LOMSS

# Characterization of Die-Attach Thermal Interface of High-Power Light-Emitting Diodes: An Inverse Approach

**Sponsor:** UNIVERSITY OF MARYLAND

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## Motivation

- The different size of voids can be generated in high power LEDs due to outgassing during solder reflow process, which results in different heat dissipation and thus different junction temperature.
- Characterization of the die-attach thermal interface (DTI) in high power LEDs is one of the most important tasks for assessing performance range (center wavelength and power efficiency) and reliability.

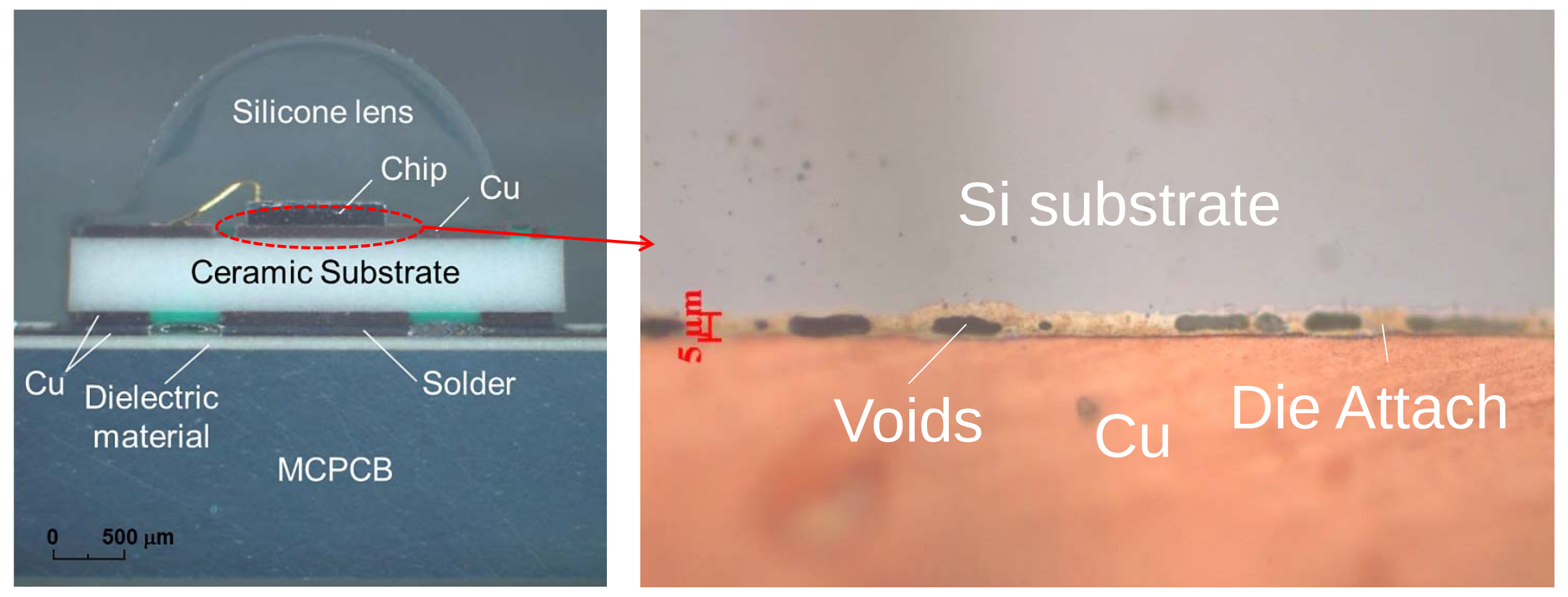
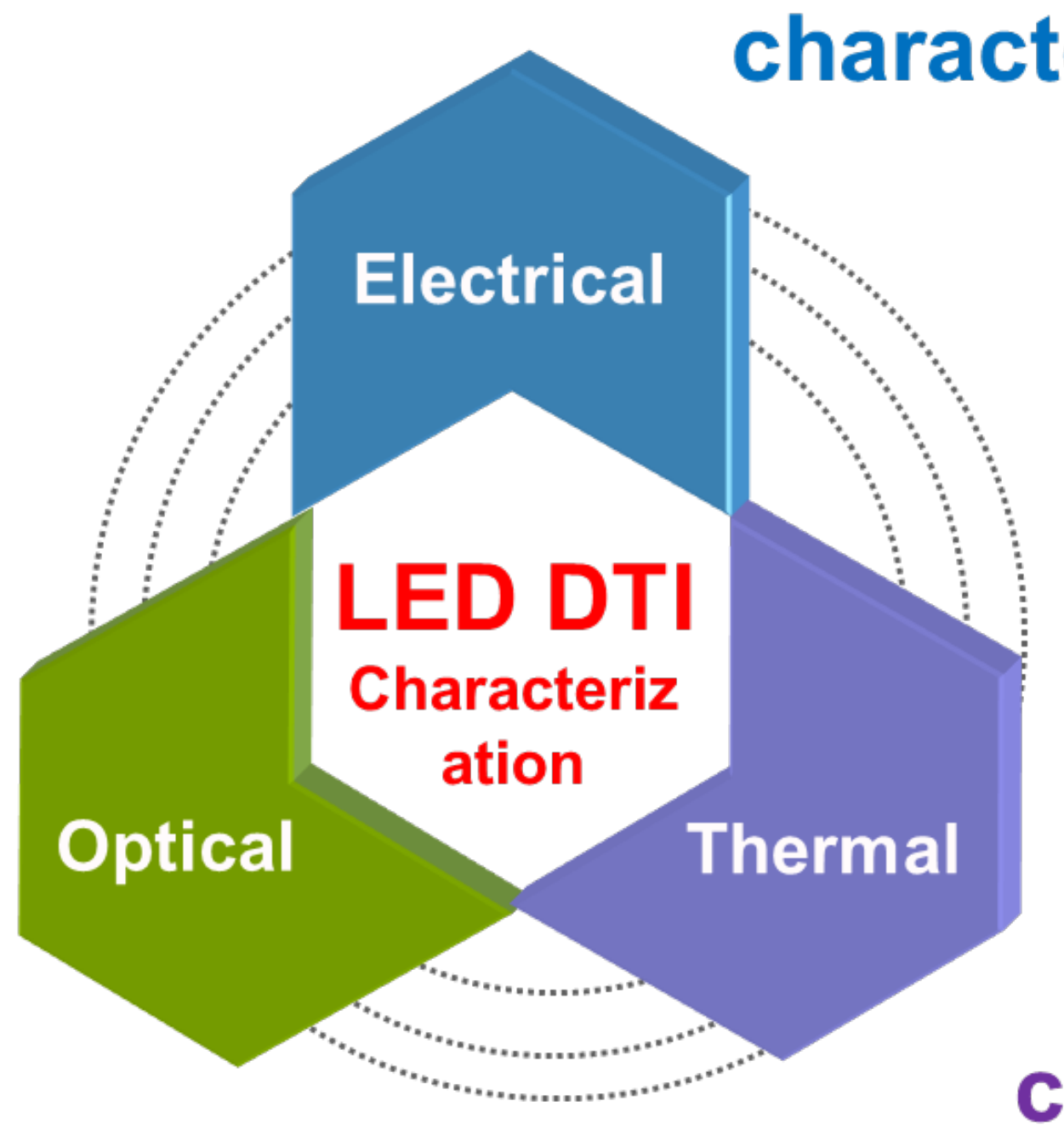


