TITLE: **Thermal test of Eccosorb disk with copper slab and pyramids manufactured by Off. Pasquali**

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Prepared by	**F. CUTTAIA** **A. DE ROSA** **L. TERENZI** **IASF – Bo**	**Date:** **Signature:**	**April, 2012** _____
Agreed by	**L. VALENZIANO** **IASF – Bo**	**Date:** **Signature:**	**April, 2012** _____
Approved by	**N. MANDOLESI** **IASF – Bo**	**Date:** **Signature:**	**April, 2012** _____

DISTRIBUTION LIST

Recipient	**Company / Institute**	
R. LAPINI	OFF. PASQUALI	r.lapini@officinepasquali.it
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CHANGE RECORD

Issue	Date	Sheet	Description of Change
0.1	July, 2004	All	Draft issue of this document
1.0	April, 2012	All	Final issue of the document

TABLE OF CONTENTS

1 SCOPE

1.1 Purpose

Purpose of this test is to verify the thermo-mechanical performances of the copper thin slabs bonded on the Eccosorb disk at operating temperature (approximately 4K). This activity is made under contract by Officine Pasquali.
Purpose of this report is to describe the test setup and test results.

1.2 Document Overview

An Eccosorb disk, 18 cm diameter and 1 cm thick, is casted to some copper slabs, 0.25 mm thick, of different shapes and dimensions and is tested in the IASF 4K cryofacility.
Four thermal cycles have been performed to check the thermal and structural behaviour of the sample, with particular attention to the heat transfer between Eccosorb and cooler cold flange through the copper slabs. The cryo facility is opened and visual inspections of the samples are performed after the first and the fourth cycle.
In this document, we report the test instrumentation, the mounting design and the sample preparation in Section 3 and 4.
In Section 5, details about all the cycles, together with temperature curves and pictures taken during the visual inspections, are reported.
Finally, in Section 6, main conclusions are drawn.

1.3 TERMS and ACRONYMS

CF: Cryo Facility
SUT: Sample under test

2 APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable documents

AD 1: ECCOSORB pyramid panels fixation study: thermal cycle test procedures, IASF-BO-IR-04/002, Ver 1.0

2.2 Reference documents

RD 1: Lakeshore DT670 data sheet
RD 2: *The 4KRL cryo facility*, PL-LFI-TES-TN-010

3 Test setup

Test is performed in the IASF-Bo 4K cryo facility, fully described in RD 2. Parts are manufactured by Officine Pasquali and delivered to IASF on July, 1st, 2004.

3.1 Temperature sensor characteristics

The temperature sensors used are LakeShore DT670 silicon diode and CX-1050 cernox RTDs; the accuracy of uncalibrated diodes is ±0.25K at 4 K, while for calibrated diodes and cernox is 20 mK and 5 mK respectively at temperatures lower than 10 K, as reported in RD 1.
Sensors are read by means of a LakeShore temperature controller model 340, which, at 4 K, reads out temperature with a sensitivity of 0.4 mK for silicon diodes and 0.1 mK for Cernox resistances.

4 Sample preparation

The sample consists of an Eccosorb CR110 disk, 10 mm thick, with a diameter of 180 mm. The Eccosorb was casted upon a number of copper, 99.9% purity, thin slabes, 0.25 mm thick. Thermal straps, soldered to slabs, between the copper slabs and the facility cold flange allow the optimal heat transfer for the cooldown and warm up stages. The slabs were designed with little extruded holes (3 mm diameter), in order to optimize the grip between slab and Eccosorb and to minimize the contact surface stressed by differential contraction of the two materials.

