 64.44 m

20mm long, 30 mm focal length. Demag = 1210

K-B mirrors 64.40 m

40mm long, 60 mm focal length. Demag = 1073

Slit

40 x 50 μm²

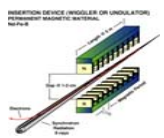
Removable Small-displacement Monochromator

56.5 m

The beam can be rapidly switched between monochromatic (ΔE/E ~2x10⁻⁴) and polychromatic (ΔE/E ~1) options and the monochromatic beam can be tuned over a wide energy range of ~7-22 keV.

L5 slit

28.1 m



Source

0 m

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