Figure 1. Cross-sectional image of the high-power blue LED and the zoomed-in view of the die attach

## Objective

- An advanced inverse approach is proposed and implemented to more accurately determine the effective DTI resistance by understanding unique electrical/optical/ thermal characteristic of high power LEDs.



**PN junction diode characterization**

**Optical power characterization**

**Transient junction temperature characterization**

## Approach

- A hybrid analytical/numerical model is first used to determine the approximate transient junction temperature behavior, which is governed predominantly by the resistance of the DTI.
- The DTI resistance is determined inversely from the experimental data using numerical modeling.

## Hybrid Experimental/Analytical/Numerical Model

### Test setup

- A sourcemeter, a DAQ, and a thermoelectric cooler (TEC), an integrating sphere are integrated into a LabVIEW program.

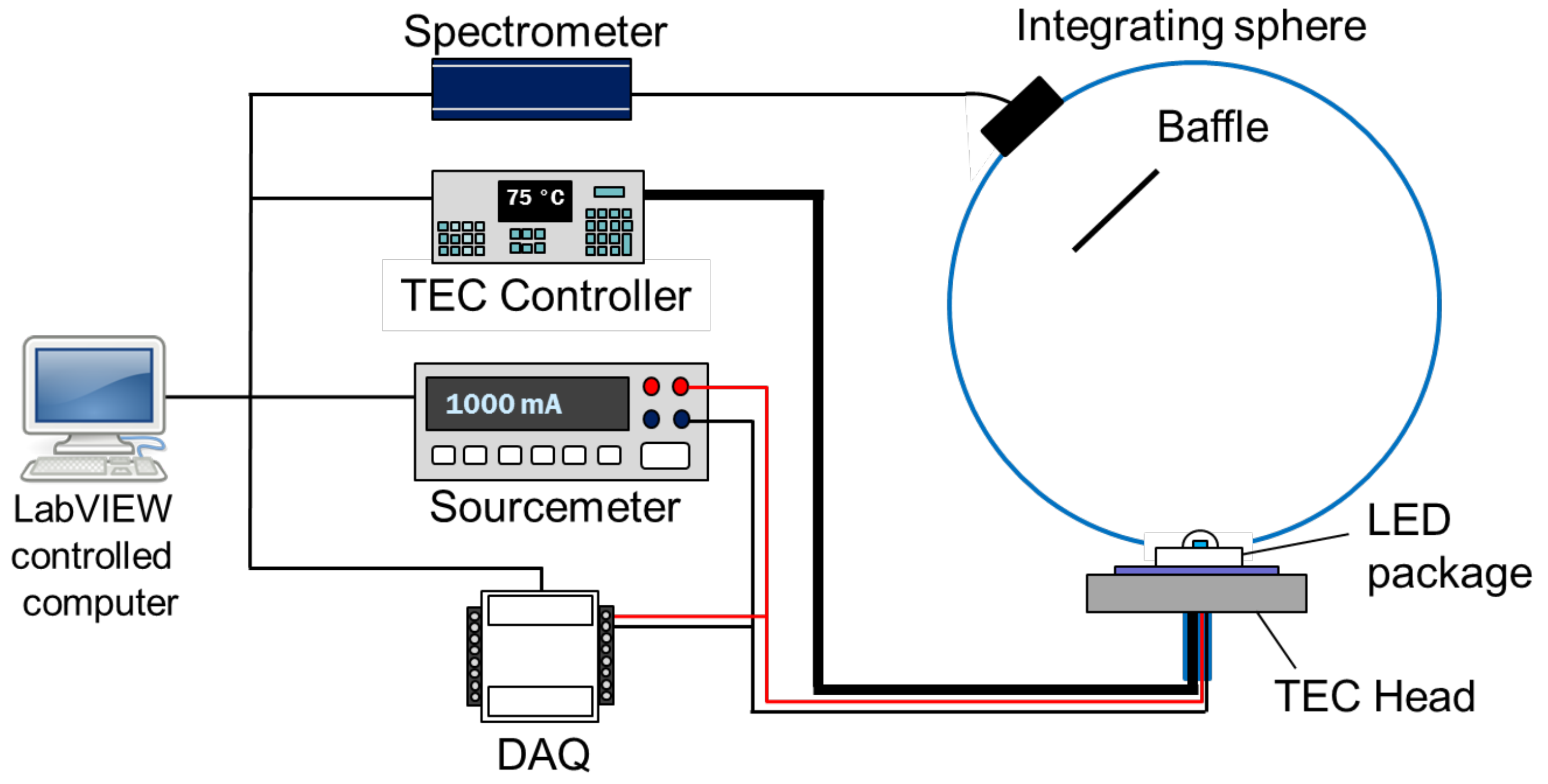


Figure 2. Schematic of the measurement setup

### Experimental results

- The transient junction temperature behavior of an LED is first measured by the forward voltage method.
- The radiant flux was measured by the integrating sphere to calculate the heat dissipation.

