Microelectronics Reliability 84 (2018) 95–104

Contents lists available at ScienceDirect

Microelectronics Reliability

journal homepage: www.elsevier.com/locate/microrel

Stability of low ohmic thick-film resistors under pulsed operation

Arkadiusz Dąbrowski*, Andrzej Dziedzic

Faculty of Microsystem Electronics and Photonics, Wrocław University of Science and Technology, Wybrzeże Wyspiańskiego 27, 50-370 Wrocław, Poland

ARTICLE INFO

Keywords:
Pulse load stability
Thick-film resistors, low ohmic resistors

ABSTRACT

Durability of low ohmic thick-film resistors on pulse load with micro- and millisecond duration are described in this paper. Standard thick-film resistive compositions with sheet resistance of 10 Ohms/sq. (4311 and QS871 - DuPont; R400-10A - Heraeus) and 3 Ohms/sq. (QS870 - DuPont) were tested. Test resistors with resistance of 3 Ω were prepared on alumina substrates. Resistance changes were measured after 50 pulses at each voltage. Then the voltage was increased and the series of pulses were repeated until the resistance change exceeded 0.5%.

Impact of long and short pulses was analyzed for selected pulse duration of 10 µs and 20 ms, respectively. The measurements were carried out for some selected resistors length. The resistors stressed by long pulses exhibited the highest durability, when the thermal interface between substrate and heatsink was filled by thermally conductive grease. In this case resistors made of 4311 and QS871 pastes can withstand the highest power density of about 19 W/mm^2 and 18 W/mm^2 for the samples with and without the overglaze, respectively. Short (microsecond) pulses had the least influence on overglazed resistors made of QS871 paste, for which the resistance change of +0.5% was observed at electric field intensity of about 85 ± 10 V/mm.

Additionally, the critical electric field intensity and critical power density were determined for different pulse duration for selected resistor length of 2 mm. Pulse duration from 10 µs to 1 s with one point per decade were taken into account. The results shown, that overglazed resistors exhibit better durability for all tested resistive pastes for short pulses. However for the long pulses, the results are almost the same. This fact can be explained by limitation of heat transfer in the substrate.

Repetitive pulse load was applied for selected samples. The results show that resistors exhibited very good stability after test with 0.1 million pulses with amplitude of 70% of critical electric field intensity values.

1. Introduction

Number of passives in modern circuits is increased together with number of active components in electronic devices [1 and references herein]. Miniaturization and the highest reliability are required, however the smaller components are, the less power can be dissipated. Modern high efficiency power circuits, especially drivers of amplifiers, inverters, DC/DC converters are working in pulsed regime, rarely in continuous or linear mode. Considering fastness of resistors to pulse stress, typically maximum non-destructive pulse amplitude is increased with decreasing pulse duration [2]. Besides passive components, high current pulses can affect also conductive layers [3] and *via* holes in substrates [4]. Because of these facts, testing of the components under pulsed load is necessary.

Standards of pulse durability testing including surge immunity and ESD fastness testing applied for electronic components base on determination of strength to a pulse with proper transient parameters, simulating typical overvoltage incoming from power network, electrostatic discharge or lightning strikes. Typical transients described by telecommunication and electromagnetic compatibility (EMC) standards are characterized by some nominal rise/decay times of voltage or current pulses, *e.g.* 10 µs rise/700 µs decay time, 10/1000, 0.5/700, 2/50 µs [5]. Such transients are typically applied during investigation of pulse load durability [5,6]. Nevertheless loading waveform applied to resistors during intentional pulsed operation can be different from typical overvoltage transients. Therefore fastness of the components should be determined under similar load conditions as assumed in a final system. For example, current limiting resistors in some devices can be loaded with nearly square waveform instead of standard exponentially decayed pulses. Duration of the voltage or current pulse has a great impact on resistors durability including those made in thick-film technology [7]. Effect of pulses on resistors for "short" pulses, which means pulses with duration of several hundred nanoseconds to several microseconds is different from effect of "long" pulses, which means single to some dozen microseconds, resulting mainly from thermal effects during "long" pulses [8]. Dependence of surface (or volume) power

* Corresponding author.
E-mail address: arkadiusz.dabrowski@pwr.edu.pl (A. Dąbrowski).

https://doi.org/10.1016/j.microrel.2018.03.024
Received 16 October 2017; Received in revised form 20 February 2018; Accepted 19 March 2018
Available online 22 March 2018
0026-2714/ © 2018 Elsevier Ltd. All rights reserved.

