NANOTHERM

Innovative Nano and Micro Technologies for Advanced Thermo and Mechanical Interfaces

December 2015 **Newsletter #3**

NANOTHERM is a European large-scale integrating project aiming at the development, integration and manufacturability of advanced interface technologies for superior thermal and thermo-mechanical design for heterogeneously integrated power systems on different technology platforms for different market segments in industry.

Viking & BME

The versatile capabilities of the Viking reliability control box were demonstrated with several sample sets from different industrial partners. The multi-market Infineon S-FET samples will serve now as an example for introducing the results of a power cycling enhanced with intermittent thermal transient testing and sample monitoring. 150 ℃ junction temperature amplitude was used along with extra thermal resistance under the package to mimic passive cycling.

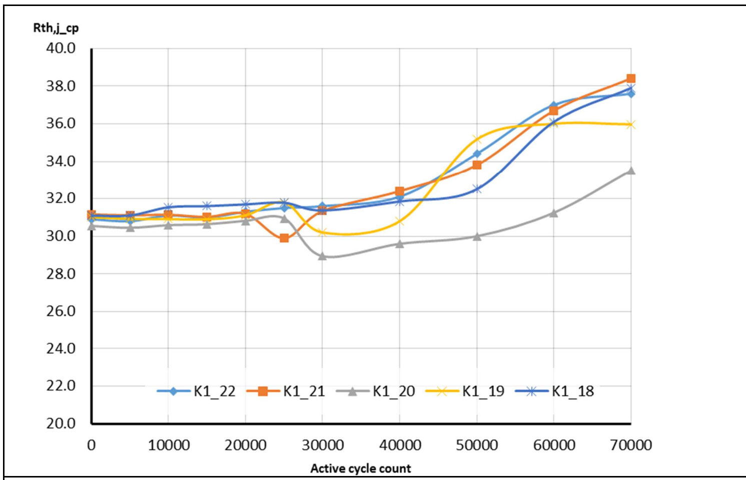

Figure 1. Time evolution of Rth for all samples

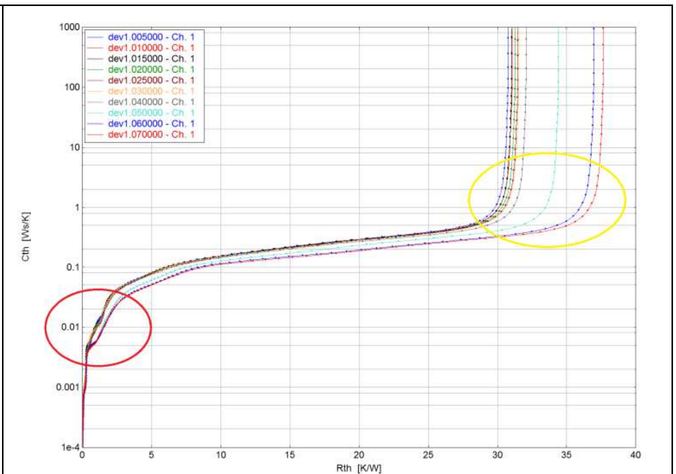

Figure 2: Structure function deviations

Until 40,000 cycles, no degradation was observed for all samples – figure 1. However, it was visible that some structural fatigue was started. At 50,000 cycles all samples started a slight but clearly detectable aging. This aging affected also the chip itself and the FR4 substrate. Structure function analysis was used to differentiate between the degradation of the chip and of the outer assembly (soldering, FR4 carrier). In the graph shown on the right, the aging of an individual sample can be seen. The two circles indicate the observed structural changes at the chip (red circle) and at the outer assembly (yellow circle) observed during cycling. The aging induced structural change at the chip region is relatively small compared to the whole aging of the assembly. The chip level Rth increase was in the range of 0.4-0.5 K/W. The measurement technique is able to capture such small deviations with good signal to noise ratio besides the overall (2 orders of magnitude larger) thermal resistances.

The power cycling of the Infineon demonstrator samples with the Viking reliability test environment clearly shows that in-situ thermal transient measurements during aging followed by structure function analysis can be successfully applied for fatigue tracking. The developed test environment unites the advantages of the laboratory level thermal transient testing, and the high throughput demands of industrial test equipment. The result is a highly scalable reliability control box with customizable test environment and pre-programmed test methods.

