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Application Note

Preparing Device Samples for Thermal Analysis and Thermal Mapping Using the Thermoreflectance Imaging Analyzer

The Future of Thermal Imaging is Here!!!

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Introduction

Thermoreflectance imaging of electronic and optoelectronic devices is a technique that offers excellent spatial, temporal, and thermal resolution. The thermoreflectance technique exploits the change in material reflectivity due to a change in temperature. This approach employs a probing light source in the visible wavelength range to detect the change in magnitude of the reflected light. The relationship between the reflectivity and temperature is related by the ***Thermoreflectance Coefficient*** (C_{th}), a property of the material. Once this coefficient is determined for the specific material or sample being analyzed, the coefficient can be used for all future measurements and calibration for subsequent measurements on the same material is not necessary. The short wavelength light source provides better spatial resolution compared to other thermal imaging techniques but does require some sample preparation for best results. This application note provides recommendations for sample preparation and measurement procedures for thermoreflectance thermal imaging using the ***Microsanj NanoTherm Series Thermal Image Analyzers***.

Sample Preparation

Since the thermoreflectance technique uses visible wavelengths to detect and measure the surface temperature of the Device-Under-Test (DUT), one can expect to get a good thermal image of any area on the DUT that can be clearly seen with a standard optical microscope. If the sample is covered with an opaque material, you will not be able to use this approach to get a good thermal image of the device. It is necessary therefore to use a de-capsulated sample for the thermal measurement.

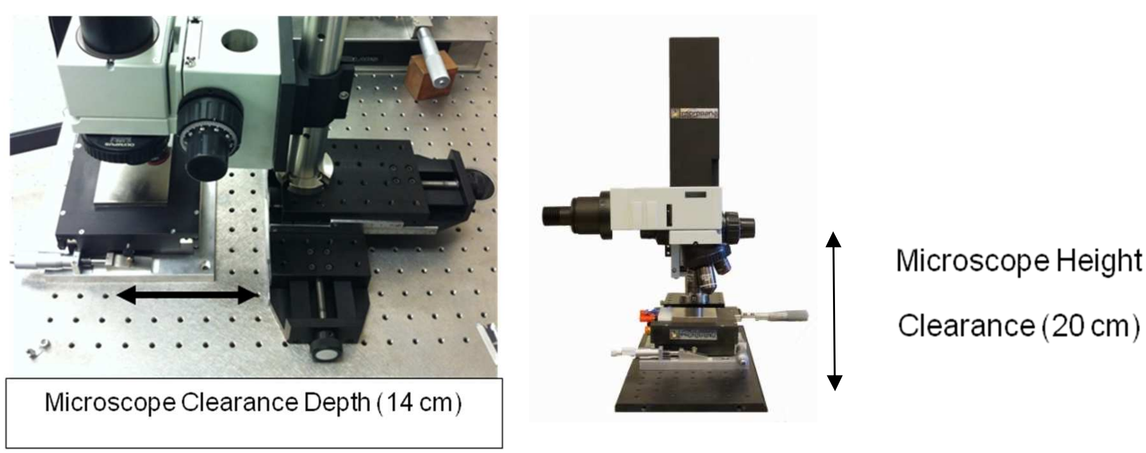
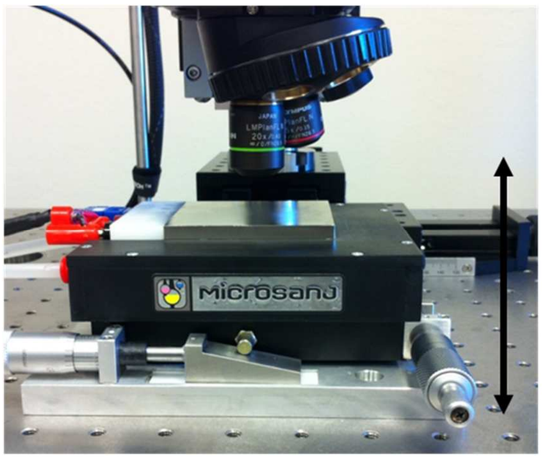


Figure 1: Microscope Clearances

Spatial resolution is also greatly dependent on the working distance. It is recommended to use wire-bonded samples and provide a clear optical access to the DUT. Transparent passivation layers are usually satisfactory for measurement but, in some cases, they may distort the image quality.