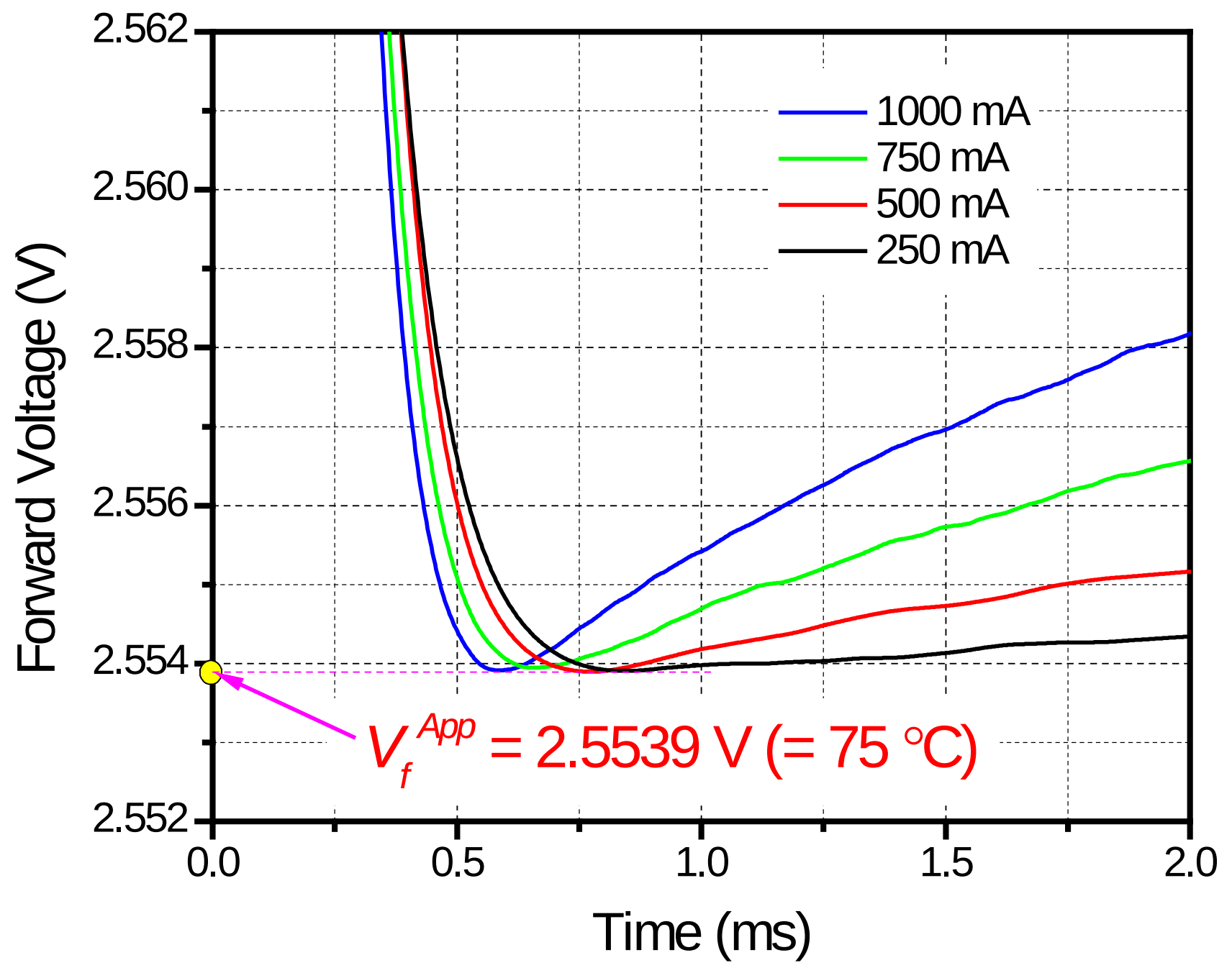


Figure 3. Transient voltage behaviors under four different operating currents

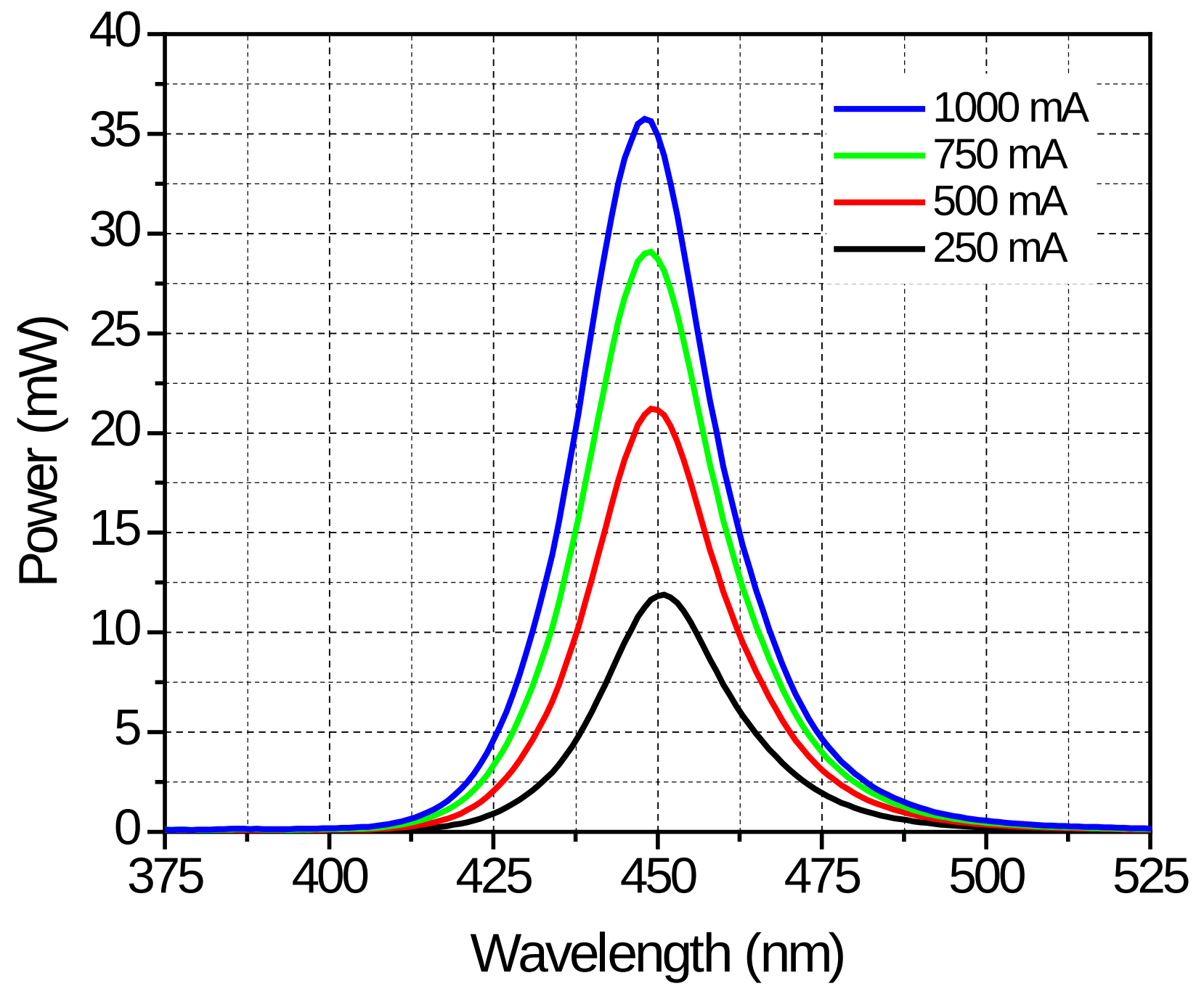


Figure 4. Spectral power Distributions (SPDs) under the different operating currents

## Hybrid Analytical/Numerical Model

- The transient time domain governed predominantly by the resistance of the DTI is selected using a hybrid analytical/numerical solution.

