HEATPACK H2020 Project

WP2

Deliverable D2.1

First active cooler available

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CHANGE RECORDS

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1.0	01/04/2020	Creation. 1st issue	A. Hoogerwerf
2.0	06/07/2021	Corrections implemented with respect to the expert's comments as part of the second year Review: several additions to chapter 2 with more details on the manufacturing process of the active cooler.	A. Hoogerwerf

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1. INTRODUCTION

This document is a deliverable issued in the frame of the H2020 project **HEATPACK** (new generation of **H**igh th**E**rm**A**l efficiency componen**T**s **PACK**ages for space, Research & Innovation action, Work programme SPACE-10-TEC-2018-2020, Grant Agreement number 821963).

It is issued in the frame of Work Package n°2 – Innovative thermal management features development.

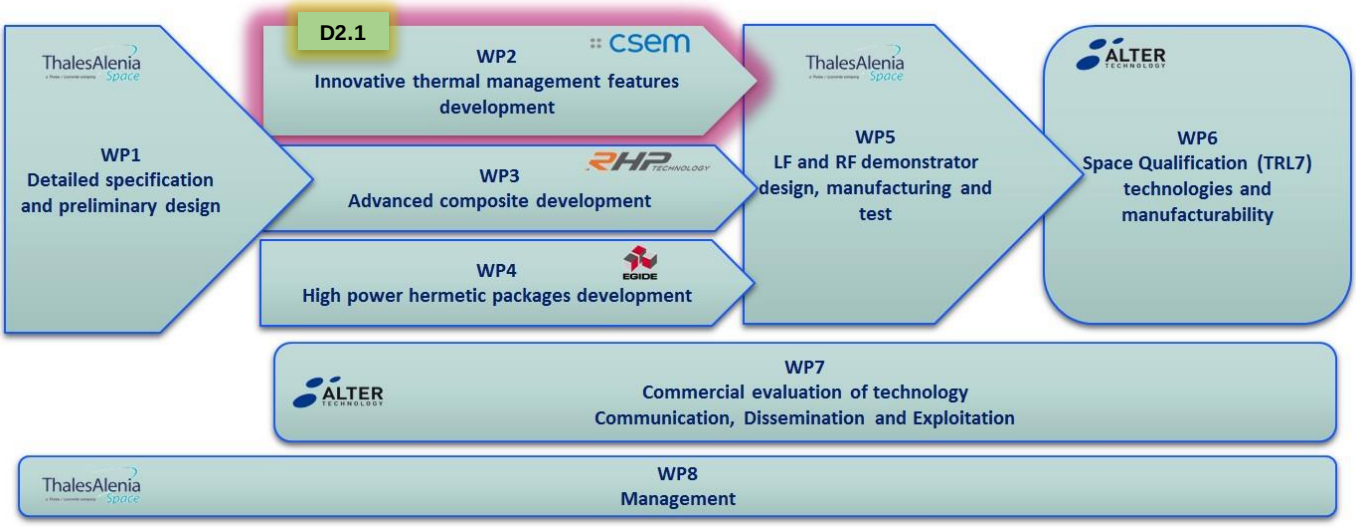

Figure 1: identification of the present document within the project's work breakdown structure

The purpose of this report is to document the availability of the first coolers, developed within WP2.

2. COOLER FABRICATION

2.1 Cooler structure fabrication

The cooler is fabricated as a silicon-glass sandwich, whose schematic cross-section is depicted in Figure 2. The fabrication starts with a photolithography defining the channels on one side of the silicon wafer. The photoresist pattern is transferred into the silicon by Deep Reactive Ion Etching (DRIE). A photolithography step is carried out on the other side of the wafer to define the filling holes and a DRIE step is carried out to etch the filling holes until they meet the channel on the other side of the wafer. The structured silicon wafer is cleaned and bonded to an blank glass wafer using anodic bonding. The fabricated wafer assembly is shown in Figure 3. The anodic bonding creates a hermetic seal between the glass and the silicon. The wafer stack is then metallized on the silicon side with a solderable metal (gold) and diced into individual coolers.

