**Performance of a High Count Rate Silicon Drift X-ray Detector on The ANL 300 KV AAEM**

**N.J. Zaluzec**  
- Argonne National Lab  
J. S. Iwanczyk, B. E. Patt, S. Barkan, L. Feng  
- Photon Imaging Inc.

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### Why are we still working on XEDS systems?

Modern nanoscale characterization using x-ray energy dispersive spectroscopy in the Analytical Electron Microscope is limited by a number of factors:

- Foremost among these is the inability of an investigator to detect all characteristic x-ray emission from the region of interest of the specimen.
- Experimental operating condition of the microscope dictate the physics of the generation of x-ray emission from the sample.
- To maximize sensitivity of the technique, only improvements in the detector can accomplish this task. This improvements can be achieved by optimizing the detector to maximize the:
  1. subtending solid angle of the collected x-rays
  2. conversion (detection) efficiency for x-rays
  3. count rate (pulse ) efficiency

### ANL Applications

- DOE TEAM Project : Next Generation Medium Voltage FEG AEM's...  
  Aberration correction increase probe current!
- Scanning Confocal Electron Microscopy

### Others:

- Conventional BULK specimen SEM data (Mapping)  
- Conventional FEG AEM TEM's
X-ray Detector Systems for the AEM

• Wavelength Dispersive Spectrometers (WDS)
• Energy Dispersive Spectrometers (EDS)
  Si(Li) Detectors
  HPGe Detectors
• Superconducting Calorimeters/Bolometers
• Silicon Drift Detectors

Installation of a Crystal Spectrometer in a TEM - EMMA-4 System
Microcalorimeter
Solid Angle
\[ \Omega = \frac{A}{R^2} \]
\[ = \frac{(0.5 \times 0.5 \text{ mm})^2}{(37 \text{ mm})^2} \]
\[ = 0.00018 \text{ sr} \]
Resolution Loss with Count Rate

![Graph showing resolution loss with count rate for different voltages (100 kV, 200 kV, 300 kV).]

Silicon Drift Detector Construction

![Diagram of silicon drift detector with anode, field strips, path of electrons, and back contact.]

Lechner et al NIM in PR. A 458, (2001)

Thinner devices -> Low Capacitance -> High Count Rates
Silicon Drift Detector Construction

Detector Area = 50 mm²
Peltier Cooled -> No LN₂
Low Capacitance (250 fF) -> High Count Rates

ANL Experimental Configuration
Silicon Drift Detector Construction

Comparison: Stnd vs SDD
LN2 Dewar vs Peltier Cooler

\[ \text{ANL } \sim 0.41 \text{ sr} \]

Counts

Energy

Mo-Si/Cu Slot Grid

Count Rate = \sim 200 \text{ Kcps}
Time = 100 \text{ sec}
Integral = 50,000,000 \text{ counts}!
Resolution vs Count Rate

Resolution vs Time Constant
Comparing SDD vs Si(Li) @ $E_0 = 300$ keV

Dead Time vs Count Rate

Input Count Rate (Kcps)

Dead Time (%)

Si(Li)

SDD

Solid State Detector Construction

Solid State Detectors: Si(Li) or Intrinsic (High Purity) Ge

Using a simple absorption model, define the relative detector efficiency $E(E)$ by the following procedure:

$$E(E) = 1 - I_0 \exp (- \frac{E}{E_0}) - I_0 \exp (- \frac{E}{E_0})$$
**Relative Detector Efficiency**

<table>
<thead>
<tr>
<th>Detector Window Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Au Contact Layer</td>
<td>250 Å</td>
</tr>
<tr>
<td>Si Dead Layer</td>
<td>1000 Å</td>
</tr>
<tr>
<td>Si Active Layer</td>
<td>3 mm</td>
</tr>
</tbody>
</table>

**Resolution vs Tc and Energy**

- 0.5 usec
- 2.0 usec
- 16.0 usec
Resolution vs Tc and Energy
Large Solid Angles Are Important for the Next Generation of AEM

Electron Damage Effects
The Effects of Electron Irradiation

Relative Detector Efficiency
**Count Rate** = ~ 200 Kcps

**Time** = 100 sec

**Integral** = 50,000,000 counts!

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**Spectrum Imaging**

![Energy vs. Position/Angle](chart.png)
Thanks
Questions?