LaTIMA™ - Lateral Thermal Interface Material Analyzer

Highly conductive materials are a great challenge for common thermal and electrical characterization methods. The measurement resolution often does not suffice characterizing thermal and electrical conductivities with satisfying accuracy. Additionally, providing samples suitable for available characterizations often is a great challenge.

NANOTEST developed within the NANOTHERM project a test stand for electrical and thermal characterization of highly conductive materials such as sintered silver.

The LaTIMA™ philosophy is to provide a measurement system that fits around the sample, not vice versa.

Thermal conductivity characterization with LaTIMA™ is based on steady-state technique following the well-known TIMA™ measurement system. A constant heat flow is applied between hot and cold plate and measured using metal-based heat flow sensors. The thermal conductivity is calculated from the specimen's geometry, the heat flow and the temperature gradient measured with an integrated infrared camera. The test stand has been designed for minimum parasitic effects with respect to materials and geometry to assure a measurement accuracy for the targeted materials of better than ± 5%.

Electrical conductivity characterization is realized with four-terminal-sensing and pulse delta technique as integrated function in LaTIMA™. Ultra-short periodic pulses and the resulting differential voltage drop deliver the electrical resistance which – using the specimen's geometry – the electrical conductivity is calculated from. Applying high-precision measurement equipment, an accuracy of over ± 0.5% is available.

Mohamad Abo Ras et.al published at the 21st International Workshop on Thermal Investigation of ICs and Systems (Therminic 2015) a paper with the title "LaTIMA – an Innovative Test Stand for Thermal and Electrical Characterization of Highly Conductive Metals, Die Attach, and Substrate Materials" and earned the Best Paper Award.