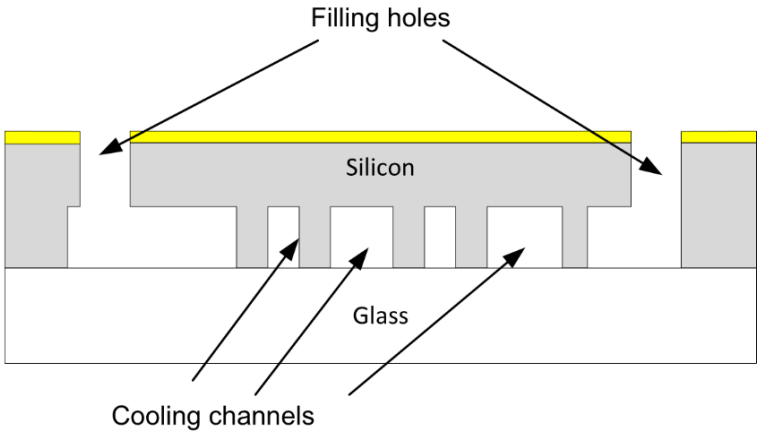

Figure 2: schematic cross-section of the active cooler structure

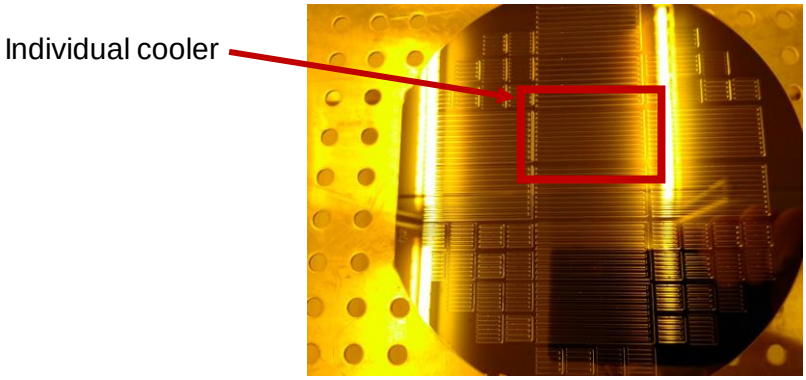

Figure 3: picture of the glass silicon wafer assembly

An individual cooler is shown in Figure 4 from the glass side. The serpentine pattern of the cooler channel is well visible. The location of the filling holes is also indicated on this picture. The filling holes traverse the silicon wafer and can be used to fill the cooler with a fluid.

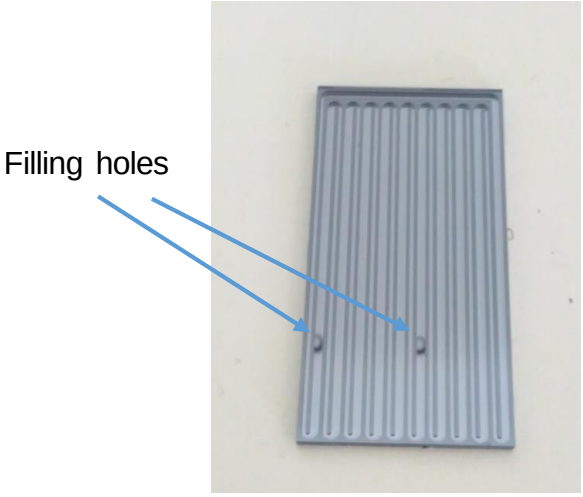

Figure 4: picture of an active cooler

2.2 Cooler filling

The cooler is subsequently filled with a liquid using a special filling rig, depicted in Figure 5. The filling rig consists of an aluminum part and a PMMA cover. The outline of the cooler is recessed into the aluminum block to align the cooler to holes drilled in the block. These holes connect to fluidic ports in the side of the block. The small round parts in Figure 5 are O-rings to seal the holes in the aluminum block to the filling holes in the cooler. There are three O-rings and holes in the aluminum block, since not all filling holes are located in the same place. Only two out of three holes in the aluminum are used at the same time.