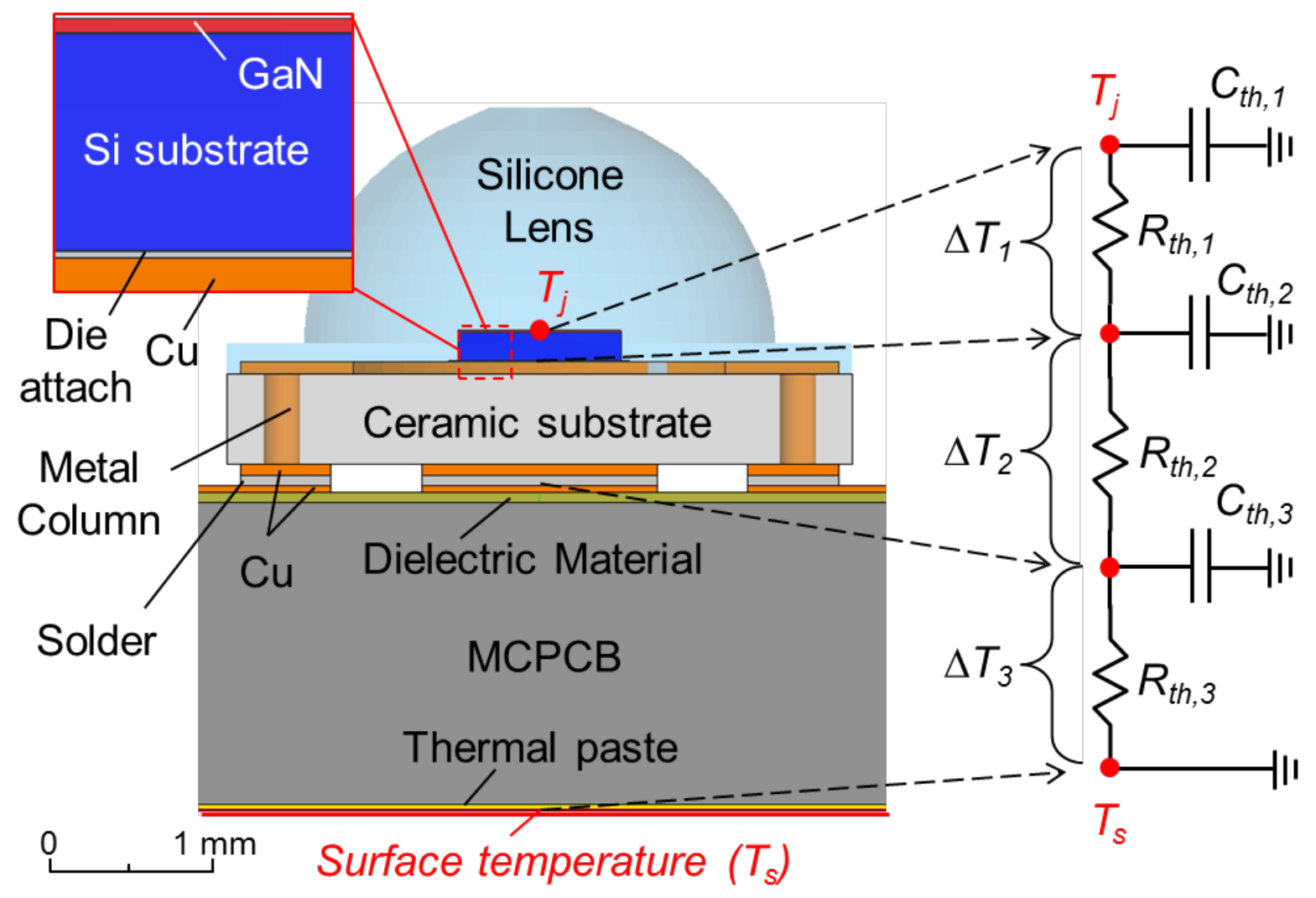


Figure 5. Schematic of the hybrid analytical/numerical model

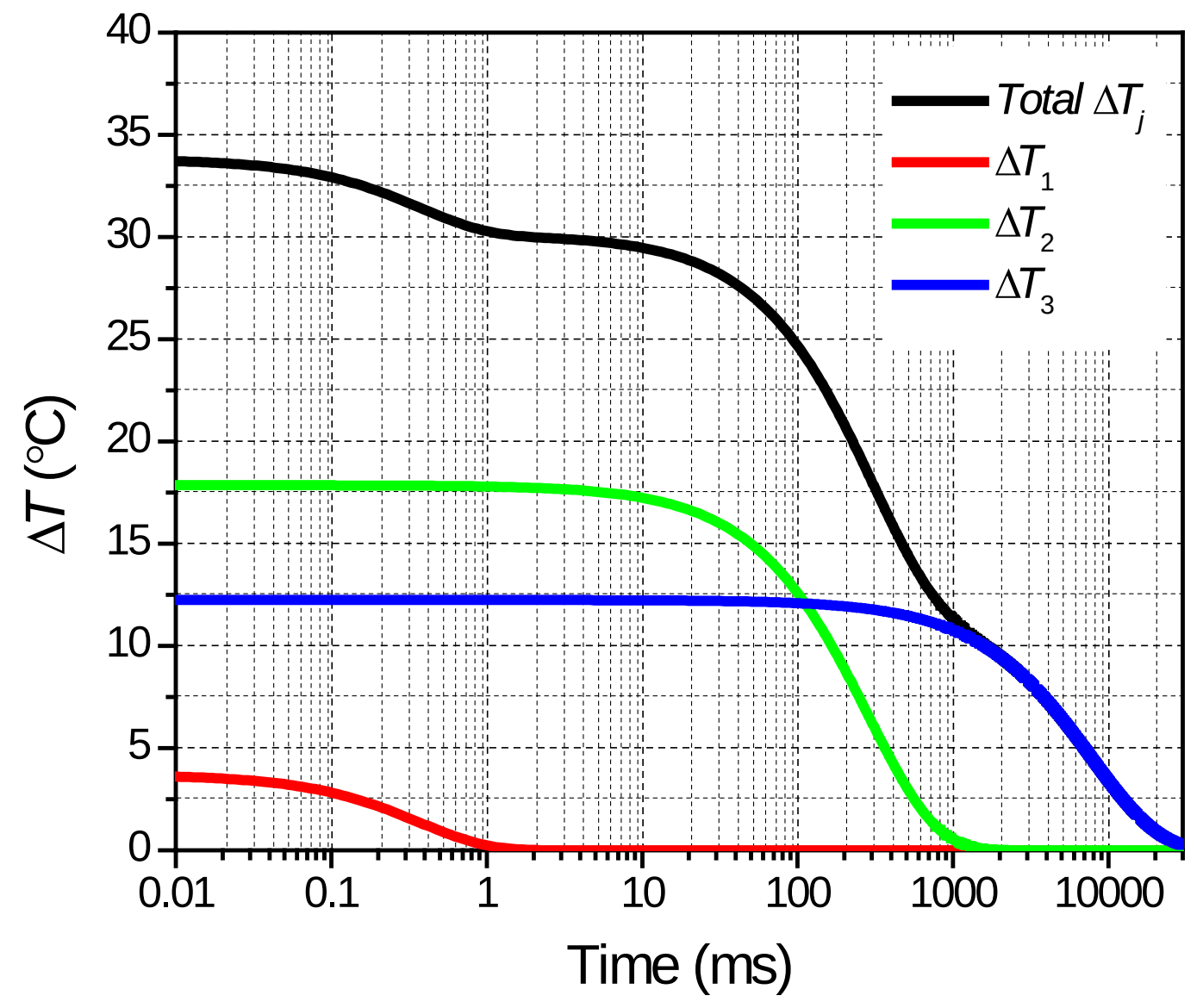


Figure 6. Transient behavior of the temperature difference of each layer

## DTI measurements and Verification

- The resistance of the DTI was determined inversely from the experimental data over the predetermined transient time domain using numerical modeling.

