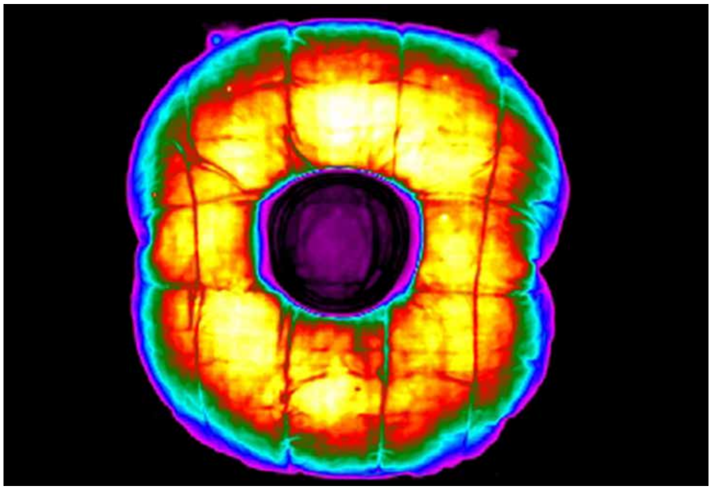
Technical Note

The Advantages of LWIR SLS Thermal Cameras

Thermal infrared cameras have reimagined how we perform thermal measurements for research and science testing. In recent years, we've seen significant readout and camera electronic advances that push the limits of resolution, speed, and sensitivity. This allows us to solve many of the most difficult thermal testing challenges, such as high speed thermal measurement on air bags, failure analysis on micron-scale electronics, and optical gas imaging on visibly translucent gases. However, it wasn't until the recent introduction of Type II Strained Layer Superlattice (SLS) that we saw significant advances in thermal imaging. This new detector material brings thermal camera performance in line with their read-out integrated circuit (ROIC) and camera electronic counterparts. The integration of SLS into commercially available thermal cameras offers a new longwave IR solution with significant improvements in speed, temperature range, uniformity, and stability that costs less than analogous detector materials.



Stop-motion image of inflating airbag

Speed Improvements

While SLS works in both the longwave and midwave infrared bands, you will see the biggest performance benefits when it is filtered to the LWIR band exclusively. In fact, one of the key benefits of SLS is its short integration times, or snapshot speeds, compared with other infrared camera materials. Tables 1 and 2 demonstrate the difference between the LWIR SLS and the MWIR indium antimonide (InSb) performance metrics. Looking just at the first temperature range in row one, we see that SLS offers 12.6 times faster snapshot speeds than that same range for the MWIR InSb detector camera.

Faster snapshot speeds allow you to stop motion on high speed targets in order to get accurate temperature measurements. If the integration time is too slow, blurring in the resulting image could impact temperature readings. Similarly, faster snapshot speeds allow for faster frame rates. Quite often, the long integration time requirements of InSb and other detector materials cause the camera to operate at a frame rate that's slower than the detector maximum. For example, say you have a camera

LWIR SLS Camera, f/2.5 7.5-10.5 µm		
Int T (ms)	Temp Range (°C)	Filter
0.1600 ms	-20°C to 150°C	None
0.0410 ms	55°C to 350°C	None
0.0146 ms	150°C to 650°C	None
0.0718 ms	250°C to 1000°C	ND1
0.0280 ms	400°C to 2000°C	ND1

Table 1 – LWIR SLS Camera Performance Metrics

MWIR InSb Camera, f/2.5 3.0-5.0 µm		
Int T (ms)	Temp Range (°C)	Filter
2.0205 ms	-20°C to 55°C	None
0.8442 ms	10°C to 90°C	None
0.2403 ms	35°C to 150°C	None
0.1040 ms	80°C to 200°C	None
0.0179 ms	150°C to 350°C	None
0.3218 ms	250°C to 600°C	ND2
0.0535 ms	500°C to 1200°C	ND2
0.0191 ms	850°C to 2000°C	ND2

Table 2 – MWIR InSb Camera Performance Metrics

that can image at 640 x 512 at 1000 frames per second, but it operates in a bandpass that requires an integration time of 1.2 ms. The camera would not be able to achieve its full frame rate potential due to the longer integration time constraint. This can cause problems when imaging targets that heat up quickly. Slower sampling can cause you to inaccurately characterize the thermal transient of your part, perhaps missing a critical temperature spike in the boot up cycle on an electronics board.

Wider Temperature Bands

A second benefit of LWIR SLS thermal cameras is their wider temperature bands. In Table 1, we see that the LWIR SLS camera has a starting temperature range from -20°C to 150°C with one integration time. To achieve the same temperature band with MWIR InSb, you'd need to cycle through (superframe) three integration times, each representing a different temperature range. Cycling through three temperature ranges in order to superframe them into one complete -20°C to 150°C temperature range results in only one superframe image per three frames captured from the camera. This means three times more work when calibrating the camera as well as a one-third reduction in overall frame rate.

