

TESLA HF COUPLERS: OUTGASSING OF COPPER PLATED AISI 304L SAMPLES

G. ARNAUD, G. DI BARTOLO, A. ROBEIRI, M. ROCH.

Laboratoire de l'Accélérateur Linéaire,
IN2P3-CNRS et Université de Paris-Sud, BP 34, F-91898 Orsay Cedex, France

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INTRODUCTION

In TESLA HF power couplers there are some parts which are copper plated stainless steel made.

Copper layer role is to allow HF current flow towards the accelerating structures, while minimizing the thermal flux between room temperature and LHe temperature parts.

In order to minimize outgassing in UHV regions, copper coated parts undergo a 24h baking at 400°C. While experience shows that after such a thermal treatment residual gases spectra and surfaces outgassing rates coming from bare stainless steel are acceptable, copper coating deposition procedure could have introduced unacceptable polluting elements.

In order to assess the compatibility of copper coating procedure with couplers UHV requirements, residual gas spectra and surfaces outgassing rates have been measured on copper plated stainless steel samples.

I. TEST BENCH: (See fig.1)

The test bench is composed of a test chamber where samples are placed, followed by:

- Vacuum gauge head E (A1)
- Measurement orifice C1 ($\Phi = 5$ mm; Conductance = 2.13l/s N₂)
- Vacuum gauge head S (B1)
- Residual gas analyzer
- Pumping orifice C2 ($\Phi = 16$ mm; Conductance = 23.2l/s N₂)
- Turbomolecular pump

Overall internal surface: around 9000 cm²

Test chamber internal surface: around 5000 cm²

Material: Stainless steel

- Pump

- Turbomolecular Pump: ALCATEL type 5150 n°93099
- Pumping speed: 140 l/s for N₂.

- Vacuum gauges

- Inverted Magnetron type: Pfeiffer Balzers IKR60.

- Residual gas analyzer.

- Pfeiffer Prisma quadrupole mass spectrometer (0-200 amu)

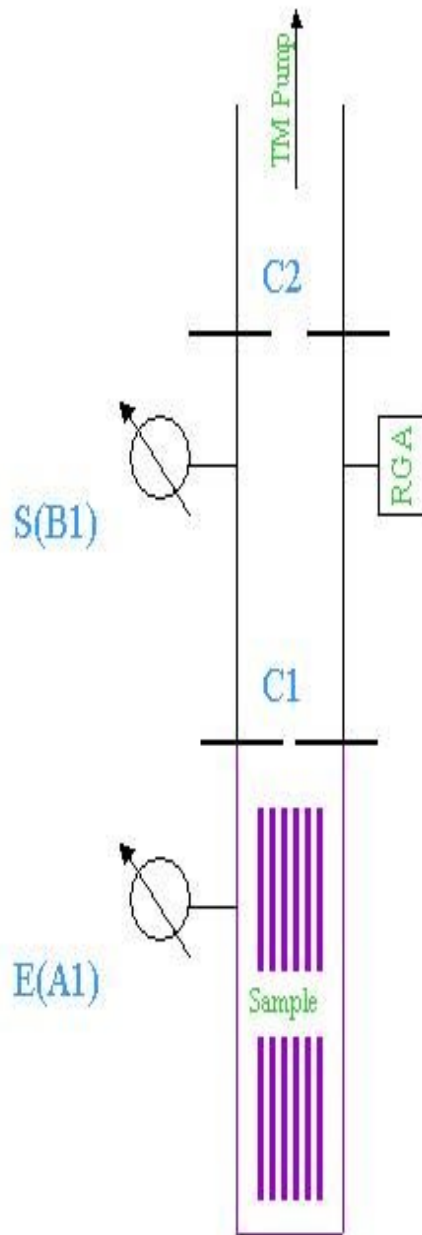


Fig.1: Test bench sketch.

II. SAMPLE DESCRIPTION (See fig.2a, fig2b)

Samples are composed of two stacks of 27 plates. Each plate (350x70x1 mm) is made of copper plated rolled 304L SS. Nominal copper thickness is 5 μm for one stack plates and 15 μm for the other ones.

Overall surface is 27000 cm^2 .

Plates are spaced by 1 mm thick washers. Bolts, nuts and washers used for stacks assembly are SS made and underwent a 24h 400°C baking prior to use.

Copper plating was performed following the procedure described in appendix 1. In order to minimize the release of polluting elements from copper layers in UHV regions, no shining and wetting agents were used. The detailed procedure description allows reproducing the process for coupler parts thus virtually getting the same final quality.

