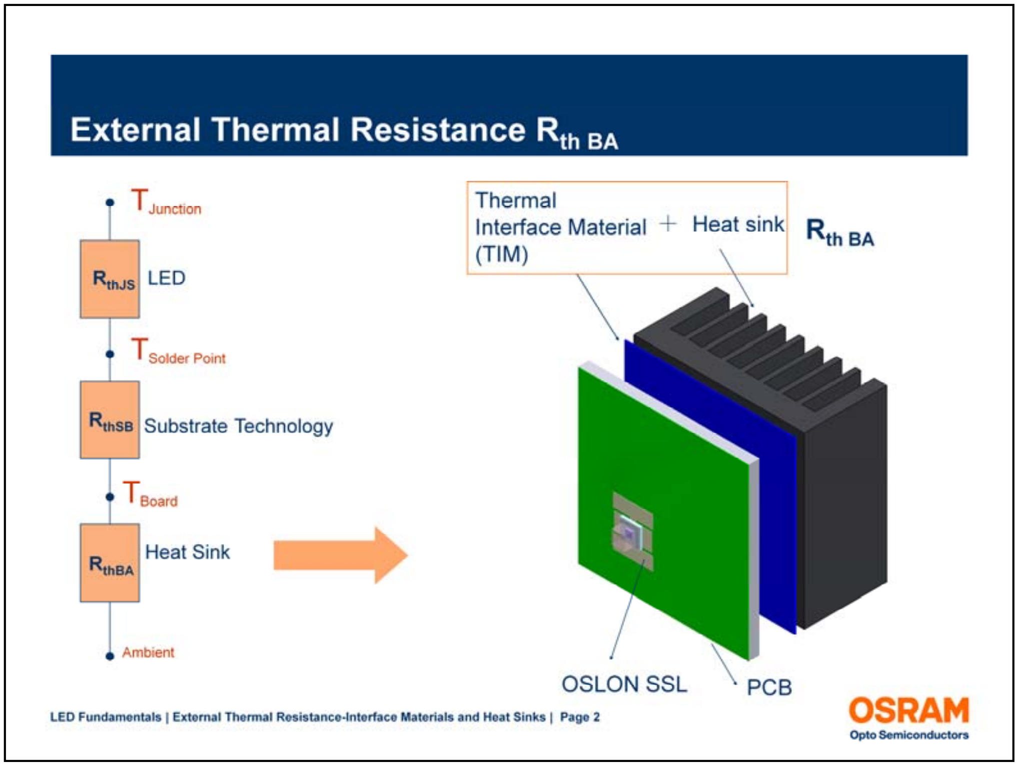
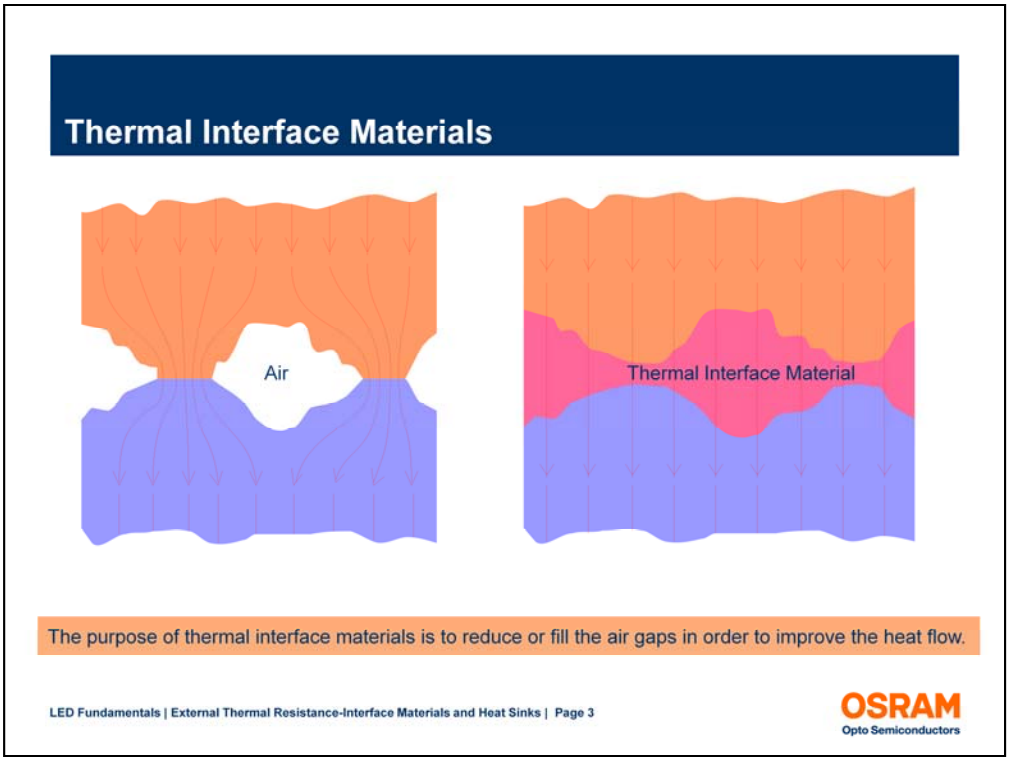
Hello and welcome to this presentation on “External Thermal Resistance- Interface Materials and Heat Sinks,” part of OSRAM Opto Semiconductors‘ LED Fundamentals series.

