Member of the T3Ster group in production testing T3Ster in production testing

DA testing with structure functions, high throughput measurements
Structure functions: tools for structural analysis and comparison

**Reference device with good DA**

![Reference Device Diagram]

- Chip
- Base
- Junction
- Die attach
- Grease
- Cold-plate

**Unknown device with suspected DA voids**

![Unknown Device Diagram]

- Chip
- Base
- Junction
- Die attach
- Grease
- Cold-plate

Identify its structure function:

Copy the reference structure function into this plot

This increase suggests DA voids

**Application example:** Die attach testing of LEDs

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Structure functions: tools for structural analysis and comparison

Reference device with good DA

Unknown device with suspected DA voids

Copy the reference structure function into this plot

Shift of peak: Increased die attach thermal resistance indicates voids

Application example: Die attach testing of LEDs
Easy setup of a diode measurement

- connect to $I_E$ to get heating current
- connect to one of the $I_{\text{sense}}$ sources
- connect to a measurement channel

Application example: Die attach testing of LEDs
Module for the engineer to set up the measurement:
Once the parameters are set by the engineer, the operator needs to press NEXT buttons:

Graphical feedback about the progress of measurement is provided.
The first 0.5s .. 1s section of the transient already contains enough data for DA qualification:

![Graph showing temperature rise over time with different labels: good DA (red), good DA, measurement stopped at 0.5s, bad DA (blue).]
The first 0.5s .. 1s section of the transient already contains enough data for DA qualification:

**T3Ster Master: cumulative structure function(s)**

- good - Ch. 0
- good_0.5seccut - Ch. 0
- wrong - Ch. 0

**good DA, structure function from incomplete transient**
Reference $C_{th}$ level and $R_{th}$ tolerance to be set by thermal engineer

Details: EPTC'06 Proceedings

Reference level of $C_{th}$ not reached within the given $R_{th}$ range, thus, DA is bad
Member of the FloMerics group

In-line DA testing of LEDs

Method based on short term transients
TO252 package:

Necessary time for a short tern transient measurement:

\[ 2\text{mWs/K} \times 2\text{K/W} = 4\text{ms} \]

Similar structure as power LEDs

See further power package examples in the paper…
Voids and delaminations at solder bumps & in die attach layer raise the thermal resistance.
Several power LED samples from the same type were tested.

One from the best (Good die attach) and other from the worst (Poor die attach) were examined in details, using thermal transient measurements and the structure function evaluation method.

Both the electrical power and the emitted optical power were measured for proper calculations of derived functions (to obtain exact structural map and thermal impedance).
Thermal impedance curves of two devices with Good and Poor die attach quality.

At some milliseconds the difference can be identified.

Further sections are not strictly necessary to be measured for establishing the die attach quality.
Structure function view

Structure functions of the devices with Good and Poor die attach layers

The minimal required measurement time can be approximated as follows: 0.5mWs/K*8K/W=4ms
A power pulse was used to obtain short time transients: 10ms heating, 50ms cooling

This cooling thermal transient is used in our further analysis.
The measured long term and short term thermal transients seem to be the same up to 4ms.

- Good DA
- Poor DA

Difference at 4ms!

TSP calibration and $P_{\text{opt}}$ correction was performed.
The **structure function view** is applicable to qualify the die attach from short term transients.

Application example: Die attach testing of LEDs
We examined dozens of samples of the same type with short term thermal transient measurement.

Temperature change induced *forward voltage transients* of the samples:

Three samples chosen for further analysis.

The beginning of the transients are different as the LED samples have different sensitivities of $V_F$. 
Structure functions of the three characteristics were calculated by an assumed, uniform TSP:

The beginning of the structure functions differ … as a consequence of scatter in TSP

Due to the same geometry, chip regions must have appeared identical.
The individual TSP-s (temperature sensitivities of $V_F$) were measured and the thermal impedance curves were calculated using these values:

The initial parts (heat propagation in the chip) seem to be identical now!

The elevations of the three curves can be used to identify differences among samples cca within 4ms!
Structure functions of the three characteristic samples were calculated with the *measured*, individual $V_F$ sensitivities:

The initial parts of the structure functions are the same since this region corresponds to the chip region that has identical geometry in these devices.
No need for TSP calibration…

▶ Characteristic times $T_1$ and $T_2$ can be calculated from points $P_1$ and $P_2$ of test structure functions.

▶ Measured $\Delta V_F(t)$ transients need to be fitted between $T_1$ and $T_2$.

▶ Temperature elevation at $\sim 2xT_2 \ldots 4xT_2$ is a good indicator of DA quality.

▶ No need for TSP calibration.