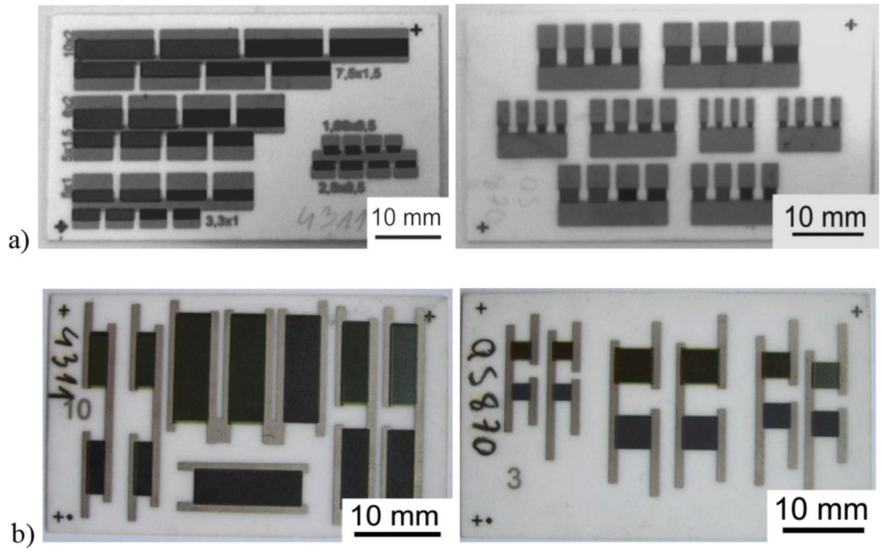

Fig. 1. Test samples for 10 μs (a) and 20 ms (b) pulses.

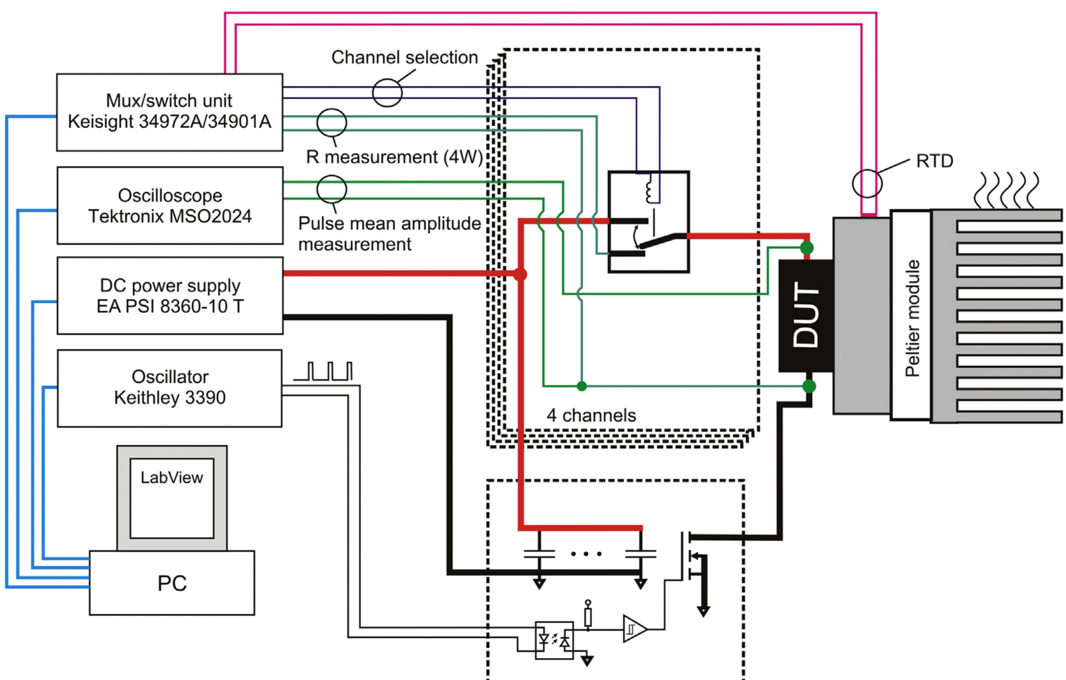

Fig. 2. Test setup.

density or electric field intensity necessary for resistor damage can be described by power function of the pulse duration [9]. In case of surface power density (P_D) the formula can be expressed as (1).

$$P_D = A \bullet (t_{imp})^{-B} \tag{1}$$

where t_{imp} – pulse duration, A and B – constants. The above equation is based on Wunsch-Bell model, which is used for analyzing power-to-failure behavior of single-component semiconductors [10]. The analytical model for resistor burn-out under pulsed conditions was proposed *e.g.* in [11].

For specified material configuration and technology of the resistor, the function can be used to calculate fastness of the resistors for different pulse duration from another pulse duration. For example in case of thin-film resistors built in printed circuit boards the exponent parameter is close to 0.4 whereas for polymer thick-film ones – very close to 0.7 [9].

Pulse load of the resistors first of all is used for analysis of the resistors reliability during such operation to estimate its limits for further application. However short single pulses with high enough energy can be applied for controlled for trimming resistors [8,12,13].

In this paper pulse load fastness of low ohmic resistors made in thick-film technology are described for different pulse duration. Detailed analysis was carried out for duration time of 20 ms and 10 μs. The samples made of four different resistive compositions were examined and compared for various resistors length. Different ways of substrate assembly to the heatsink were tested from the point of view of heat carrying away.

Durability of thick-film resistors series made of the same pastes with only one length were examined for different pulse duration in the range from 10 μs to 1 s with decade step. The experiment was carried out using the thermally conductive grease at the interface between the substrate and the heatsink, which was determined as the best on the

Download English Version:

https://daneshyari.com/en/article/6945607

Download Persian Version:

https://daneshyari.com/article/6945607

Daneshyari.com