Q: Which software did you use for transient or steady state thermal analysis?
A: This is a measurement, that means, our equations are solved by real life. For post-processing we use T3Ster-Master software, a Mentor Graphics product.

Q: Why have metals positive thermal coefficient and semiconductors negative?
A: The answer is pretty simple. In metals practically all electrons are freely moving. In a perfect crystal lattice the crystal represents no obstacle against this movement, the electric conductivity is infinite. But, at a certain temperature the atoms are oscillating with an amplitude corresponding to the temperature, and so they are not at the place where they “should be”. The electrons collide with these displaced atoms (called phonons). At higher temperature oscillation amplitudes are larger and the probability of collision is proportionally higher. This way metals have positive thermal coefficient.

Semiconductors behave differently. The charge carriers (electrons) are tied to the lattice. Only a very few of them can move, which are released at a certain temperature. But, with increasing temperature the number of freely moving carriers grows dramatically, that means the same current can be gained at lower voltage. This way, semiconductors have negative thermal coefficient.

Q: When powering a complex system how can you distinguish what was the portion of the power on the component and what on the leads towards the component?
A: We typically use four wire power driving, that means we have FORCE wires towards the component and separate SENSE wires for detecting the voltage on the component. In such a way we can get rid of most of the powering error. There are also leads within the package, in such a way a fraction of the power rather belongs to these, not to the component itself.

The power on the resistive portion, I mean the leads is quadratic, that means applying double current we have four times higher power. On the active components, for example diodes, it is rather proportional, because the diode forward voltage is more or less stable, at double current we get approximately double power. Applying different current levels we can subtract the quadratic term and we can calculate the actual power level on the active device.

Q: Do we really need to calibrate each device or sub-assembly one-by-one?
A: Calibration is a very tedious process. We have to put some components or a whole system into a thermostat or oven. We have to program several temperature levels and we have to measure some characteristic system parameters like currents or voltages at all temperatures.
Life is a bit easier with silicon because the technology shows small scatter. Using components from the same manufacturing batch we can calibrate just a few of them and then we can use these values for all the systems built from
these components. At LED devices the technology scatter is much higher and we cannot avoid calibrating each of them.

We have a technique called “correlation instead of calibration”. Some structural elements show very high stability, so the size of the chip, the shape of some cooling mounts can be much the same. And these can be well identified in the heating or cooling curves and in the structure function. Measuring first these stable parts and then fitting all measured curves with their specific sections onto the reference curves we can avoid one-by-one calibration.

Q: How can one identify which section of the structure function belongs to which piece of the structure?
A: I would like to emphasize that the structure function technique is not a black box methodology. You cannot simply say that this is the chip and that is the die attach. What you can do is some comparison.

Either you build a synthetic structure function. In case you are the manufacturer of the system you know volumes and materials. You can build up an Rth-Cth function, in Excel for example. You can then compare the measured structure function to the synthetic one.

Another way is using simulation tools like our FloTHERM family. Import the transient of your simulated solid model and then compare it to the measured structure function. Changing the sizes or material parameters you can adjust your simulated transient in a very fine way. Comparing again the measured and simulated structure function you can identify structure details.

The third method is the one used in production lines. There are so called golden samples, kept for future reference. The actual production has to be compared to these golden samples, so the small structure changes caused by shifts in the production can be easily detected and followed.