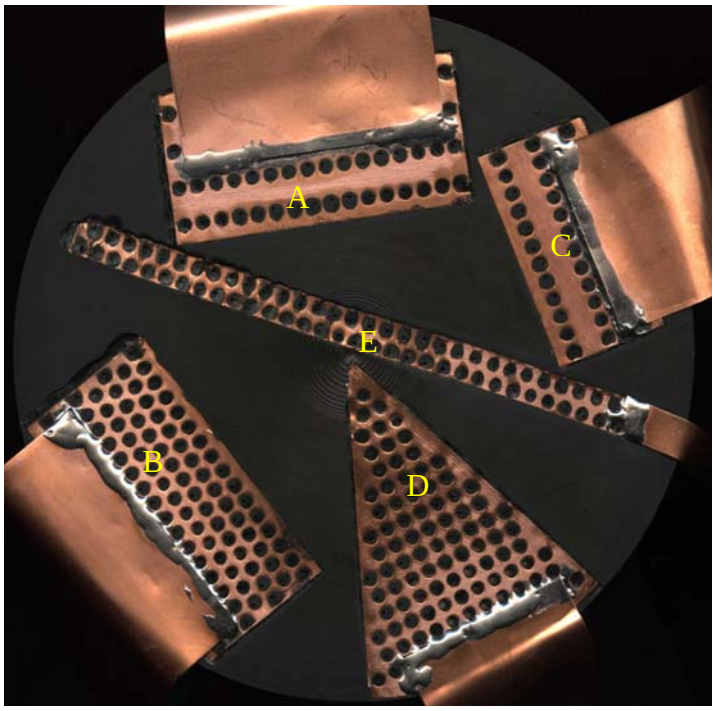

Fig. 1 A scanned image of the disk surface were copper slabs are located.

There are five slabs (see Fig. 1):

A. A rectangular flange (40 mm X 80 mm) with four longitudinal rows of holes
B. A rectangular flange (40 mm X 80 mm) with seven longitudinal rows of holes
C. A rectangular flange (30 mm X 60 mm) with three longitudinal rows of holes
D. A circular section (45º aperture angle from center)
E. A long strip (120 mm X 10 mm) with two longitudinal rows of holes

In the opposite disk face a panel with pyramid was glued, in order to check the system thermalization time and homogenity (Fig. 2).

Fig. 2 Global view of the sample. The pyramid panel is visible together with copper thermal straps.

4.1 Preliminary inspection of the parts

The sample wase inspected before mounting it in the cryofacility.
No crack is observed, no flaking is observed. Some pyramids are damaged since this is a test panel. The actual status of the panel has no influence on this kind of test. One temperature sensor is mounted at the tip of one pyramid with manufactured nominal quality.

4.2 Sample mounting

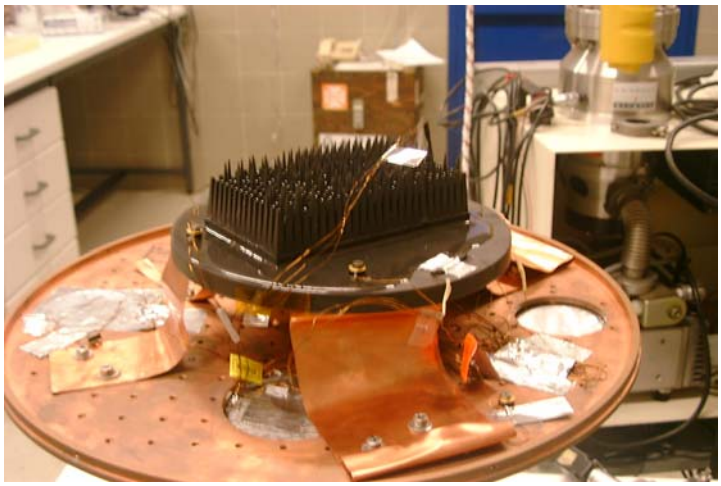

Fig. 3 Sample mounted in the cryofacility. Rigid thermal straps are screwed to the cold flange, providing also a mechanical support to the sample.

Sample parts are cleaned with alcohol. Thermal straps were screwed to the facility cold flange providing both thermal contact and mechanical support (see Fig. 3). Temperature sensors were mounted on copper and also in the opposite side of the disk, as reported in Table 1.