In this final presentation in the thermal discipline of our LED Fundamentals series, we will look at thermal interface materials, influencing factors for heat sink selection, and steps to indentify the right heat sink for an LED system design.



Previously, we looked at the internal thermal resistance of the LED package ($R_{th\ JS}$) and the thermal resistance offered by the substrate technology ($R_{th\ SB}$) used in an LED system.

In this segment, we cover the thermal resistance from the substrate to the ambient. This typically involves an interface material and a heat sink or a housing to which the printed circuit board is attached.



Real surfaces always exhibit a certain amount of roughness at the micro level and are never perfectly smooth.

Physical contact between two surfaces only occurs at isolated points with air pockets in between these points. Since air is a poor conductor of heat, a more conductive material can be used in order to reduce the thermal resistance and to increase the heat flow between the two surfaces. Without an appropriate optimal interface, only a certain amount of heat transfer occurs between the two surfaces leading to overheating of components. In order to improve the heat transfer and reduce the thermal contact resistance, several interface materials are available.

Thermal Interface Materials

Description	Material	Advantages	Disadvantages
Thermal Grease	Typically silicone based with thermal conductive particles	▪ Thinnest joint with minimal pressure ▪ High thermal conductivity ▪ No delamination issues	▪ Flow out beyond the edges ▪ Messy for high volume manufacturing ▪ Greased joints can pump out and separate with time ▪ Compounds requires curing process
Thermal Conductive Compound	Improvement of thermal grease. Compounds are converted to a cured rubber film after application at the thermal interface		
Phase Change Materials	Typically polyester or acrylic materials with low glass transition temperature filled with conductive particles	▪ Easy handling and installation ▪ No delamination issues ▪ No curing	▪ Requires attachment pressure ▪ Pre-treatment heating necessary
Thermal Conductive Elastomers	Typically silicone elastomer pads filled with thermally conductive particles. Often reinforced with glass fiber or dielectric films	▪ No pump out or migration concerns ▪ No curing required	▪ Delamination issues ▪ Thermal conductivity is moderate ▪ Requires attachment pressure
Thermal Conductive Adhesive Tapes	Typically double sided pressure adhesive films filled with sufficient particles to balance their thermal and adhesive properties		

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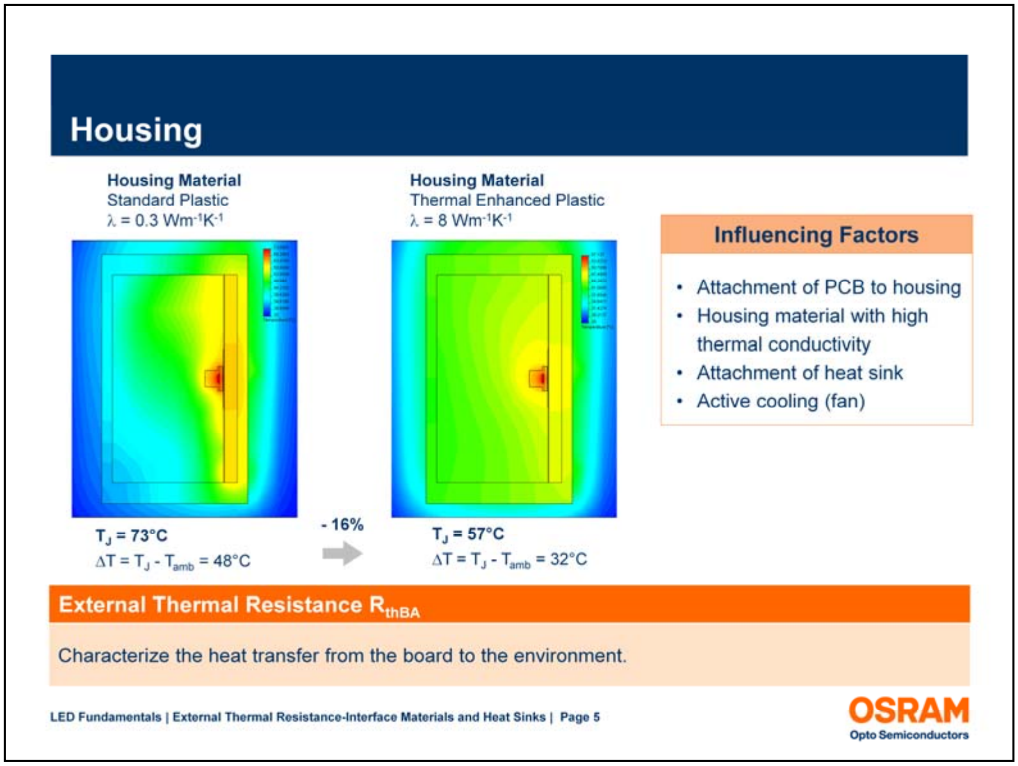
This slide provides a summary of the most commonly used thermal interface materials, along with their advantages and disadvantages.

