SPARC-RF-09/002
April 30, 2009

Status report on SALAF technical activity during the first half of 2009

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As known the activity of the SALAF Group is presently dedicated to the construction of 3 cells structures working at 11.4 GHz.
The fields under investigation are presently the following :
-high temperature brazing (800-1000)°C
-low temperature brazing (250-300)°C
- electroforming

The construction is essentially based on two different processes: BRAZING and ELECTROFORMING as well as the combination of them and essentially there are three types of material under investigation:
COPPER OFHC , ZYRCONIUM COPPER and MOLYBDENUM.

A contact between cells of a vacuum tight quality is important in case of electroforming because the galvanic bath cannot absolutely enter the structure (the very low roughness of the inner surface could be damaged).

High temperature brazing
High temperature brazing can be used in principle in any case , with the exception of the alloy ZYRCONIUM COPPER that cannot sustain a temperature over 300°C. Generally in our activity the brazing alloy Cusil and Palcusil are adopted .Palcusil for STAINLESS-STEEL and MOLYBDENUM. ; Cusil for COPPER and its alloys. Fig. 1 shows high temperature brazed 3 cells Cu structure with the vacuum system. Dimensional tests on each sizes have shown to be within ± 1.5 µm with a roughness of about 0.08 µm achieved by using a poly-crystal tool (or mono-crystal tool depending on the used material) for turning machine with no chemical etching. Moreover high power tests made at SLAC last September 2008 , gave excellent results, too.

If necessary the alloy Ag/Cu 72/28 can be used in any case if STAINLESS-STEEL and MOLYBDENUM are covered with a thin layer of Copper or Nickel; this procedure is obtained by using a galvanoplastic or sputtering procedure; an high temperature vacuum treatment is done in order to fix these metals (fig 2).
Normally for Copper galvanoplastic we use an acid bath made with copper sulphate (about 150 g/l) plus sulphuric acid (about 30g/l) with a little bit (<0.1 g/l) of Cervione glue , a glue of proteic nature manufactured from animal bones soluble in water and with excellent adhesiveness properties.

The galvanoplastic parameters, assuming a theoretical value for efficiency equal to one , in order to deposit 31.8 grams of copper we need at least 26,8 A/h .
Knowing the density of copper the value for current and the deposition time , we can estimate the thickness of the deposited Copper .

Low temperature brazing

Low temperature brazing can be adopted when the metal used for the RF structures can not sustain high temperature . The alloy Sn/Ag 95/5 (melting point 230°C) is under investigation.
Preliminary tests on COPPER have given good results.
As a next step , the realization of an Cu-Zr three cells section , applying the soft brazing method (low temperature brazing) has been scheduled .
The use of this alloy on special metals as Stainless-steel and Molybdenum will be tested following the above procedure , that is with a plating of copper or nickel before the vacuum brazing .

Electroforming

The electroforming procedure is presently use for the encapsulation of the RF structures , as already described in the last report.
In detail the whole procedure would consist in :
-machining the single cells, the end parts and the flanges
-assembling and strengthening together al the components
-covering the structure with a Cu thick electrolytic layer
A couple of bolts with a proper torque are used to maintain fixed all the components .They are eliminated after the electroforming procedure.

One of the points under investigation for the above procedure is the contact among cells before electroforming.
This contact must be very good not only for the RF field but also because when the structure is put into the galvanoplastic bath , this one has not to penetrate inside the cells .

Fortunately the low roughness obtained (at least for Cu) gives a vacuum tight contact , as it has been seen from some preliminary tests on Cu component machined at very low roughness.
The surfaces in contact are vacuum tight with a leak of about $10^{-10}\,\frac{mbar*l}{\sec}$ when a pressure of some N/mm^2 is applied. This structure will be sent to the company GALVAIR for depositing the copper by electroforming process.

In addition, we also are studying the possibility of depositing tin by galvanoplastic or the alloy Sn/Ag 95/5 by sputtering procedure on contact points of cells in order to decrease the roughness at joints to reduce or eliminate RF energy power losses due to electric field discharge. Some tests have been done on Copper (figs 3-4).

For the sputtering procedure a dedicated system has been realized and optimised in order to deposit thin materials layer , like gold , copper , nickel , titanium molybdenum , Sn/Ag 95/5 and so on.

A three cells , Cu OFHC structure has been delivered to us by the company specialized in the high precision machining (Ra <0.1μm).

It has be tightened at a proper torque ; vacuum and RF tested and finally encapsulated by means of an electroforming , ready for the RF power tests.
Fig 5 shows the encapsulation(or electroforming) procedure, proposed at LNF for a three cells , Cu OFHC structure, following the described previous approach (copper galvanoplastic bath) .
The preliminary results , before RF power tests , seem good , in the sense that vacuum test is positive (fig 6) , a leak rate of about $5*10^{-10}\ \frac{mbar*l}{\sec}$ has been measured.
We are studying and testing this procedure(low Ra machining plus electroforming) because it absolutely avoids any thermal stress on the material, that can preserve the roughness and the quality of the machining surfaces .
Obviously the goal is to apply this procedure to metals or alloy different from Cu , for example to the molybdenum and to the alloys Cu/Zr and W/Cu.