Sensor ID	Type	Fixation	Location
A	DT670 SD (cal)	Kapton tape	Pyramid tip
B	Cernox CX 1050 (cal)	Screw	Opp. to panel A
C1	DT670 CU	Screw	Opp. to panel B
C2	DT670 SD	Kapton tape	Panel C
C3	DT670 SD	Kapton tape	Opp. to panel A
C4	DT670 CU	Screw	Opp. to CR110 space
D1	DT 670 CU	Al tape	Panel D
D2	DT670 CU	Al tape	Panel E
D3	DT670 CU	Al tape	Panel B
D4	DT670 CU	Screw	Opp. to panel C

Table 1 Sensor location for the first cycle.

5 Thermal cycles

5.1 Cycle 1

The test started on July, 2nd, 2004 at 12:44. The CF was evacuated using a dry rotative pump. When a pressure of 1.1E-1 mbar was reached, the cooler was started at 9:40. Acquisition of temperature sensors was started at 9:40 on July, 3rd. Acquisition period was set to 60s. The pump was stopped when the pressure reached 2.2E-2 mbar. Cool-down data are reported in Fig. 4 and Fig. 5.

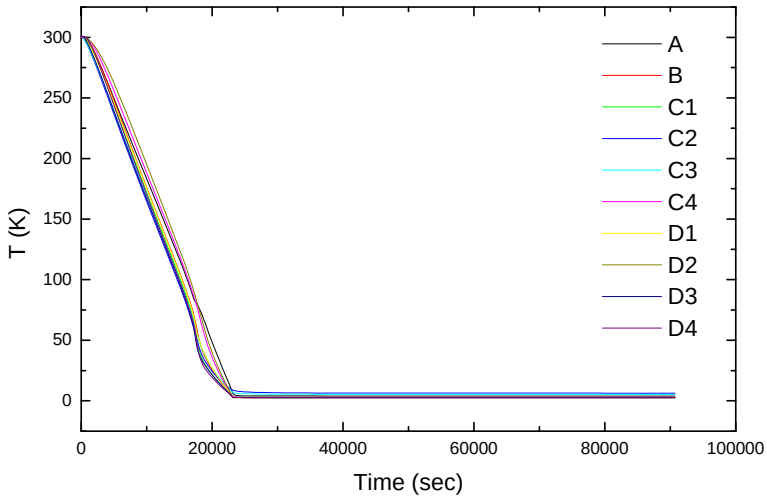

Fig. 4 Cooldown curves for the first cycle

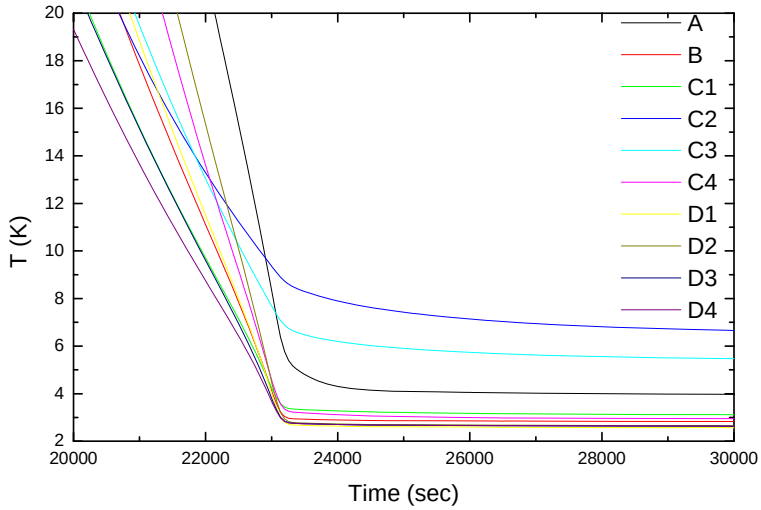

Fig. 5 Detailed view of low temperature thermalization during the first cycle. As evident, sensors C2 and C3 have an unexpected temperature higher than the pyramid one.