In order to fill the cooler, the screws in the cover are unscrewed and the cover is removed. The active cooler, oriented as in Figure 4, is placed in the recess in the aluminum base. The cover is placed on top of the cooler and the screws are fastened. This presses the cooler against the O-rings, thus assuring the leaks tightness of the fluidic connection. The filling holes in the cooler are now connected to the fluidic connectors. A syringe is attached to one fluidic connector and the cooling liquid is pushed into the cooler, while the excess air is removed through the other filling hole. Once sufficient liquid has been pushed into the cooler, the syringe is exchanged for an air-filled one and the liquid is pressed further into the cooler until it is halfway between the two filling holes. A detail of a cooler filled in this way is shown in Figure 6. The wick between the air and the liquid is clearly visible.

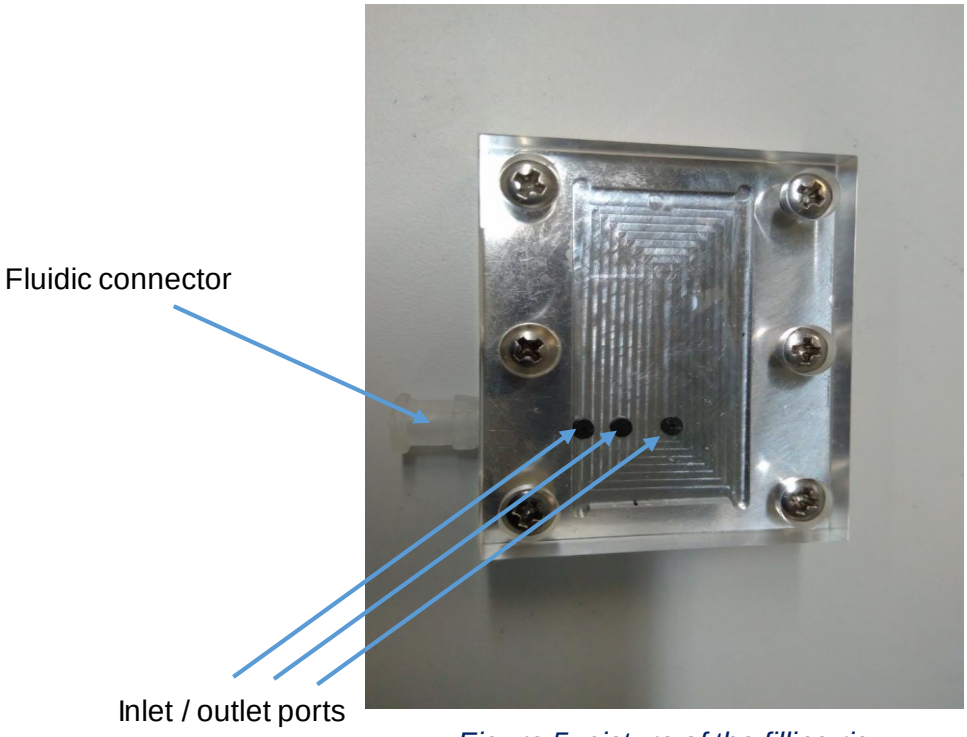

Figure 5: picture of the filling rig

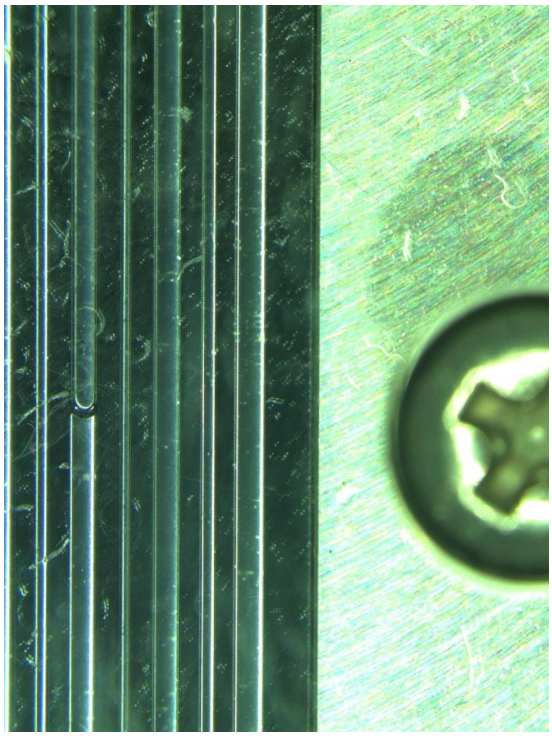

Figure 6: close-up picture of a filled cooler

2.3 Cooler closing

The cooler is closed by soldering a heater chip to the filled cooler, as schematically depicted in Figure 7. The filled cooler chip is placed in a closing holder and a sheet of solder (In52-Sn48, melting temperature 118°C) is placed over the filling holes of the cooler chip. A heater chip is placed on the solder sheet and is connected with pogo pins. The assembly is pumped to a vacuum and a current is flown through the heater chip. The heater chip heats up, melts the solder, and is permanently soldered to the cooler when the current is cut and the chip cools down.