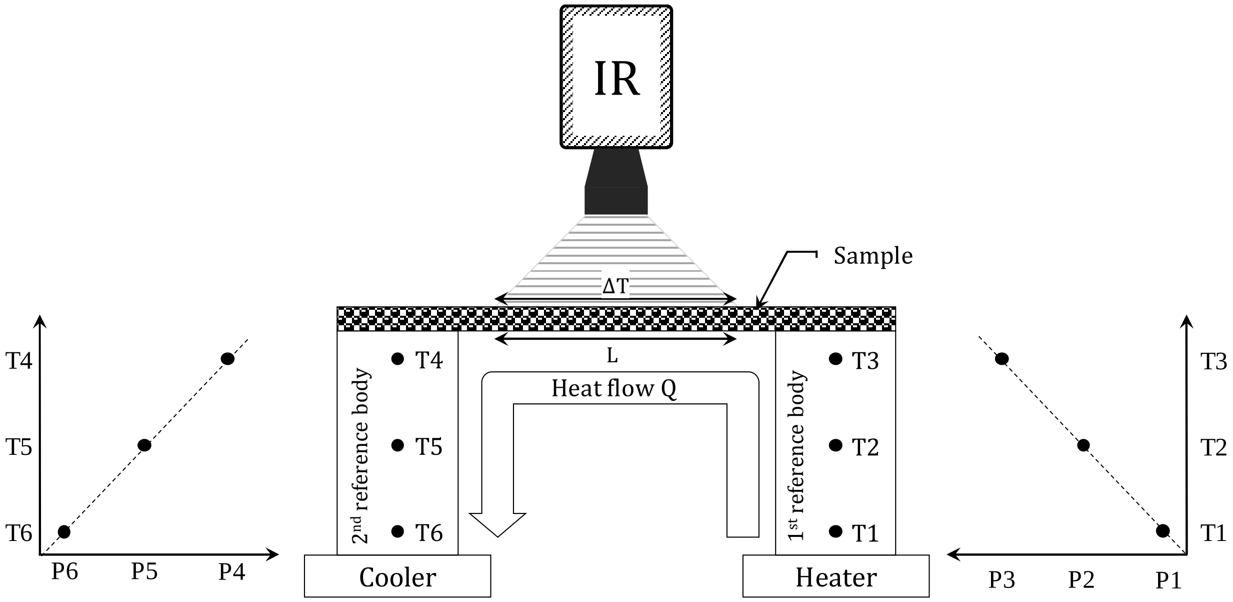

Figure 3 - Schematic of the new test stand LaTIMA

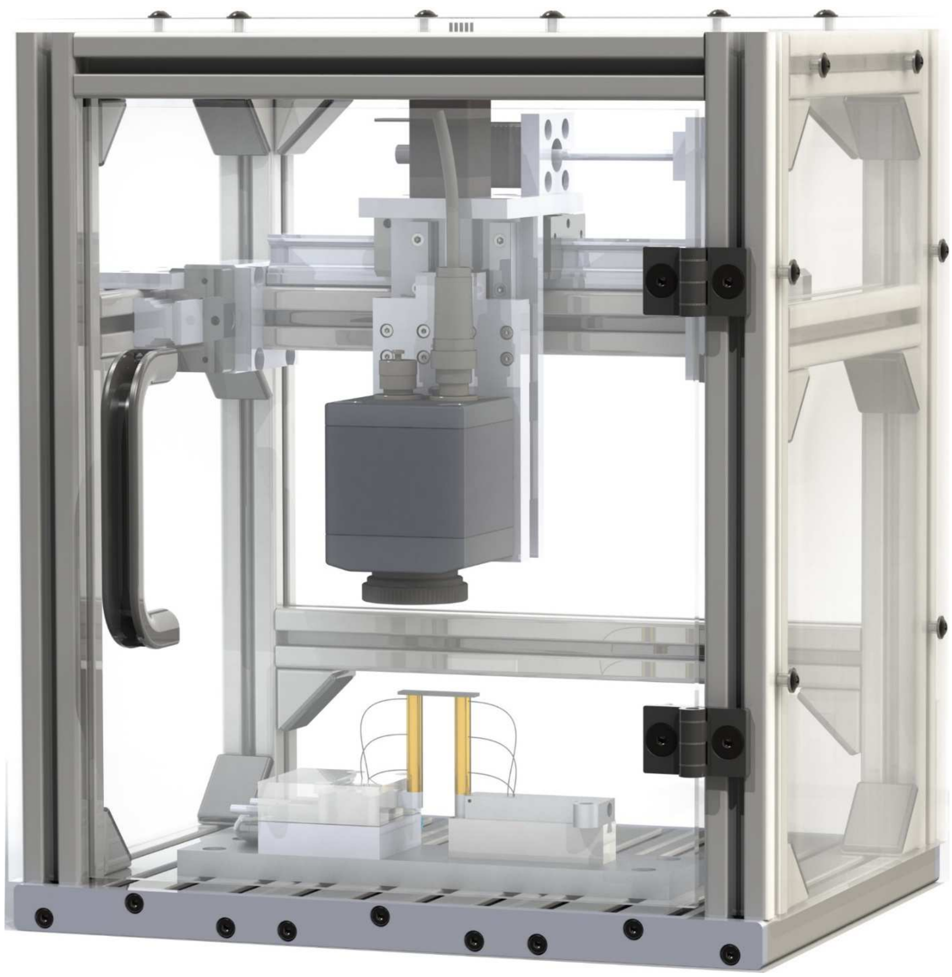

Figure 4 - Photography of the new test stand LaTIMA

NanoTIM

Amepox Microelectronics during NANOTHERM project worked with new, highly thermally conductive formula (NanoTIM) based on mixture of different silver fillers (silver nanoparticles size 50-60 nm - "Fig. 5a" and silver flake size 2-4 µm - "Fig. 5b") and small amount of epoxy resin. Such a material in dependence from proportion and the kind of components will achieve the value of thermally conductive the several tens of W/mK (Table 1.).

