Laboratório Nacional de Luz Síncrotron

Glidcop Brazing in Sirius' Front-End High Heat Load Components

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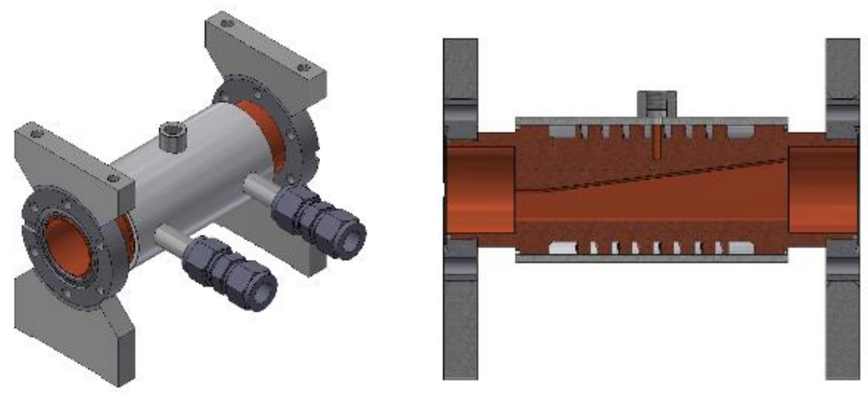
ABSTRACT

Currently under construction, Sirius is a 3 GeV, fourth generation synchrotron light source. Sirius is designed to have up to 37 beamlines with ultra-low emittance and high brightness, which will allow high-level research and development on a large range of areas as structural biology, materials science and nanoscience. Given its high quality, its components rely on fine requirements on size, safety and cooling capability, having their design on the state of the art. Taking Front-End power absorbers as example: the refrigeration of these components is complex due to their reduced size allied to the high thermal load that is irradiated on them. To solve this problem, engineered materials must be used. The Glidcop is a good choice due to its good thermal conductivity and preservation of mechanical properties after heating cycles. The difficulty of this project lies on the fact that dissimilar metal components (*i.e.* Glidcop and Stainless Steel) must be attached and it is needed to isolate both the vacuum and the water chambers. Thus, the joint must be resistant to hold the pressure in the water chamber and must be tight to not allow the transport of small atmosphere molecules to the vacuum chamber. As a trial to manufacture these components, given its specific features, the brazing was chosen as a joining process.

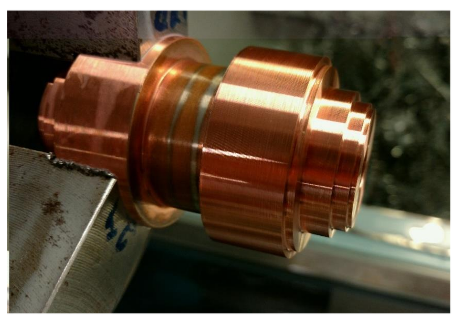
Sirius' construction status in August, 29th.

THE COMPONENTS

The photon shutter component (shown on isometric view at the left and on half section view on the right) is one of the power absorbers which will be built by this brazing process. Apart from this one, the fixed mask and the high-power slits will also be manufactured by this chain.



MATERIALS AND METHODS



Glidcop Component Machining
- It's done in order to reach the final shape and mechanical precision.

Glidcop Electroplating
- After cleaning and etching, nickel and copper coatings are electroplated on the component.

Stainless Steel Parts Machining
- It is done to give the shape to those parts, according to the desired mechanical adjusts.