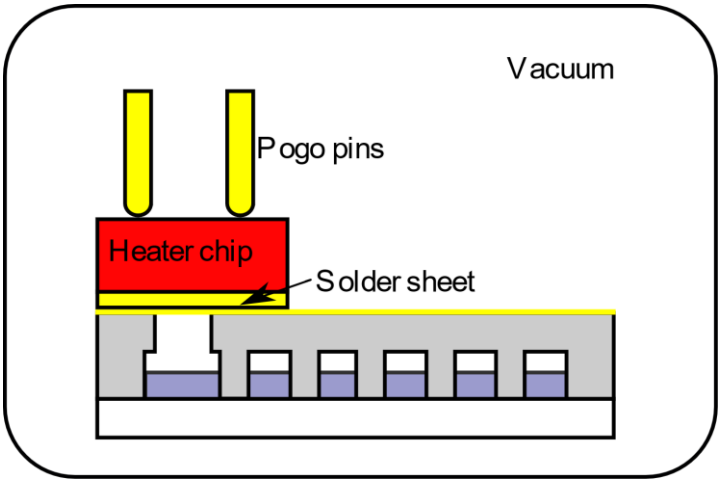

Figure 7: schematic representation of the closing of the cooler chip

An X-ray image of the solder joint thus formed is shown in Figure 8. It shows the part of the cooler chip where the heater chip covers the filling holes. The picture is taken from the side of the heater chip. The central part of the image shows the molten and re-solidified solder sheet through the heater chip. The solder appears to be very uniformly distributed, apart from some accumulation near the top of the picture. The cooler with its channels is vaguely visible through the solder sheet and more clearly in the left hand side of the picture, where the solder and heater chips are not present.

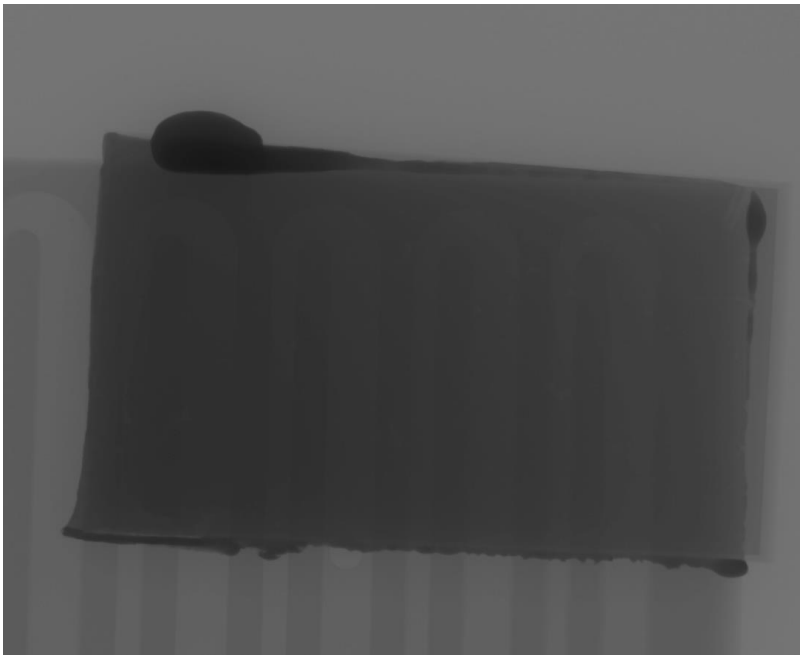

Figure 8: X-ray image of the solder joint used for closing the cooler

A video of a cooler operation has already been made but has not been included in this document.

3. CONCLUSION

The present document demonstrates and illustrates the availability of the first active cooler demonstrator.

END OF DOCUMENT