MATERIALS PHYSICS AND PROCESSING (MPP)

BROOKHAVEN NATIONAL LABORATORY

NATIONAL SYNCHROTRON LIGHT SOURCE II

SCIENTIFIC SCOPE

The Materials Physics and Processing (MPP) beamline will be optimized for the novel materials challenges from the semiconductor industry, and will enable X-ray diffraction studies of structural changes in materials as a result of, or during, processing steps. Specifically, MPP will allow high-throughput, real-time, *in-situ* rapid thermal annealing (RTA) studies of structural changes in thin films, film stacks, and nanopatterned samples.

BEAMLINE CHARACTERISTICS

TECHNIQUES:

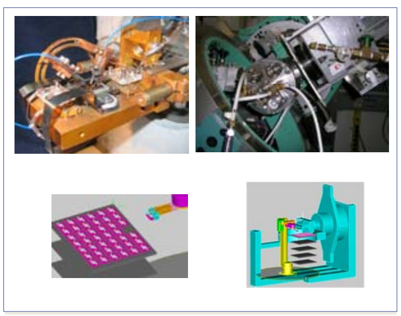
- X-ray Diffraction
- Texture
- Reflectivity/Interfacial Roughness

ENDSTATION 1 (RTA/High Flux):

- Robot Sample Exchange
- Rapid Thermal Anneal (100C/s).

ENDSTATION 2 (High Resolution):

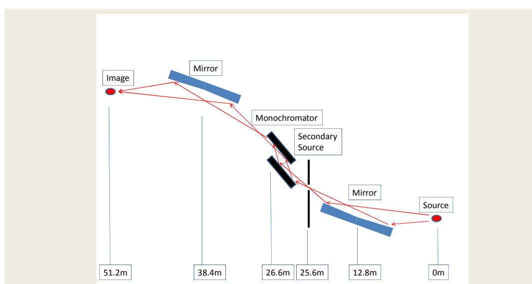
- Standard Huber 4 circle with flexible sample environments.



RTA endstation– high x-ray flux (multilayers), *in-situ* rapid thermal anneals to 1100°C, resistivity and optical light scattering measurements, robotic sample handling and remote control of expt, and linear and area detectors

MPP at NSLS-II:

- Phase transformations, texture changes, barrier failure, interfacial roughening, *etc*.
- X-ray diffraction (XRD) and scattering techniques on solids, including thin films, stacks, nanopatterned samples, magnetic and strongly correlated systems, and bulk materials.
- Resonant scattering, magnetic scattering, pole figures, phase ID, strain, reflectivity, *etc.*



Optical Configuration: 3 Pole Wiggler source, two opposing toroidal mirrors with secondary source, dual-bandpass monochromator (Si(111) or multilayers). Projected Flux density gain at MPP compared with X20 ~ 240.

Overview

PORT: 3-BM

SOURCE: Three Pole Wiggler

ENERGY RANGE: 5 – 14 keV

ENERGY RESOLUTION: $\Delta E/E = 10^{-4}$

SPATIAL RESOLUTION: 50 um

CONSTRUCTION PROJECT: NXTGEN

BEAMLINE STATUS: Design

AVAILABLE TO USERS: Spring 2018

Beamline Team

STAFF

K. Evans-Lutterodt: beamline scientist

Lukas Lienhard: mechanical engineer

Michael Johanson: designer

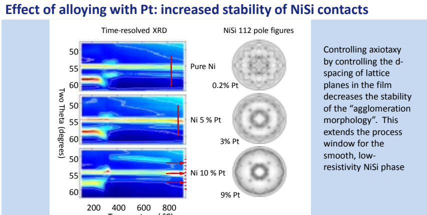
Z. Yin: controls engineer

BEAMLINE DEV. PROPOSAL LEAD

J.L. Jordan-Sweet (IBM Research Division)

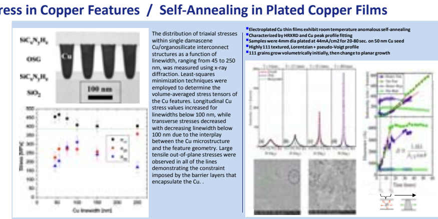
SCIENTIFIC APPLICATIONS

Effect of alloying with Pt: increased stability of NiSi contacts



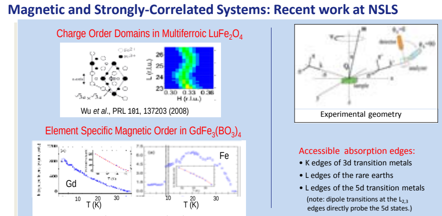
Real-time, *in-situ* annealing is used to study phase transformation sequences and kinetics of materials used in chip manufacturing and those being developed for future devices, such as Phase-Change Memory. Texture and strain also play an important role in device performance. Pole figures are particularly useful for understanding the behavior of metal silicides used as electrical contacts to the device layer in chips.

Stress in Copper Features / Self-Annealing in Plated Copper Films



High-resolution XRD is a valuable technique for determining stress/strain, grain size, lattice defects, and other structural subtleties that can strongly affect the behavior of chip components. BEOL (back-end-of-the-line) processes such as metal deposition, trench lining and capping, dielectric formation, chemical-mechanical polishing, and annealing can all lead to mechanical and chemical effects that require in-depth structural characterization

Magnetic and Strongly-Correlated Systems: Recent work at NSLS



Resonant and non-resonant x-ray scattering (XRS) will be used to study electronic ordering phenomena such as magnetic, orbital, charge, and multipole order. Nonresonant XRS is well-suited to characterize the weak lattice distortions that often accompany electronic ordering, while resonant XRS is element specific and provides additional information through measurements of energy, polarization, and azimuthal dependencies.