Characteristics of the MBE1 Endstation at PNC/XOR

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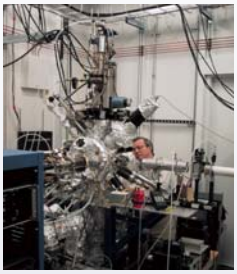
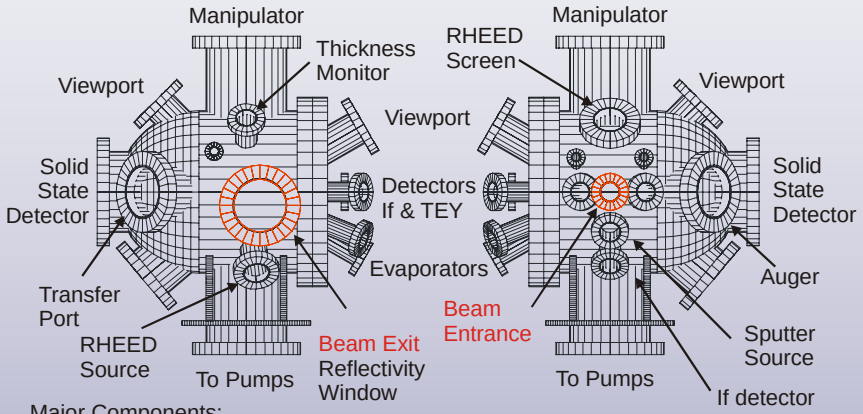
Abstract

An end-station for in-situ characterization of thin films at the PNC/XOR undulator beamline, Sector 20 of the Advanced Photon Source, is detailed. The ability to study films in-situ on a beamline enables examination of surfaces and interfaces on freshly-prepared films, without the influence of a capping layer. The MBE1 molecular beam epitaxy system was designed with this in mind. Now in routine operation and available for General Users on a collaborative basis, the primary function of MBE1 is to undertake polarization-dependent XAFS studies on fresh or stored films, but it also has the capability to do X-ray Standing Wave and Reflectivity measurements. The characteristics of the MBE1 system - its ranges of motions and detector options - are described in detail, with example data illustrating its functionality



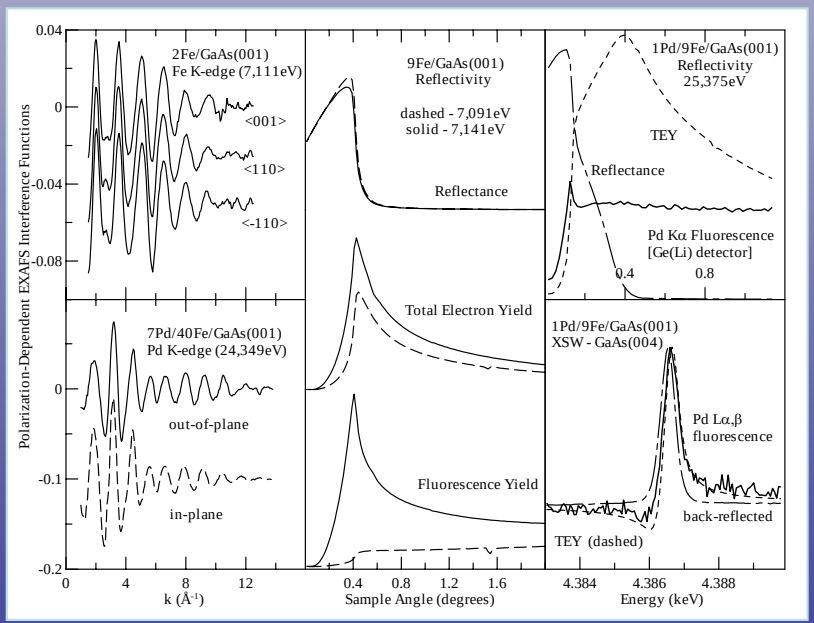
Chamber Layout



Major Components:
Thermionics GB-16 manipulator
Omicron EFM3 Evaporators
Kimball Physics EMG-14 RHEED Gun
PHI 04-161 Sputter Gun
Carousel for storage of up to 4 samples

RBD TFA-200 CMA/Auger
Custom Fluorescence Detectors[2]
Leybold Thickness Monitor
Ion, Turbo, Ti Sublimation Pumps

XAFS, Reflectivity and X-ray Standing Wave Capabilities

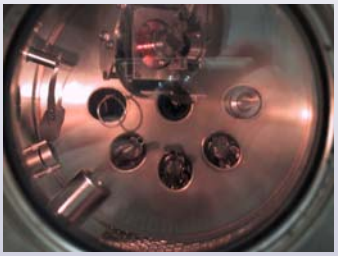


Example data taken in-situ in the MBE1 system. XAFS measurements (left) were made at 2/3 the critical angle illustrated in the reflectivity (middle, upper right).

THE MBE1 SYSTEM

MBE1 exists to perform *in-situ* X-ray investigations of epitaxially-grown thin films using the techniques of Surface XAFS, X-ray Standing Wave and small angle Reflectivity under UHV conditions. Primarily intended for deposition of metal films[1,3] on metal or semi-conductor substrates, the system can also be used for mineral surfaces or other *in-situ* surface studies.

The Core of the System



Custom Sample Positioning based on the GB-16 Goniometer from Thermionics:

3 Translations
3 Rotations
Heating to 800°C
Cooling to -110°C

Orientations from grazing angle to normal incidence for surface XAFS studies, small-angle/30°/Back-reflection X-ray Standing Wave measurements or Reflectivity up to 7º angle, with X-ray polarization in or out of the plane of the sample.

Options for Fluorescence Detection

7-element Ge(Li) solid state detector

Fluorescence Ionization chamber

Cyberstar Detector

Operations

The entire system was assembled on a custom table with vertical and horizontal travel and tilt capability for positioning in the X-ray beam with or without a toroidal mirror in use. MBE1 is situated in the last hutch on the 20-ID undulator beamline at the APS. With appropriate scheduling, samples can be prepared in advance without interfering with experiments being conducted in a hutch upstream.

Summary

The MBE1 end-station is a versatile surface science facility located at the PNC/XOR beamline, Sector 20 of the Advanced Photon Source. It possesses the ability to prepare and examine thin films and surfaces in-situ using the methods of XAFS, XSW and Reflectivity. The system is available for General Users on a collaborative basis.

References:
1. R. A. Gordon, E. D. Crozier, D. T. Jiang, T. L. Monchesky, B. Heinrich, "Distorted iron films on GaAs(001)-(4X6)," Phys. Rev. B 62 (3), July, 2151-2157 (2000).
2. R. A. Gordon, E. D. Crozier, J. Shoults, D. T. Jiang, "Ultrahigh vacuum-compatible fluorescence x-ray absorption fine structure detector," Rev. Sci. Instrum. 73 (8), August, 2849-2851 (2002).
2. R. A. Gordon, E.D. Crozier, D.-T. Jiang, P.S. Budnik, T.L. Monchesky, B. Heinrich, "In-situ XAFS study of Fe epitaxially grown by MBE on GaAs(001)-4x6," Surf. Sci. **581** (1), April, 47-57 (2005).

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