Thermal greases and compounds provide the lowest thermal interface resistance, but require care in handling.

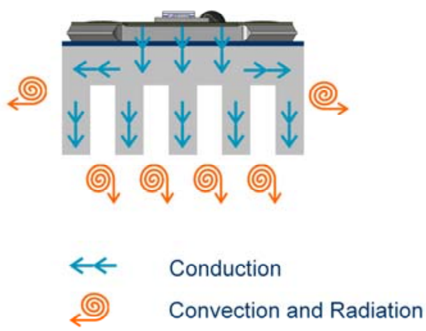
Elastomers and tapes eliminate handling problems but require compressive loads even with well prepared surfaces.

The success of a particular thermal interface material is dependent on the quality and processing of the material in a particular design.



Beyond the thermal interface material used, the housing or the heat sink, to which the printed circuit board is attached, plays an important role in dissipating the heat from the LED junction to the ambient. As depicted in this slide, a housing material of higher thermal conductivity could significantly influence the junction temperature of the LED.

Heat Sinks



Influencing Factors

- Air flow conditions
- Material of heat sink
- Orientation with respect to gravity
- Base plate thickness
- Cross sectional geometry
- Fin geometry
- Number of fins
- Spacing of fins

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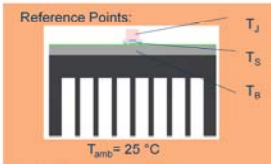
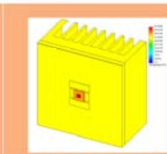
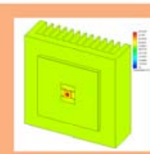
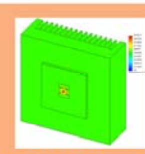
Heat sinks enable a more efficient heat transfer from a heat source to the adjacent fluid by using an extended surface area.

Heat gets moved from the heat source to the heat sink by conduction. The heat sink transfers heat to the ambient air by convection and radiation. There are various factors that influence the performance of the heat sinks.

External Thermal Resistance Rth_{BA}

 Reference Points: T_J, T_S, T_B T_{amb} = 25 °C OSLON SSL 1W on MCPCB in free convection	 25.4 x 25.4 x 12.30 mm³	 31.75 x 31.75 x 12.30 mm³	 50.80 x 50.80 x 17.38 mm³
Junction Temperature T_J	63°C	54°C	48°C
Solder Point Temperature T_S	56°C	47°C	41°C
Board Temperature T_B	52°C	43°C	37°C
Thermal Resistance Rth_{BA}	27 K/W	18 K/W	12 K/W
Thermal Resistance Rth_{JA}	38 K/W	29 K/W	23 K/W