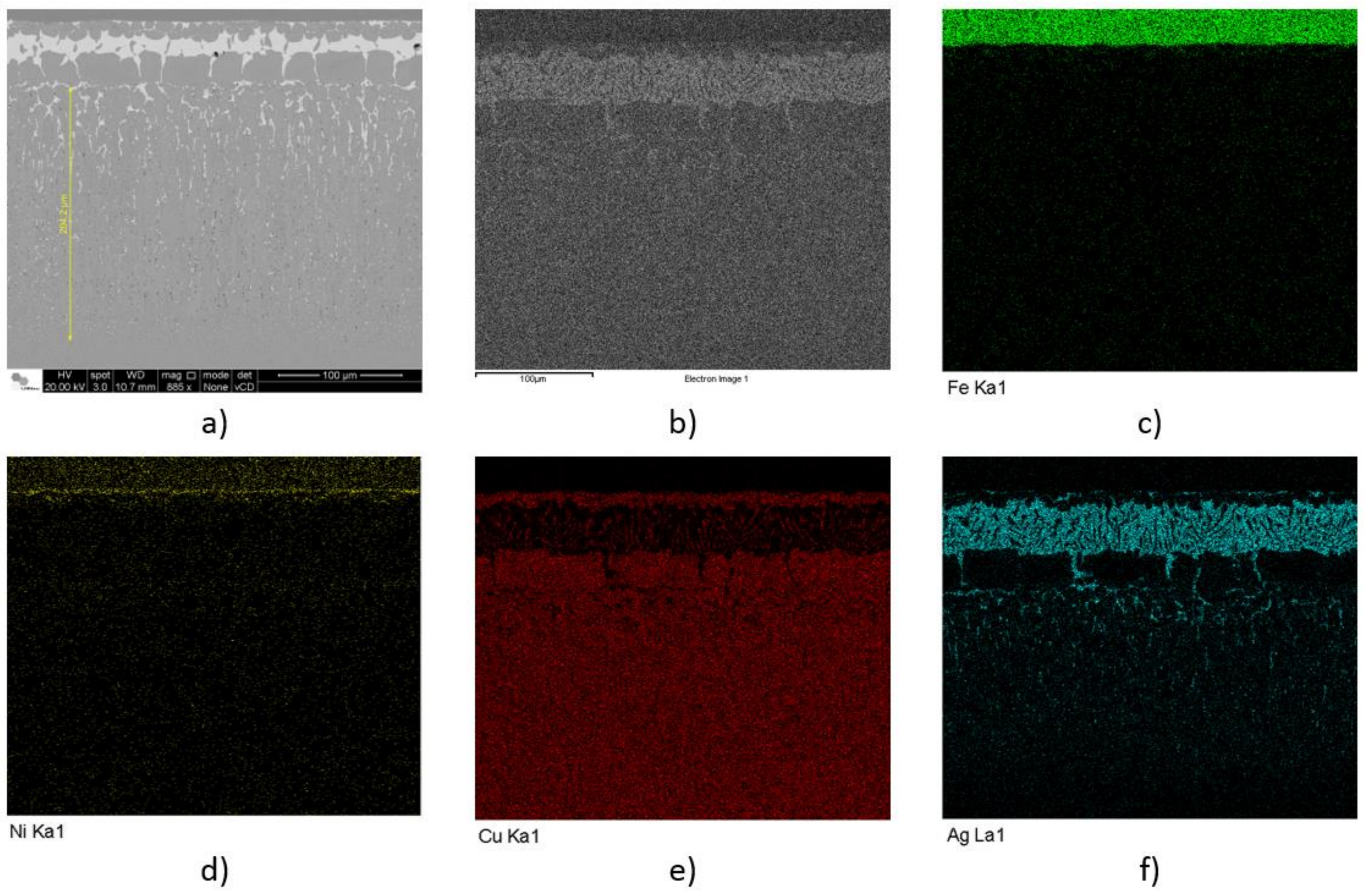
Stainless Steel Electroplating
- After cleaning and etching, a nickel coating are electroplated on the component.

Cleaning, Etching and Assembly
- Electroplated parts are submitted to a standard cleaning procedure.
- The filler is cut and the whole set is assembled in its final configuration.

Brazing
- In a vacuum furnace, the brazing is done in a temperature above the eutetic temperature with a soaking time of 4 minutes.