On July 4th, 2004, the cryocooler was turned off at 10:55. Warm-up procedure was started. Additional heating (9 W) was introduced using resistors mounted on the cold flange. Once the temperature of 295K was reached by the reference sensor (A), the CF was filled with dry air and opened.
Temperature sensors C2 and C3 which showed an unexpected behaviour at low temperature (see Fig. 5) were found slightly detached from the sample, due to kapton film low adherence. All other sensors were still in place and appeared in good physical contact with the sample. Sensor location was re-checked.

5.2 Inspection 1

Pictures were taken and no damage, crack or detachment was found

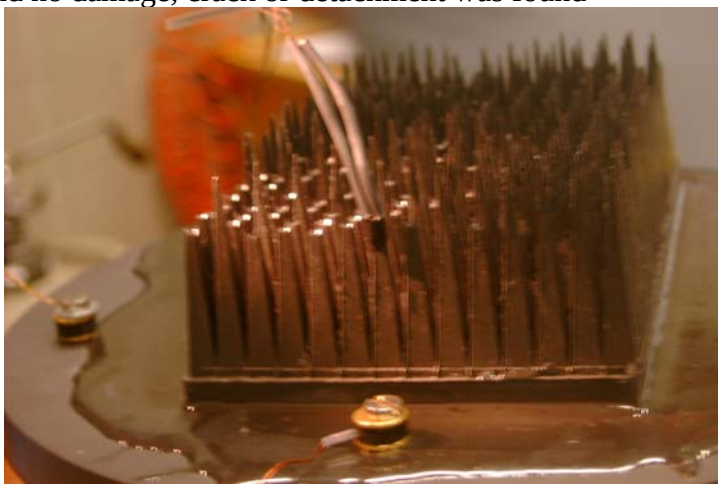

Fig. 6 Particular view of the sensors mounted on the pyramid face of the disk. Sensor fixed to the pyramid is visible.

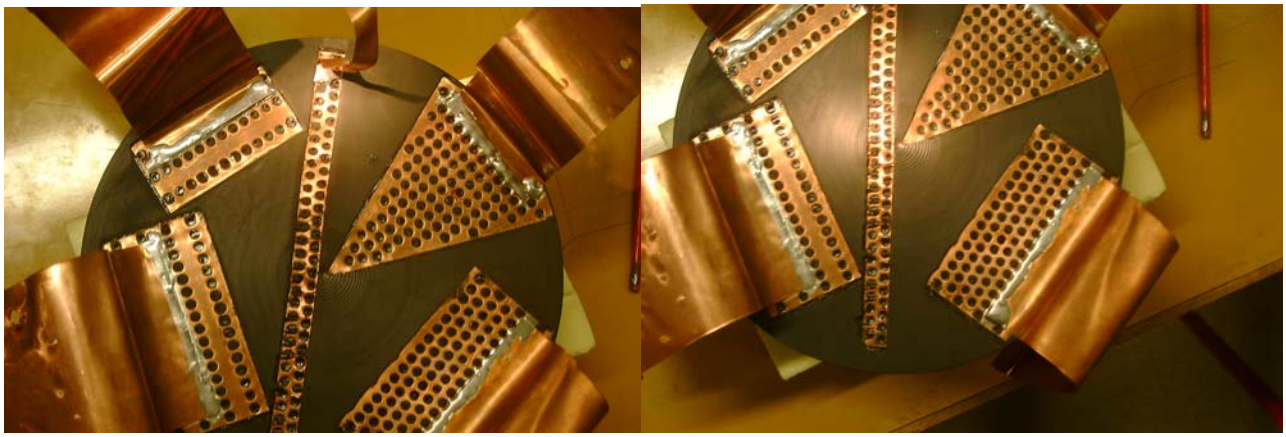

Fig. 7 Photo of the copper slabs face of the disk after the first cycle. No evidence of detachments was found

5.3 Cycles 2-4

5.3.1 Sample preparation

All parts in their contact surfaces were cleaned with ethylic alcohol.
The sample was re-mounted in the CF. Temperature sensors were mounted as reported in Table 2.