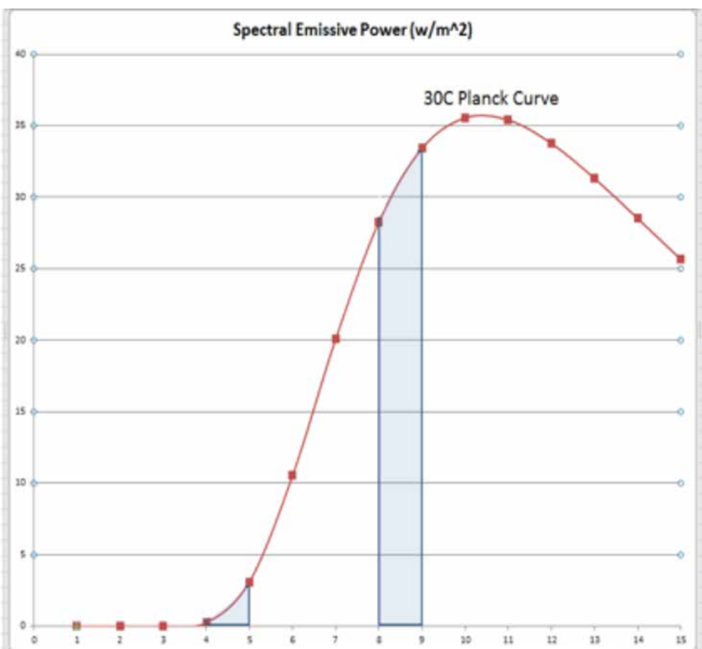


Figure 1: Spectral emissive power of a 30°C ideal blackbody

Looking at Tables 1 and 2 again, we see there is another point to consider: LWIR SLS cameras allow you to measure higher temperature ranges before needing an ND filter. The SLS camera evaluated allowed for measurements up to 650°C before needing an ND filter, whereas a MWIR InSb camera only measures up to 350°C before an ND filter is required. This is partly a function of the SLS operating in the LWIR band versus the InSb operating in the MWIR waveband.

To illustrate this, let's look at the graph in Figure 1, which shows the spectral emissive power of a 30°C ideal blackbody. The area under the curve represents the power within that waveband, which is much larger for the LWIR band than the MWIR band. When we look at Figure 2, we see that as objects heat up, the representative spectral radiant emittance curve's

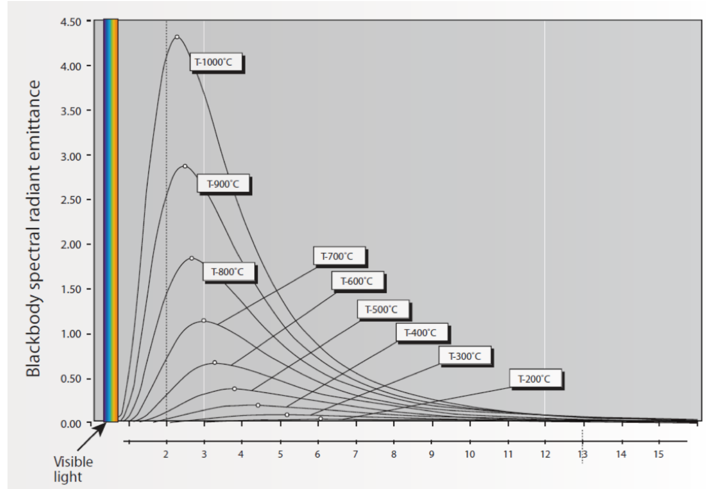


Figure 2: Spectral radiant emittance of black bodies at various temperatures

peak shifts to the left and tails off to the right. The change in power in the LWIR band is less dramatic over a range of temperatures than the more dramatic change that happens in the MWIR band. This is how the LWIR SLS detector is able to avoid over or under exposure for a given integration time, compared to the MWIR InSb detector. Note that the change in power in the MWIR band is substantial; therefore, as an object heats up, the camera would soon saturate for a single integration time.

In summary, SLS allows you to tackle challenging applications where the target heats up across a wide temperature range quickly, such as a combustion research application.

However, operating in the LWIR band is not the only factor. If we look at LWIR mercury cadmium telluride (MCT) detectors, we see they also are limited in their ranges, similar to MWIR InSb detectors. You'll notice the LWIR MCT cameras have both shorter individual ranges per integration time as well as limitations on how high they can measure before needing an ND filter to cut down the signal (see Table 3).