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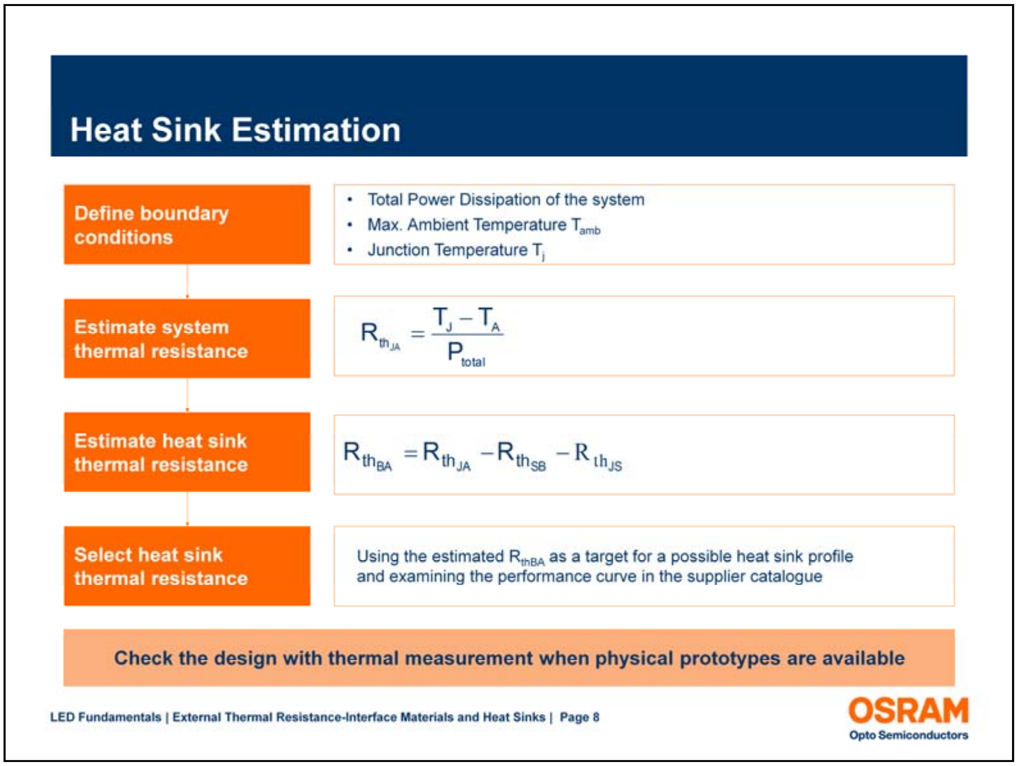
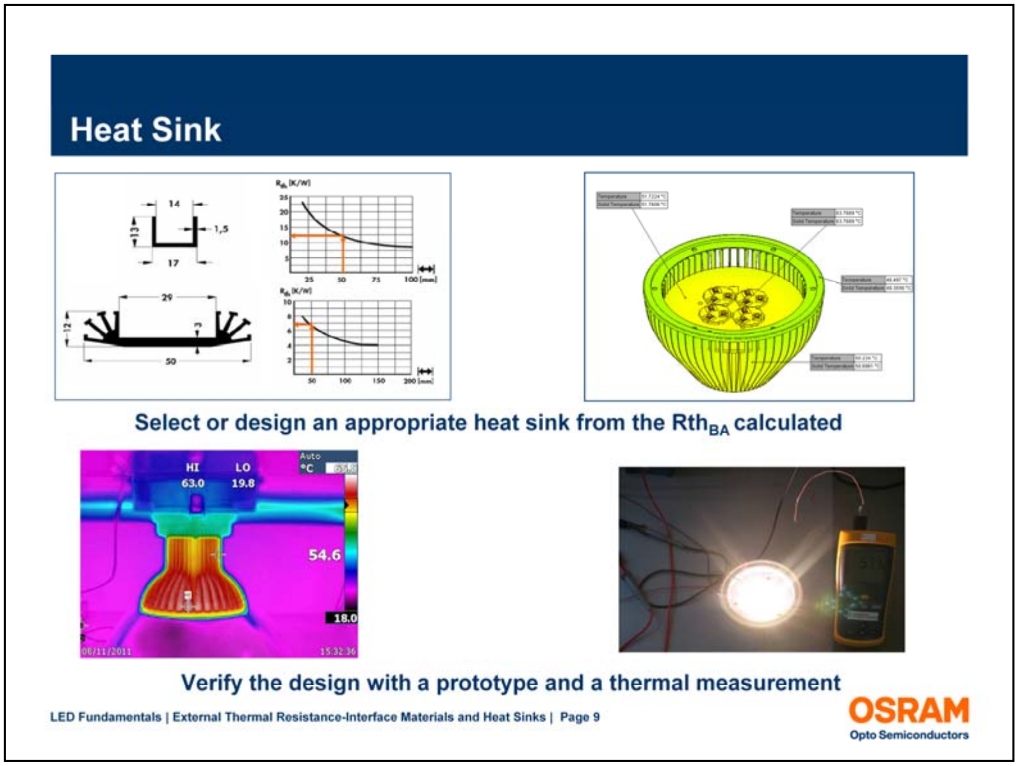
The figures on this slide show a plot of the temperature distribution under steady-state conditions for heat sinks of various surface areas. Listed are the thermal resistances of the heat sink and temperatures at various reference points.

As the surface area of the heat sink increases, the junction temperature of the LED decreases for the same applied conditions.



The steps defined on this slide can be used to estimate the value of the thermal resistance of the heat sink needed for your system design.



Once the thermal resistance of the required heat sink has been determined by calculation, an appropriate heat sink can either be designed or selected from various manufacturers. Finally, it is important to verify the effectiveness of the heat sink by thermal measurement.

Please refer to the application note **“Thermal Management of OSRAM OSTAR Projection Light Source”** on the main OSRAM Opto Semiconductors website for additional information. Thank you for viewing this presentation by OSRAM Opto Semiconductors.

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