Sensor ID	Type	Fixation	Location
A	DT670 SD (cal)	Kapton tape	Pyramid tip
B	Cernox CX 1050 (cal)	Al tape	Opp. to panel D
C1	DT670 CU	Screw	Panel E
C2	DT670 SD	Apiezon N in the hole	Opp. to Panel C
C3	DT670 SD	Apiezon N in the hole	Opp. to CR110 space
C4	DT670 CU	Screw	Cold flange
D1	DT670 CU	Al tape	Panel D
D2	DT670 CU	Al tape	Panel E
D3	DT670 CU	Al tape	Panel B
D4	DT670 CU	Screw	Opp. to panel A

Table 2 Sensor location for the second series of cycles.

This time SD packaged sensors, C2 and C3, were mounted in the screw holes filled with Apiezon N grease.

5.3.2 Thermal cycle 2-4

In the following figures cooldown curves for the second, the third and the fourth cycles are reported. As evident, in the Fig. 10, the sensor C2 measured an infinite voltage soon after the beginning of the fourth test.

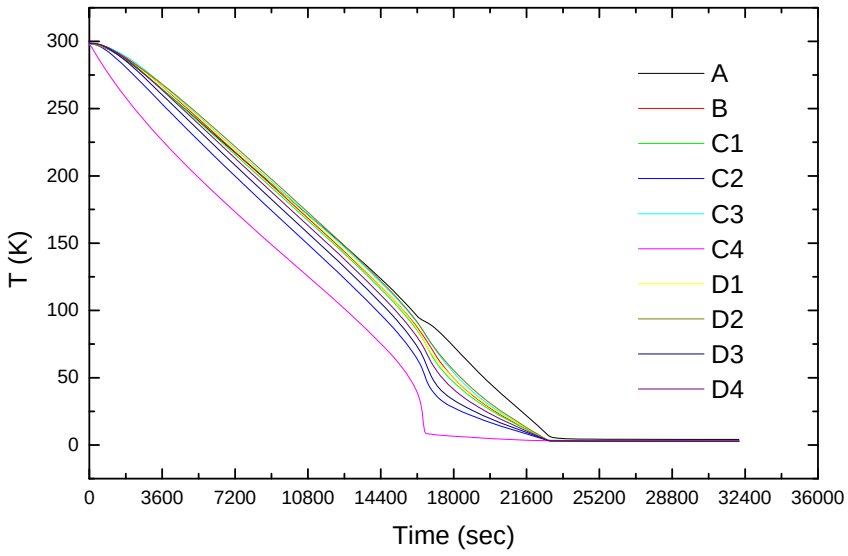

Fig. 8 Cooldown curves for cycle 2.

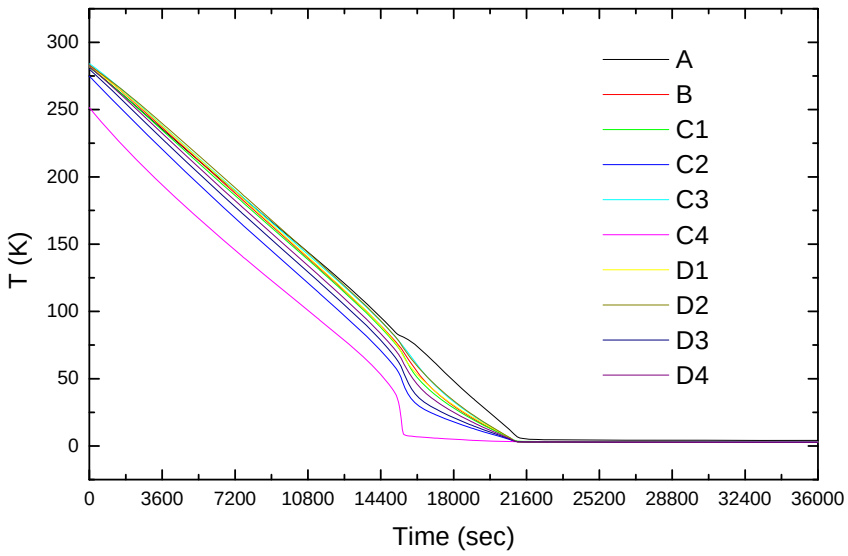

Fig. 9 Cooldown curves for cycle 3.