As a first conclusion, If we want to get a successful in higher power tests of clamped joint or electroformed) structures, we need to work on this. Since we think that copper oxides could generate breakdowns in clamped joint, we are studying the possibilities of depositing gold or rhodium in the clamped joint region, too.

Figure captions:

Fig 1 Brazed 3 cells Cu structure with the vacuum system.

Fig 2 Copper electrolitically deposited on the molybdenum cell with the Cusil alloy after thermal treatment

Fig 3 The Ag/Sn alloy deposited on copper object by sputtering technique.

Fig 4 Electrolitically deposited Sn on copper object **.**

Fig 5 The encapsulation procedure for a three cells , Cu OFHC structure.

Fig 6 : A 3 cell Cu OFHC structure, encapsulated by galvanoplastic procedure under vacuum leak test.

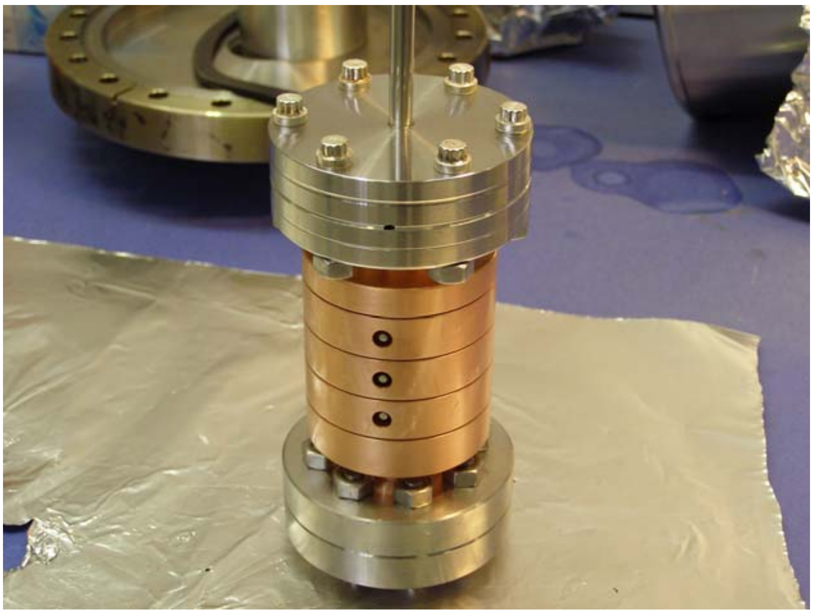

Fig 1: Brazed 3 cells Cu structure with the vacuum system.

Fig 2 : Copper electrolitically deposited on the molybdenum cell with the Cusil alloy after thermal treatment .

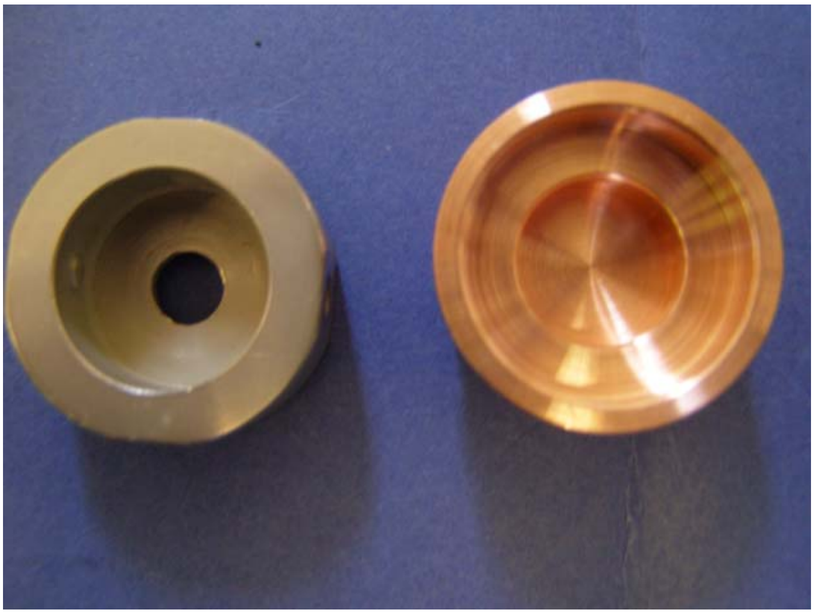

Fig 3 : The Ag/Sn alloy deposited on copper object by sputtering technique.

Fig 4 : Electrolitically deposited Sn on copper object

Fig 5 The encapsulation procedure for a three cells , Cu OFHC structure.

Fig 6 : A 3 cell Cu OFHC structure, encapsulated by galvanoplastic procedure under vacuum leak test.