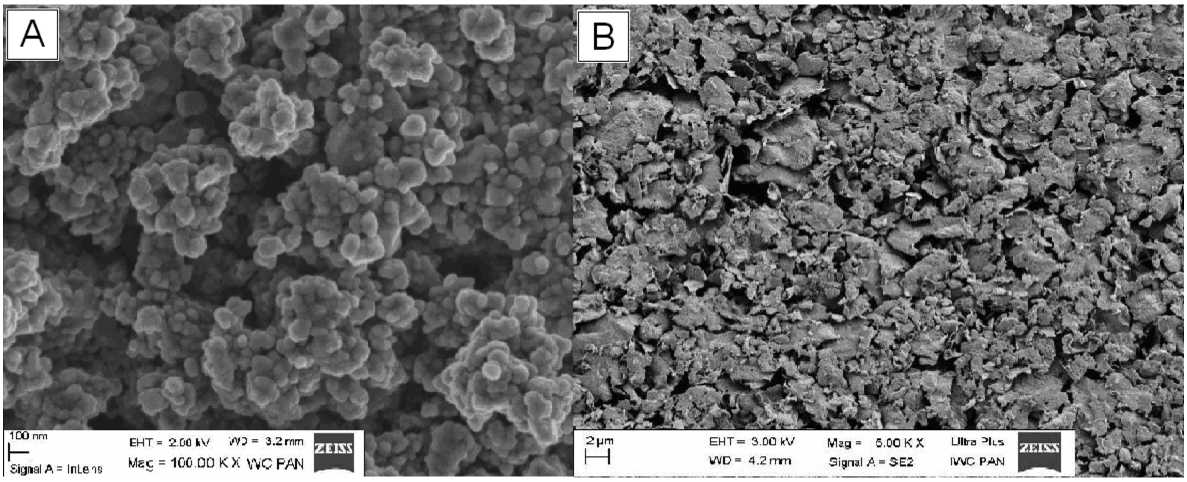

Figure 5 – a) Silver nanoparticles in size 50-60nm, b) Silver flake in size 2-4 µm.

Thermal interface materials	**Thermal conductivity [W/mK]**	**Shear strength test * [N]**
92% Silver fillers (60% silver nanoparticles \ 40% silver flake) + 8% Epoxy resin	52±9	26,7
90% Silver fillers (60% silver nanoparticles \ 40% silver flake) + 10% Epoxy resin	37±9	94

* *Gold surfaces*

Table 1 - Results of thermal conductivity and shear strength test

for exemplary NanoTIM formulations

Amepox Microelectronics in cooperation with the Technical University of Wroclaw prepared prototype sub-demonstrators based on NanoTIM formulations Fig. 6 and Fig. 7.