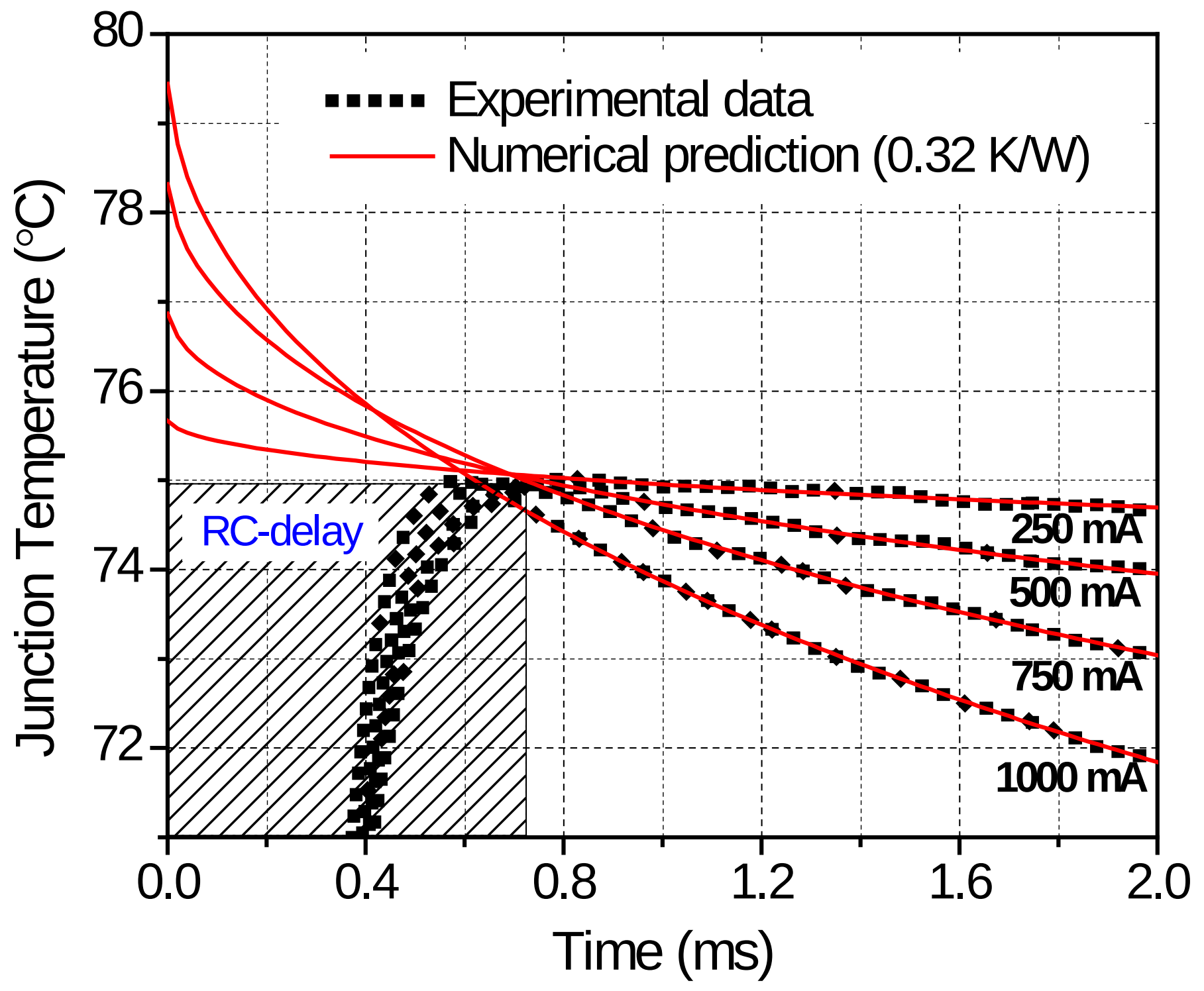


Figure 7. Predicted transient behavior of AuSn die attach at different forward currents is compared with experimental data

## Impact

- The results confirmed that the proposed approach offered a measurement accuracy of 0.01 K/W.
- With the high accuracy offered by the proposed approach, the die bonding manufacturing process can be evaluated nondestructively.

## Related publication

- D.-S. Kim, B. Han, and A. Bar-Cohen, "Characterization of Die-Attach Thermal Interface of High-Power Light-Emitting Diodes: An Inverse Approach," IEEE Transactions on Components, Packaging and Manufacturing Technology, vol. 5, pp. 1635-1643, 2015.