Copper layer adherence tests were performed on two plates (5 micron and a 15 micron).

They consisted in:

- Baking at 400°C.
- Ultrasonic bath, with distilled, previously outgassed water, at room temperature and 95°C.
- Electron scanning microscope observation of plate cross-sections (lms Lab, Ecole Polytechnique).

No adherence problem was observed.

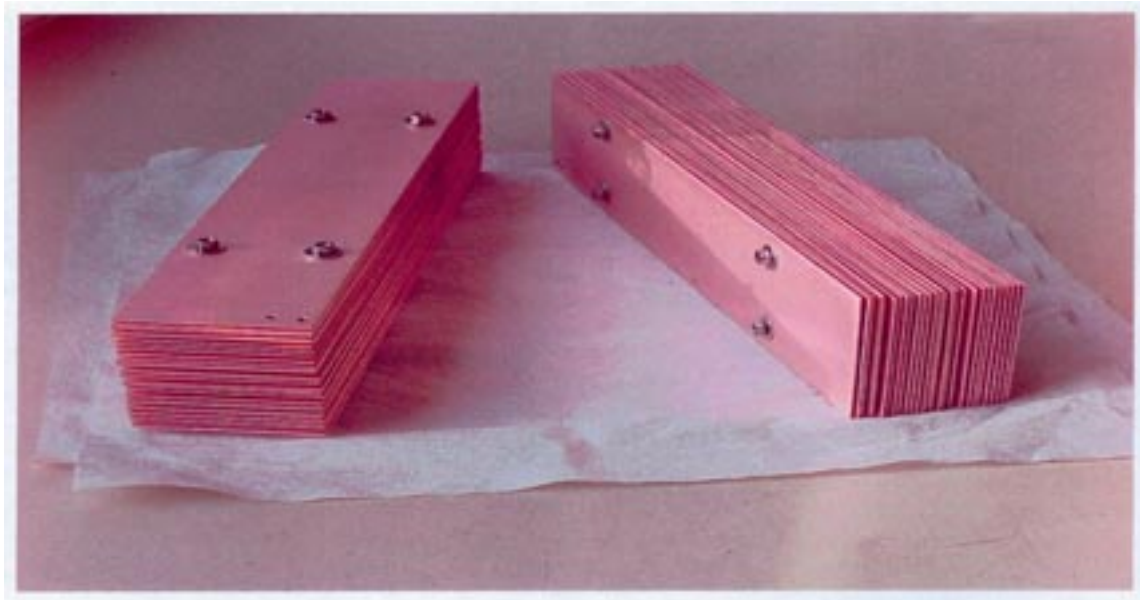


Fig.2a: samples stacks

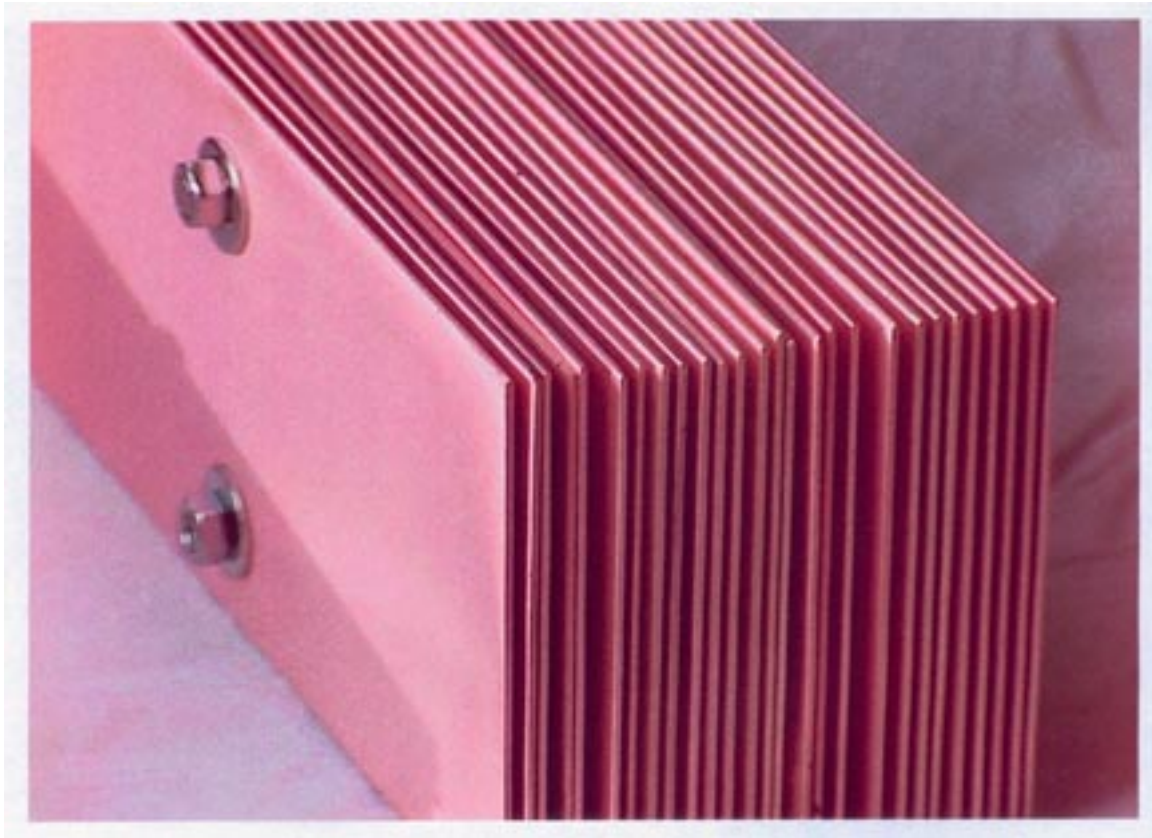


Fig.2b: samples stacks

III. TEST OPERATING PROCEDURE

- Phase 1:
 - Pumping and baking of test bench volumes with no sample in place.
 - Once the system pressure is stable enough, a reference outgassing rate value and residual gas composition spectrum are obtained.
 - (For details, see Table 1)
- Phase 2:
 - After sample introduction in the test chamber, baking and pressure stabilization, an outgassing rate value and a residual gas composition spectrum are obtained, to be compared to the reference ones.
 - (For details, see Table 1)

IV. TESTS RESULTS

-Residual Gas Spectra:

- The qualitative comparison between the residual gas composition in the empty test chamber (phase 1, fig.3) and in the test chamber with samples (phase 2, fig.4)

show that no new peak appears after samples introduction. Therefore, copper layers fabrication procedure does not originate any significant pollution.

- Hydrogen peak is largely dominant and the other peaks are typical of a UHV region gas composition.

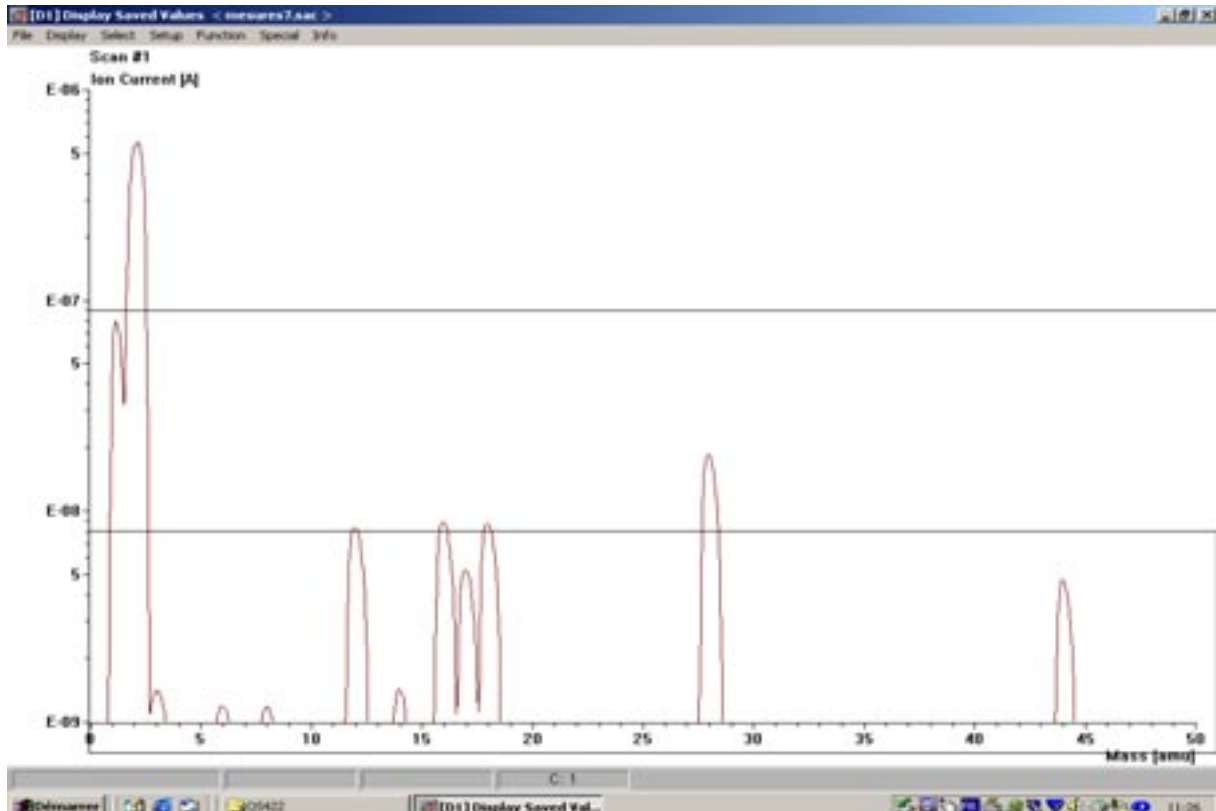
- Outgassing throughput and rate:

Input data and measurements	PHASE 1 Empty Test chamber (30/10/01)	PHASE 2 Test chamber + Samples (28/11/01)
Surface	5000 cm ²	32000 cm ²
Baking time and Temperature	27 h @T>300°C	25 h @T>370°C
A1 Pressure	9,1.10 ⁻¹⁰ mbar	6,6.10 ⁻¹⁰ mbar
B1 Pressure	6.10 ⁻¹⁰ mbar	5,1.10 ⁻¹⁰ mbar
Outgassing throughput N ₂ equivalent	6,6.10 ⁻¹⁰ mbar.l.s ⁻¹	3,2.10 ⁻¹⁰ mbar.l.s ⁻¹
Outgassing rate N ₂ equivalent	1,3.10 ⁻¹³ mb.l.s ⁻¹ .cm ⁻²	1,2.10 ⁻¹⁴ mb.l.s ⁻¹ .cm ⁻²

Table 1

NB: Pressure measurements have been made with RGA filament off.

It must be noticed that outgassing rate in phase 1 is higher than in phase 2. This is due to an effective baking of samples and to further baking of test chamber during phase 2 measurements.



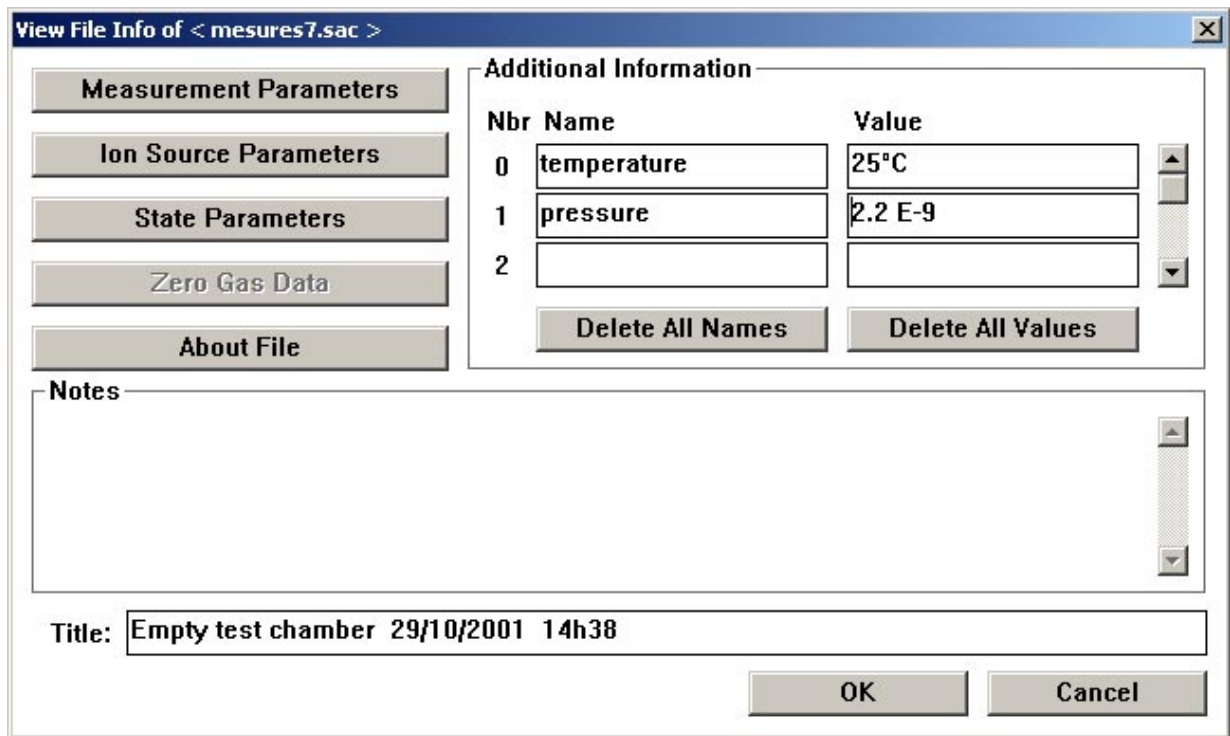
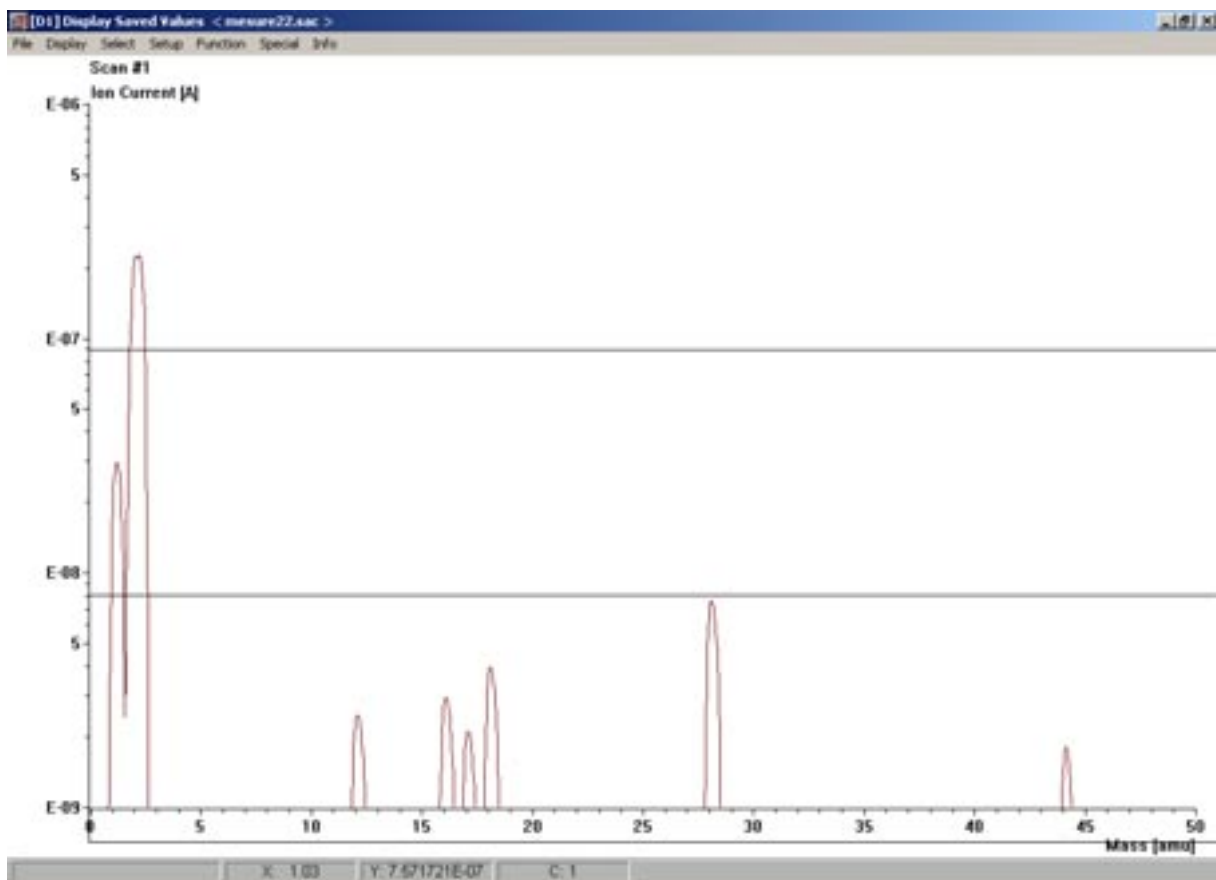