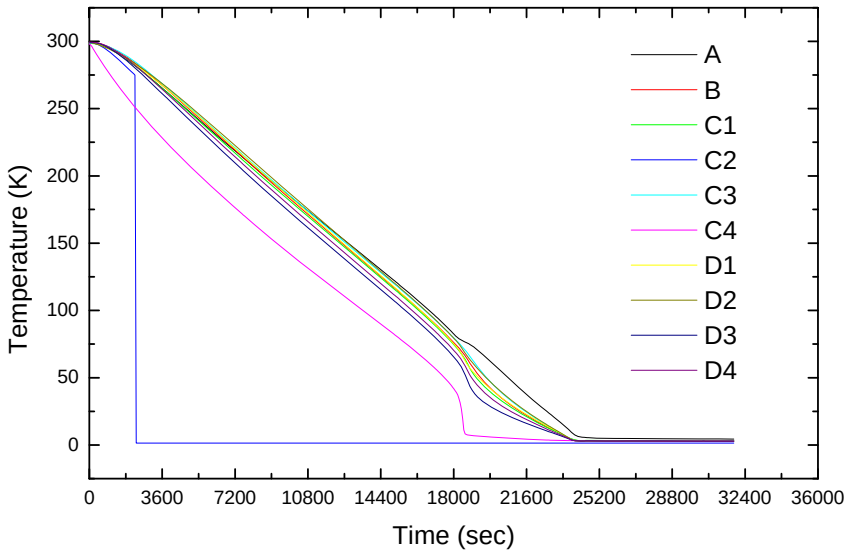

Fig. 10 Cooldown curves for cycle 4. Sensor labelled as C2 had a failure after half an hour from the beginning of cooldown.

5.4 Inspection 2

After the fourth warm up the CF was air filled and opened. The sensor C2 was in the same location and contact as before the beginning of the cycles but it had a wire unsoldered; that is why we lost informations from it during last cycle. All the other sensors were in good thermal contact with the parts.
The sample did not present any problem, crack or detachment.

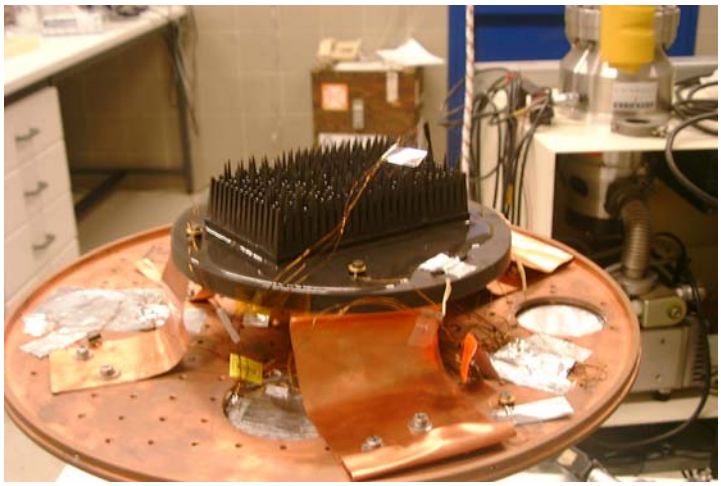

Fig. 11 Global view of the sample after the CF was opened for the second inspection.