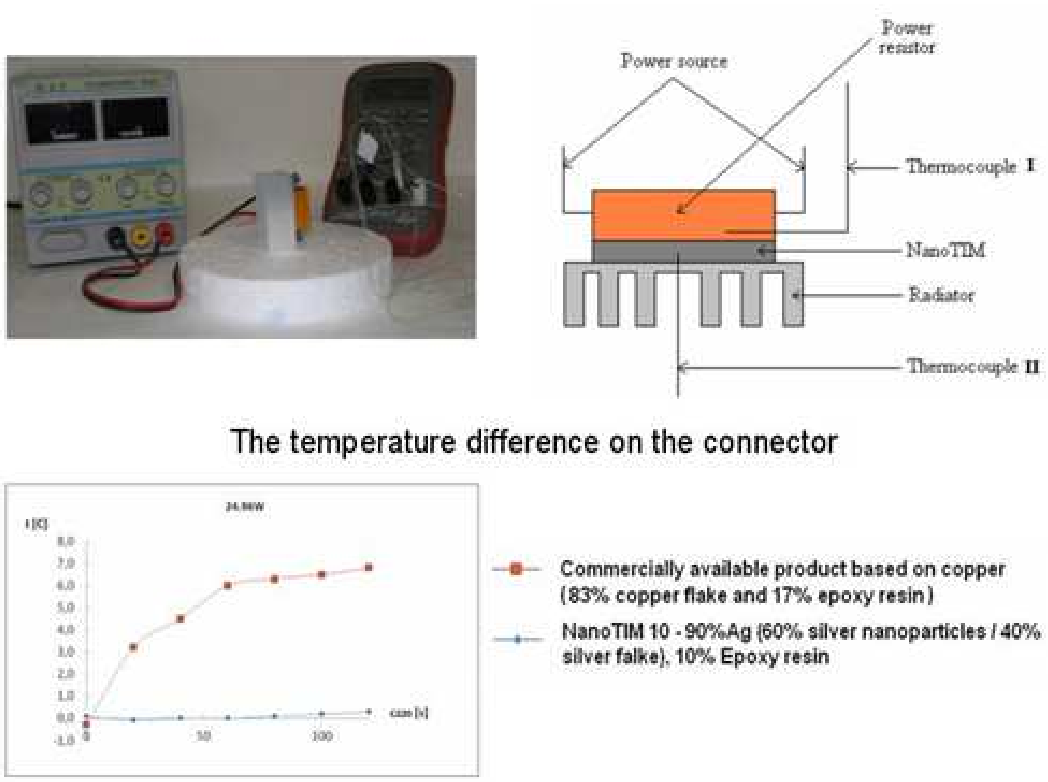

Figure 6 - The prototype sub-demonstrator based on NanoTIM 10 prepared by Amepox Microelectronics

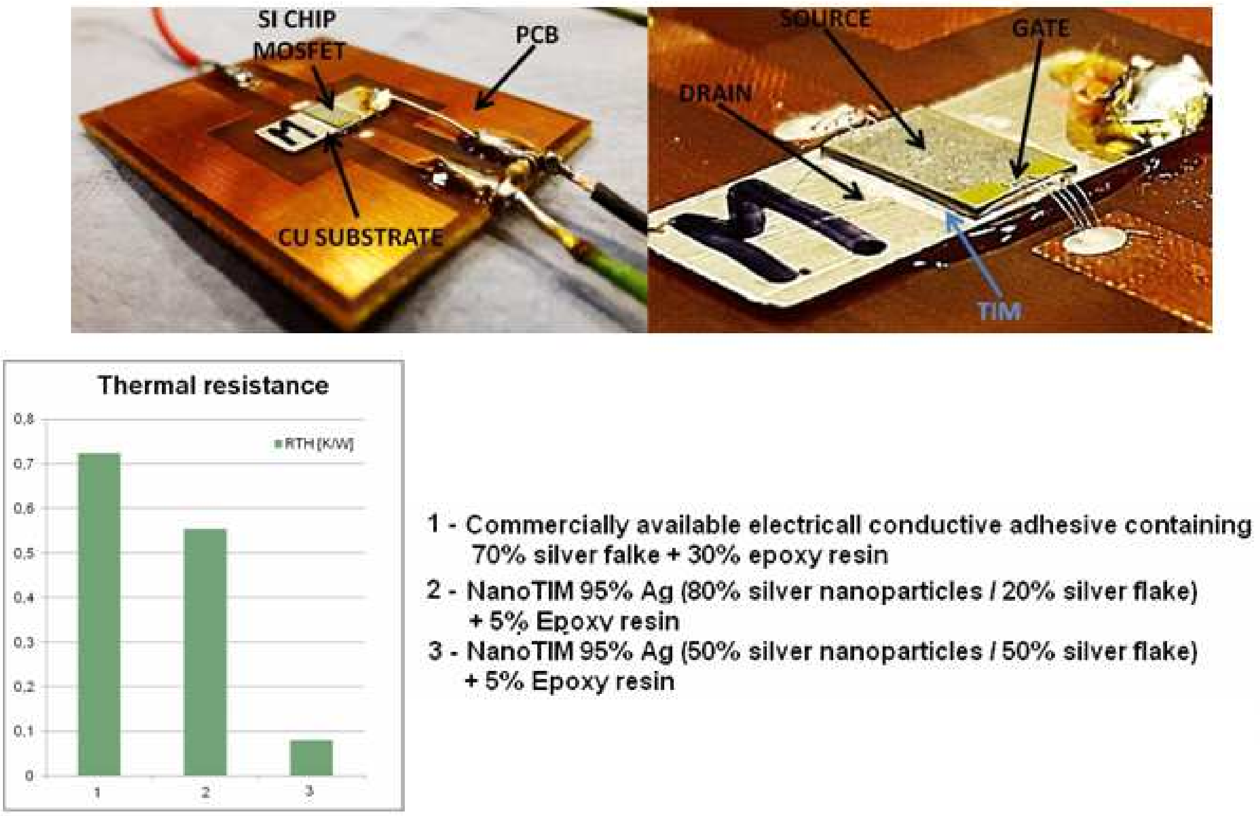

Figure 7 - The prototype sub-demonstrator prepared by Technical University of Wroclaw

Special prize at Therminic conferences 2015

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Further information at www.project-nanotherm.com