

Chamber Surface Roughness and Electron Cloud for the APS SCU

Laura Boon ECLOUD'12 June 2012



The Advanced Photon Source is an Office of Science User Facility operated for the U.S. Department of Energy Office of Science by Argonne National Laboratory

Superconducting Undulator (SCU) at APS

- The SCU being installed in the APS, a 7GeV electron storage ring, in September 2012 is an out-of-vacuum undulator. The beam chamber is cooled to 20K.
- The chamber cryo-coolers have a cooling capacity of 40 W for all heat sources.
- A detailed heat load analysis has been done for all sources.
- Preliminary calculations with POSINST predict 2 W of heating from electron cloud, but RFA data (APS, CesrTA) and vacuum data (ANKA) with electron beams do not agree with the simulations.



Electron Cloud in SCU

- RFA and vacuum data do show electron cloud with electron beams, although a smaller affect than with positron beams. For the SCU this possible heat load source is important to understand.
- The physics of multipacting due to the secondary electrons has been the focus of R&D and the photoelectrons are assumed to have a very low energy spectrum.
- For electron beams the cloud may not be dominated by secondary electrons so the photoelectron model needs to be better understood.
- Photoelectrons with energy greater then the beam potential can move away from the wall and into the vacuum chamber.



Measurement of QE vs synchrotron radiation energy

- Two samples of APS extruded AI beam chambers.
 - Top: Polished (Smooth), rms = 139nm
 - Bottom: Unpolished (Rough), rms = 1180nm
- All data was acquired at the Australian Synchrotron on their Soft X-Ray beamline, April 2012.
- The sample holder allowed for the sample current to be measured, this measures the number of emitted electrons.

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- Four incident photon angles: 3, 5, 10, 50 degrees
- All scans are from 100 eV to 2000 eV in 0.5 eV steps.
- Measurements were taken at 300K and 185K. At several angles.

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Sample Surfaces

- Two samples were measured, a polished sample(smooth) and unpolished sample (rough)
- The smooth sample was polished using an abrasive flow process, a silicon carbide paste was pushed through the aperture.
- The XPS analysis is in progress to quantify the surface chemistry and the dependence of emission on incidence angle.
- Preliminary analysis shows that the polishing process removes or covers trace elements in the Al alloy, Mg and Si.



Top: Rough sample, Bottom: Smooth sample

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Photon energy range from Synrad3d modeling of the APS SCU

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- Energy of Photons Absorbed on the SCU, taper13_norefl, 4eV filter (post-processing) 120 100 80 Number of Photons 40 20 ٥ 200 600 800 1000 1200 1400 1600 1800 2000 400 Photon Energy (eV)
 - Although the critical energy of the dipole radiation is 19keV at APS, the energy of the photons that are absorbed on the SCU are between 4-700eV.
- Simulations done assuming no diffuse scattering.
- The grazing angle of the absorbed photons has the highest flux at 0.6 degrees.

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Analysis Calculation

- I_{Si} = Current from the Si diode at the back of the sample chamber, data was taken with no sample in the path of the photon beam.
- I_{AI} = Sample current from the Al sample.
- $F(E_v) = Transmission coefficient.$
- Both calculations were normalized to the storage ring beam current.

$$Flux = \frac{I_{Si}}{q_e} \frac{3.65eV}{electron} \frac{1}{E_{photon}} F(E_{\gamma}) \left[\frac{photons}{sec} \right]$$

$$\#Electrons = \frac{I_{Al}}{q_e} \left[\frac{electrons}{\sec} \right]$$

$$QE = \frac{\# Electrons}{Flux}$$

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Results from the QE calculation

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- Peaks in the QE are present at the binding energy of the elements in the metal.
- A constant QE for all incident photon angles and energies loses some of the complexity of the physics.

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Angle dependence of QE



- The QE is strongly dependent on the surface chemistry of the material, the photon incident angle and surface roughness.
- Grazing angles and smooth surfaces have the highest QE's.



Temperature dependence of QE

- The QE was measured at 10 degrees with both a warm and cold sample.
 - Warm sample was at room temperature.
 - Cold sample was cooled to 185K.
- The warm samples always have a slightly higher QE, but the difference is <0.025.
- All of the analysis shown today ignored the temperature of the sample.

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Summary and future work

- Utilizing this, and other photoemission data will bridge the gap between Synrad3d and electron cloud simulation codes.
- The QE is more complex than a single value, which should be considered in electron cloud simulations.
- A simulation will be written to calculate the properties of the emitted electrons from synchrotron radiation.
- Photon reflectivity data was taken at BESSY using the same samples, this data will allow for a correlation between photon reflectivity and QE.
- There are plans to measure the emitted electron angle and energy using angleresolved XPS.





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Questions?



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