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Tech Note: TN-003

CHARACTERIZING NON-UNIFORM TEMPERATURE & CURRENT DISTRIBUTIONS IN SCR for ESD PROTECTION

This Technical Note describes the application of transient thermoreflectance imaging [1] for the analysis of the current distribution in a multi-finger silicon controlled rectifier (SCR) used as an electrostatic discharge (ESD) protection device. This analysis is accomplished by observing the surface temperature changes due to self-heating [2].

In this example, experimentally calibrated temperature images are obtained for a multi-finger, MOS-SCR device in snapback mode for different current levels from 1.15 A to 1.47 A, and at different time intervals from 100 ns to more than 200 µs after an ESD-like pulse.

This technique demonstrates a practical and straightforward way to characterize non-uniform temperature and current distributions in ESD structures, which can reveal the effects of non-simultaneous triggering of individual fingers on the multi-finger SCR device.

Fig 1a is an optical image of the 80 µm x 80 µm square MOS-SCR device with two cathode fingers shown on the left and three anode fingers shown on the right. The thermal image shown in Fig 1b) is taken 300 ns after an ESD-like 120 V pulse is applied. Note that breakdown voltage for this device is 104 V. This image shows highly localized heating in the in one of the cathode fingers (upper left of image in fig 1b).

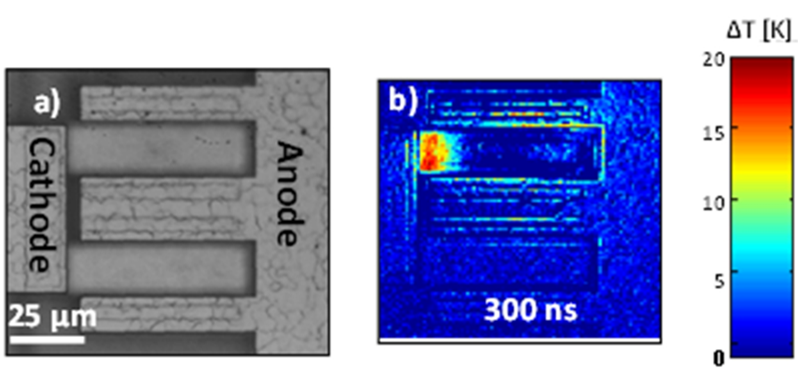

Figure 1: a) Optical image and b) Thermal image at 300 ns with SCR in snapback mode

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Fig. 2 shows a progression of four transient thermoreflectance thermal images at intervals from 10 µs to 200 µs after the applied pulse. These images clearly show the time-dependent nature of self-heating resulting from the changing current distribution as a function of time.

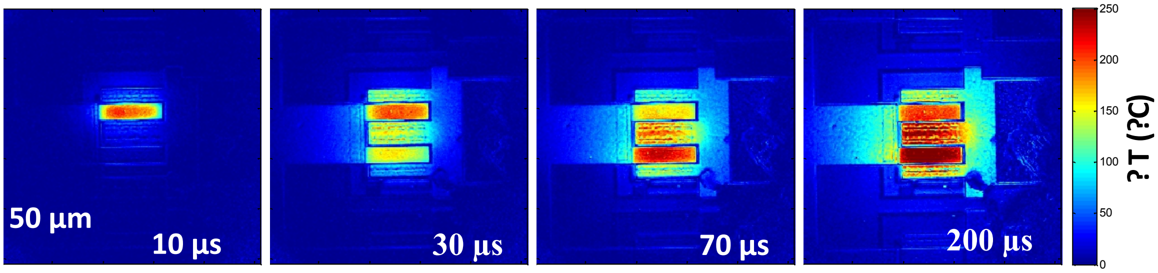

Figure 2: Non-uniform temperature profile from 10 µs to 200 µs

Summary

This note briefly describes one of the many applications for transient thermoreflectance thermal analysis in the study of time-dependent thermal events. The system used for this particular experiment was a Microsanj NT210A with a time resolution of 100 ns and a spatial resolution of 600 nm. An illumination wavelength of 470 nm was selected for its relatively high thermoreflectance coefficient for both silicon and aluminum. The temperature resolution for these measurements was 0.5 °C.

References:

Reference [1] provides additional information on transient thermal imaging with a description of another application. If there is interest in acquiring further details on the example described in this note, the reader is referred to reference [2].

[1] AN-006: Analysis of Time-Dependent Thermal Events
http://www.microsanj.com/application-notes/detecting-hot-spots-and-other-thermal-defects-sub-micron-scale-electronic-and

[2] Nanosecond Transient Thermoreflectance Imaging of Snapback in Semiconductor Controlled Rectifiers, Kerry Maize, Dustin Kendig, Ali Shakouri, Vladislav Vashchenko, IRPS – 2011.

