Control Integrated POwer System (CIPOS™)

Oxidized Copper Layer on CIPOS™ Mini Inverter IPM Products

About this document

Scope and purpose

The scope of this application note is to describe the oxidized copper layer of DCB (Direct Copper Bonded) substrates on CIPOS™ Mini inverter IPM products.

Intended audience

Power electronics engineers who want to evaluate the CIPOS™ Mini inverter IPM products.

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1.1 Introduction

CIPOS™ Mini inverter IPM comprises DCB substrates offering a low thermal resistance. The backside of such a substrate is formed by a copper layer being directly accessible for cooling purposes. Due to the contact with air during storage, the surface of this layer may oxidize. This yields a non-uniformly distributed thin oxide layer consisting mainly of copper oxide (Cu_2O / CuO) which does not affect the electrical or the thermal performance of the module. Such layers shine in different colors depending on their thicknesses (typically brown or silver).

1.2 Thermal performance of CIPOS™ Mini inverter IPM products

CIPOS™ Mini inverter IPM products need to be cooled during normal operation. Being attached to heat sinks, thermal grease is typically used in order to provide a good thermal contact between the module and the heat sink. Frequently used thermal greases have typically a thermal conductivity of 1 W/mK. In most cases one can assume a thermal grease thickness of about 100 µm.

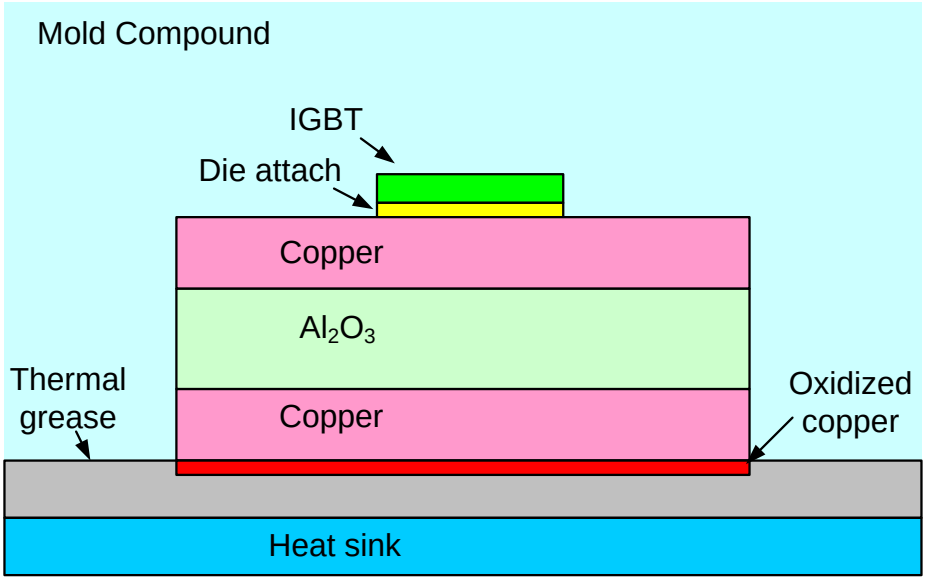

Figure 1 Simplified cross-section through the DCB of a CIPOS™ Mini inverter IPM

When the system is properly cooled, one of the main factors determining its thermal impedance is the thermal grease. Characteristic of such a layer of thermal grease is the property $R_{th,grease} \bullet A = 100\mu$ K/W•m² being much higher than the one of other layers (see Table 1).

Table 1 Rth*A of different layers

Layer	Thickness [mm]	Thermal conductivity @ 100°C [W/mK]	Rth*A [W/K*m^2]
Copper	0.3	385	7.79E-07
Al_2O_3	0.38	23	1.65E-05
Thermal Grease	0.1	1	1.00E-04
Oxidized Copper	0.0001	10	1.00E-08

Oxidized Copper Layer on CIPOS™ Mini Inverter IPM

Oxidized copper layers are typically very thin (the thickness hardly reaches 100 nm). The thermal conductivity of copper oxides ranges approximately from 10 W/mK to 40 W/mK. This yields at worst $R_{th,ox.Cu} \cdot A = 0.01\mu$ K/W•m². As heat spreading is negligible in such a thin layer, the heat flow through these layers covers the same area. Hence, the thermal resistance of the thermal grease will be approximately 10 000 times higher than the thermal resistance of the oxidized copper:

$$R_{th,grease} \geq 10000 \cdot R_{th,ox.Cu}$$

Even if one could provide an ideal thermal contact between module and heat sink, the thermal resistance of the DCB is much larger than that of the oxidized copper. Thus, the oxidized copper does not affect the thermal performance of the module.

1.3 Conclusion

It has been shown by assessing the thickness and thermal conductivity of different layers of a mounted CIPOS™ Mini inverter IPM that oxidized copper layers have no impact on the thermal performance.

Oxidized Copper Layer on CIPOS™ Mini Inverter IPM

Revision History

Major changes since the last revision

Page or Reference	Description of change
Ver1.0, Dec.03.2015 All pages	First release
Ver1.1, Aug.04.2016 All pages	Minor typo fixed Template changed
Ver1.11, Sep.09.2016 All pages	Minor typo fixed

Edition <2016-09-09>
Published by
Infineon Technologies AG
81726 Munich, Germany

Do you have a question about this document?
Email: erratum@infineon.com

Document reference
AN2016-17 Application Note

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