Figure 1 shows the clearances between the microscope and the working stage and Figure 2 shows the working distance and its relationship to the Field of View (FOV). Higher magnification provides increased resolution but with a reduced FOV. These are the standard optics, but custom optical solutions can be made for special requirements.



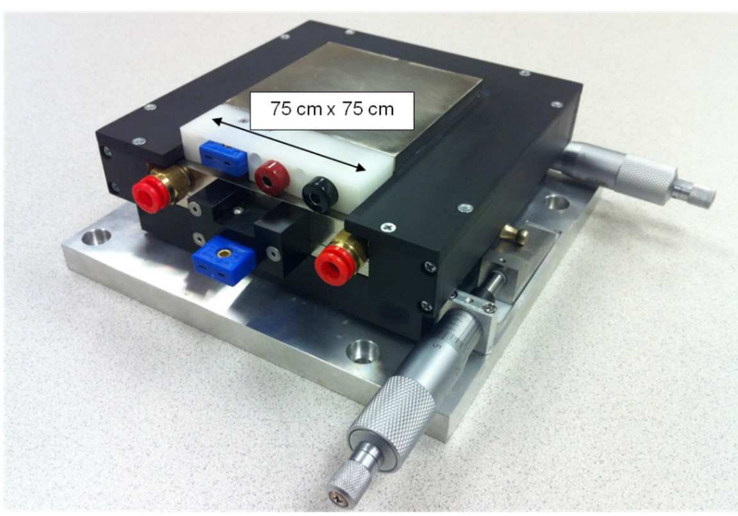
Microscope objective focal depth depends on the magnification:

	Working Distance	FOV
5x:	22.5 mm	2.5 mm x 2.5 mm
20x:	12 mm	0.6 mm x 0.6 mm
50x:	10.6 mm	250 µm x 250 µm
100x:	3.4 mm	120 µm x 120 µm

-All objectives are 26 mm in diameter

Figure 2: Working Distance and Field of View (FOV)

Optional Thermal Chuck



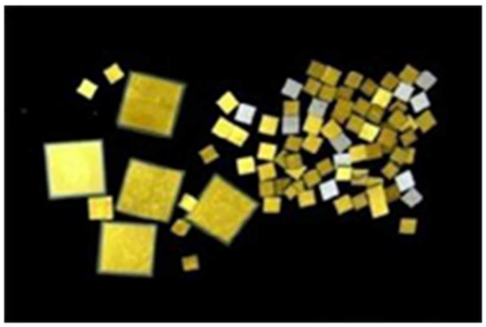
For improved thermal accuracy, Microsanj offers an optional thermal chuck. The thermal chuck, pictured in Figure 3 controls the temperature of the DUT with an accuracy of ± 0.1 °C. The chuck also provides a means for level adjustment. The temperature controlled stage has a working area of 75 cm x 75 cm.

Figure 3: The Microsanj Thermal Chuck

Although the use of the thermal chuck is not necessary for an accurate determination of relative temperatures across the surface of the DUT, its use will improve the accuracy of the absolute temperature.

Material Characterization

The Thermoreflectance Coefficient is material and illumination wavelength-dependent. In addition, the surface characteristics of the DUT can also affect the Thermoreflectance Coefficient.



It is important therefore, to characterize the material to determine the actual coefficient and the best LED wavelength to use for the illumination source. To characterize the material it is recommended to have a bare die that is less than 1 cm x 1 cm. A non-working device is sufficient for the characterization but, it is necessary that the device has undergone the same processing steps as the working device of interest. Although packaged devices can be used if necessary, it is important to note that measurement accuracy may be compromised.

Conclusion

Using the thermoreflectance technique for thermal imaging and thermal analysis of electronic and optoelectronic devices offers superior spatial and temperature resolution.

For best results it is important to:

- Use a de-capsulated, unpassivated, wire-bonded device
- Carefully observe optical clearances and working distances
- Determine the material thermoreflectance coefficient and optimal LED wavelength
- Consider the optional thermal chuck for accurate temperature control

With proper sample preparation and measurement procedures, the Microsanj NanoTherm series Thermoreflectance Thermal Analyzers will provide accurate results leading to a better understanding of device thermal performance and improved device reliability.