LWIR MCT Camera f/2.0 7.85-9.5 µm	
Int T (ms)	**Temp Range (°C)**
0.1500 ms	5°C to 50°C
	50°C to 150°C
	150°C to 500°C
	500°C to 1500°C

Table 3 – LWIR MCT Camera Performance Metrics

Better Uniformity and Stability at a Lower Cost

One of the best features of LWIR SLS cameras in comparison to other LWIR cooled camera options is the dramatically improved uniformity and stability through cool downs, especially when compared to LWIR MCT cameras. LWIR MCT detectors generally suffer from poor uniformity and stability. As a result, any time the user turns on a LWIR MCT camera, the last uniformity correction performed needs updating (See Figure 3).

This presents problems for field based applications, which are simply not conducive to equipment that requires you to update gain, offset, and bad pixel maps due to environmental conditions. Those applications may include controlling the camera remotely as it sits in a test chamber, or controlling it from outside the blast zone for a government test range. In comparison, LWIR SLS operates much like MWIR InSb, in that you just need to turn it on and start testing (see Figure 4). The uniformity correction done in the lab works just as well in the field with no extra image uniformity updates beyond possibly a one-point offset update using the internal NUC flag inside the camera. The NUC also holds well through multiple cool downs over a long time duration. The camera tested for this article has not needed a new NUC since initial fielding of the camera more than a year ago.

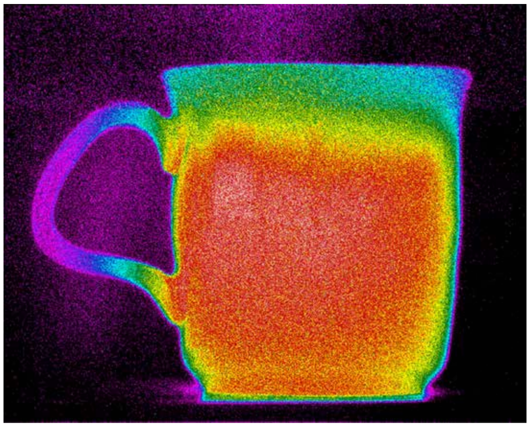


Figure 3: MCT image at start-up

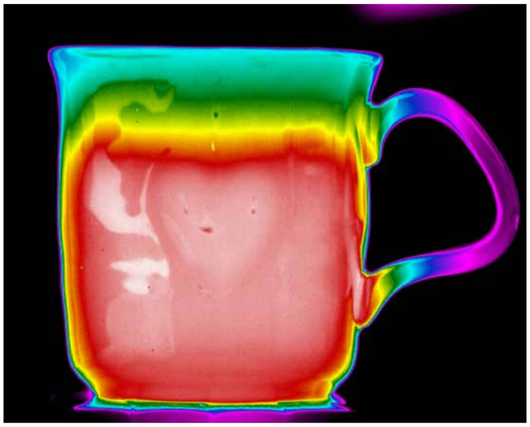
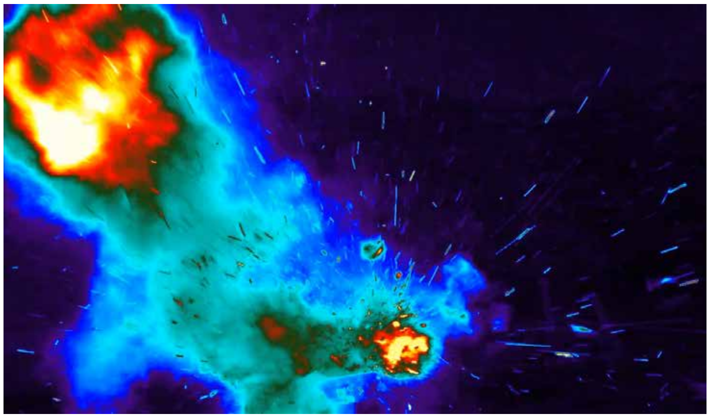


Figure 4: SLS image at start-up

While SLS cameras cost more than their MWIR InSb counterparts, they are 40 percent lower in price than comparable LWIR MCT cameras. Therefore, if your application requires shorter exposure times, wider temperature ranges, or a spectral signature only offered with cooled LWIR detector cameras, SLS offers a clear cost and uniformity advantage over current cooled LWIR MCT detector options.

Summary:

SLS LWIR detector materials are exciting because they fit a perfect niche in the performance/price spectrum by offering shorter integration times and wider temperature bands than MWIR InSb and LWIR MCT materials, along with better uniformity, stability, and price than current LWIR MCT cameras. An SLS LWIR detector is a great arrow to have in your quiver when the application calls for this special blend of performance and price.



Stop-motion image of munitions testing

For more information about thermal imaging cameras or about this application, please visit:

www.flir.com/research