Performance of Al-Mn Transition-Edge Sensor Bolometers in SPT-3G

Adam Anderson, Fermi National Accelerator Laboratory
on behalf of the SPT-3G Collaboration

South Pole Telescope and SPT-3G

The 10-m South Pole Telescope (SPT) is dedicated to observing the cosmic microwave background (CMB). In 2017, we deployed a new camera called SPT-3G with 15,000 detectors observing at 95, 150, and 220 GHz using trichroic lenslet-coupled pixels. The ongoing SPT-3G survey targets broad science goals including B-modes, CMB lensing, galaxy cluster science and more.

Al-Mn Sensors

In 2018 we developed a fabrication process at Argonne for Al-Mn transition-edge sensors (TESs). The Al-Mn process has several advantages over TESs based on bilayer designs:
- TES deposition performed in a single step
- Fine control of $R_n$ using TES geometry
- Fine control of $T_c$ using Mn doping concentration and baking of wafer at ~180 C

We fabricated an Al-Mn detector wafer at Argonne and after lab characterization, we deployed this wafer on the telescope.

Electrothermal Properties

Saturation powers, normal resistance, and critical temperature were measured in a dark cryostat and deployed on the telescope. Uniformity and agreement with fabrication targets is excellent.

Table 1: Cumulative number of detectors meeting various yield requirements.

<table>
<thead>
<tr>
<th>Yield</th>
<th>Passing detectors</th>
<th>Reasons for losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>1572 (100%)</td>
<td>N/A</td>
</tr>
<tr>
<td>Nominal warm pinout</td>
<td>1442 (91.7%)</td>
<td>on-wafer shorts and opens, wirebonding defects</td>
</tr>
<tr>
<td>Resonances detected</td>
<td>1413 (89.9%)</td>
<td>open channels in readout</td>
</tr>
<tr>
<td>Routinely operated</td>
<td>1248 (79.4%)</td>
<td>optical responsivity requirement</td>
</tr>
</tbody>
</table>

Time Constants

Optical time constants are measured in situ, using a chopped thermal source in the middle of the SPT secondary mirror. Given the SPT-3G scan speed and elevation, $f_{3\text{dB}}$ corresponds to angular multipoles of 30,000 to 90,000—well above the scales resolvable by the telescope.

Optical Efficiency

Optical efficiency is measured with a blackbody source in a dark cryostat. We control for systematic effects including parasitic resistance, stray inductance in the bias circuit, filter transmission, triplexer transmission, and wafer heating. Pixel efficiencies are high (73-83%) with good uniformity.

Still curious?

[Paper link]
[Poster link]