RESULTS ANALYSIS

Microstructure and EDS Analysis of the Brazing Regions



Microstructure analysis of a brazed specimen. On frame a) it is shown a brazing section containing silver diffusion on the Glidcop Matrix. On frames b) to f) it is presented a EDS (Energy-dispersive X-ray spectroscopy) analysis (the brazing section is illustrated on b), and elemental analysis are shown on c) to f)). Both regions of analysis are longitudinal cuts of the specimen.

- Frame a) presents that the coatings wet efficiently both surfaces (*i.e.* there are no empty spaces between a coating and the base material and the filler alloy is well bonded to the coatings over the whole surfaces, filling the whole gap.
- Frame b) shows a brazing section on which the EDS analysis was done. The stainless steel is on the upper side and the Glidcop on the lower. There is a brazing region between them.
- Frame c) shows the elemental analysis for the iron (Fe). It is present only on the stainless steel.
- Frame d) presents the elemental analysis for the nickel (Ni). It is present on the stainless steel 304L alloy in small quantities and more concentrated on its coating. The nickel coating on the Glidcop suffered diffusion to the base metal matrix during the brazing process.
- Frame e) shows copper (Cu) concentrations, on which are high: on the Glidcop (base material and coating) and on the filler metal.
- Frame f) shows distribution of the silver (Ag) contained on the filler alloy. Also, it is possible to notice some diffusion of silver on the glidcop matrix.
- It can be notice two distinct phases on the filler metal region: the first rich in copper, containing silver in solid solution; and the second one rich in silver, containing copper in solid solution.

Brazing: Process and Results Description

- The filler metal could fill the whole gap between the surfaces, distributing itself homogenously in it;
- The coatings covered the whole parts' surfaces, accompanying its irregularities;
- There was no noticeable difference of applicability between different brazing sections
- In spite of the gap orientation, the capillary action was effective on guaranteeing that the filler metal would occupy the whole empty volume on the mating zone;
- Leak Tests:
    - All the brazing regions were approved with no leak detected up to $10^{-10}\ mbar.l/s$, full scale and minimum leak rate of the equipment
- Hydrostatic Pressure Tests
    - Operational water pressure = 8 bar
    - Test 1 = 12 bar for 24 hours
    - Test 2 = 34 bar for 5 minutes
    - It supported the test without any problems

Brazing Process Description

Stage	Heating Rate [°C/min]	Temperature [°C]	Time [min]
SP1.1	4	25 - 675	-
SP1.2	-	675	15
SP2.1	3	675 - 740	-
SP2.2	-	740	5
SP3.1	1	740 - 795	-
SP3.2	-	795	4

CONCLUSIONS

The objective of the current study was to obtain a brazing process that could be integrated to the manufacture chain of the Sirius' power absorbers. Also, the joint needed to bond dissimilar metals and result on a leak-tight and mechanical-resistant structure. It is possible to conclude after microscopy analysis, leak tests and hydrostatic pressure tests that the developed process (based on nickel and copper coating and the Cusil filler alloy) attends the requisites imposed for its application. The Glidcop and stainless steel components presented satisfactory performance on the tests.

REFERENCES

[1] Yadav, D., Kaul, R., Sankar, P., Kak, A., Ganesh, P., Shiroman, R., Singh, R., Singh, A., Tiwari, P., Abhinandan, L., Kukreja, L. and Shukla, S. (2012). A study on brazing of Glidcop ® to OFE Cu for application in Photon Absorbers of Indus-2. *J. Phys.: Conf. Ser.*, 390, p.012019.

[2] Bagnato, O. R. ; FRANCISCO, F. R. ; Gabos, C. B. ; Pardine, C. . Brasagem Metal/Metal E Metal/Cerâmica Para Fabricação dos Guias de Onda e Monitores de Potência do Linac do Anel no Laboratório Nacional de Luz Síncrotron - LNLS. In: XXVII Congresso Brasileiro de Aplicações de Vácuo na Industria e Na Ciência, 2006, Itatiba. XXVII Congresso Brasileiro de Aplicações de Vácuo na Industria e Na Ciência, 2006. v. 1.