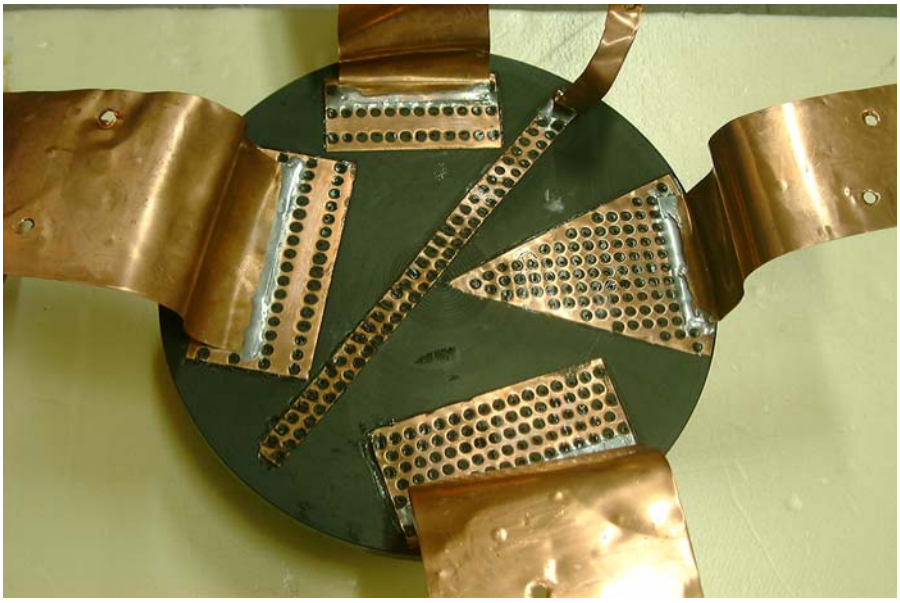

Fig. 12 Global view of the slab side after the fourth cycle

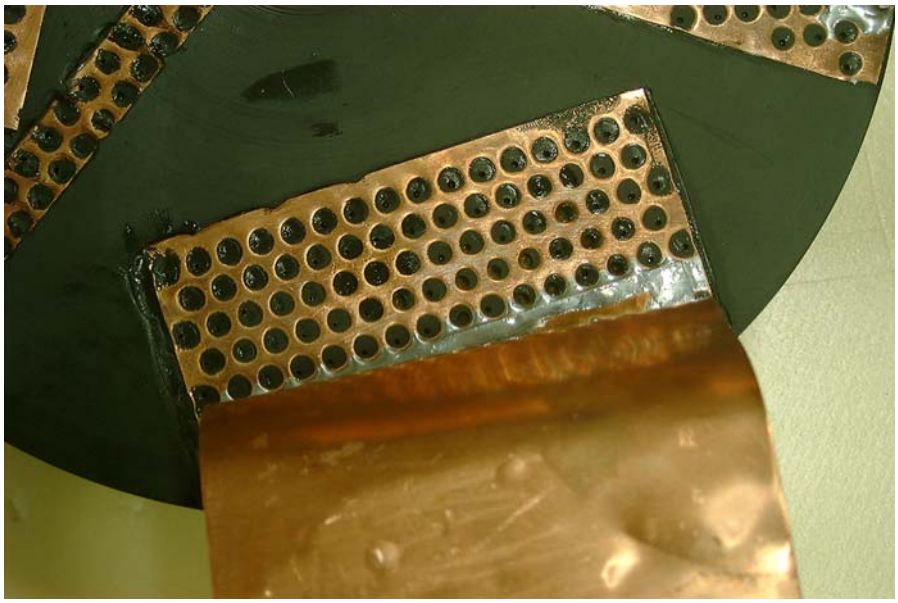

Fig. 13 Detailed view of the panel B after the fourth cycle

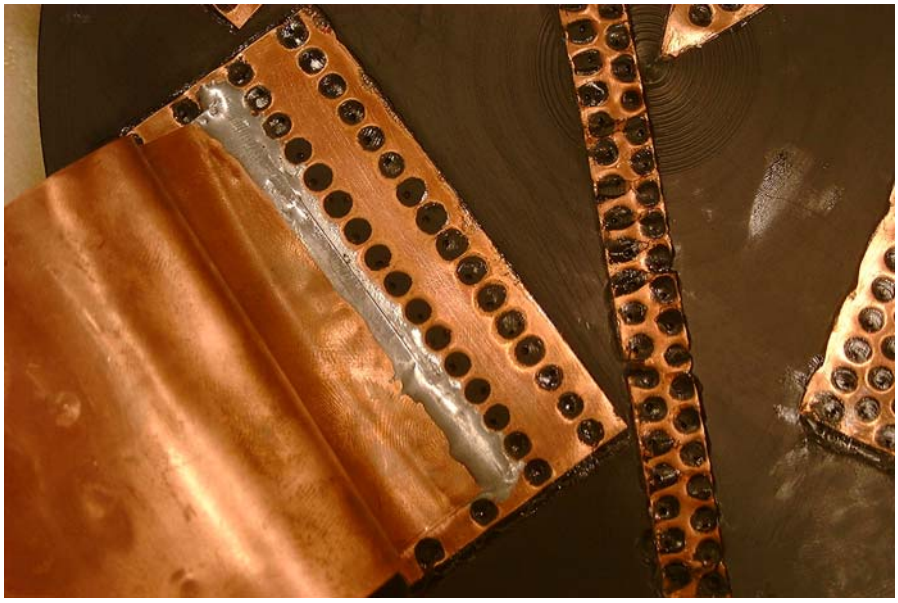

Fig. 14 Detailed view of the panel A after the fourth cycle

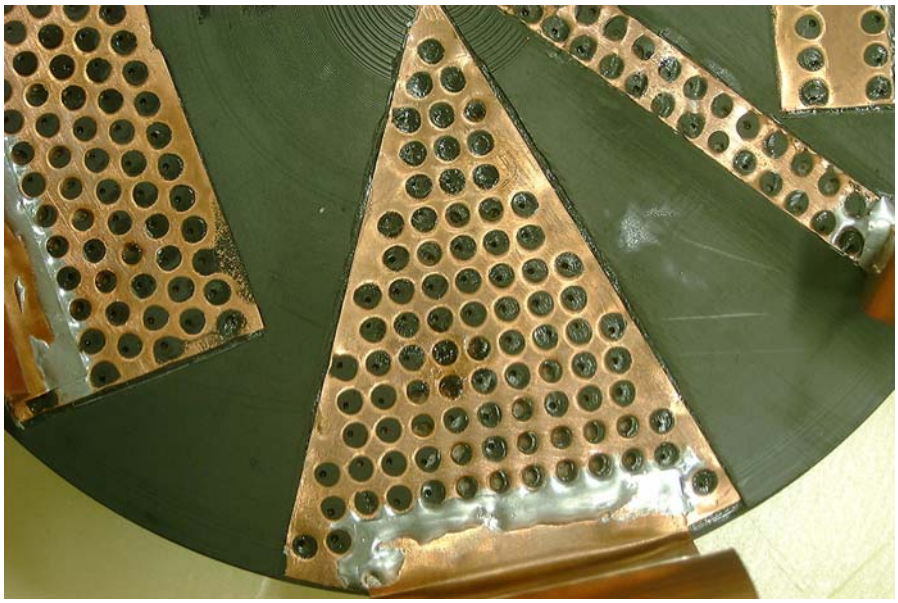

Fig. 15 Detailed view of the panel D after the fourth cycle

6 Conclusions

The sample tested did not show any problem after the first four cycles. Cooldown time (7-8 hours) and temperature homogeneity (about 0.5 K consistent with sensor accuracy), together with the absence of structural problems at low temperature, are very interesting results.
Actually, the configuration with copper thin slab on the surface of the Eccosorb seems to be a good solution to be implemented in the Planck LFI RCA facility sky load.