Fig.3: Residual gas spectrum (phase 1)



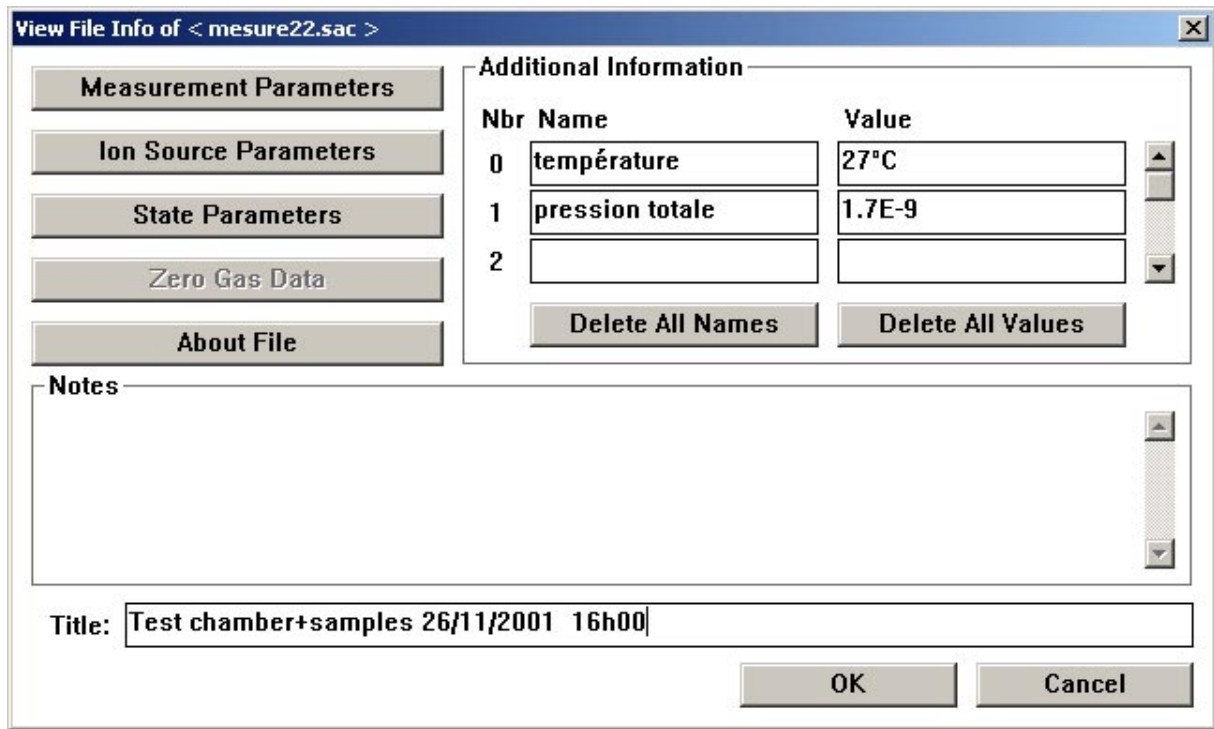


Fig.4: Residual gas spectrum (phase 2)

CONCLUSION

Dominant hydrogen percentage as well as the presence of some other gas traces (H₂O, CO, CO₂...) is typical of a UHV region gas composition. Therefore, copper layers fabrication procedure, as described in appendix 1, originates no significant pollution.

The order of magnitude of samples outgassing rate is 10^{-14} mbar.l.s⁻¹.cm⁻².

Gas composition and outgassing rates are compatible with UHV working conditions, as required for TTF-Tesla couplers operation.

APPENDIX 1

GALION SA

6, avenue des Frères Lumière
92188 ANTONY
Tél. : 01.46.66.81.87
Fax : 01.46.66.16.00

CUIVRAGE/INOX

- Dégraissage solvants chlorés : 38 à 45°C « chlorure de méthylène »
- Masquage sur plan
- Dégraissage lessive HENKEL NOVOCLEAN 909 ultrasons
 - 45 à 55°C
 - durée 3 minutes
 - composition : NOVOCLEAN 909 20g/l
- Rinçage eau déminéralisée courante
- Conditionnement des oxydes
 - composition : $\text{KMnO}_4 + \text{NaOH}$
 - durée 30 mn.
 - Température : 80 à 100°C
- Rinçage mort
- Rinçage eau déminéralisée courante
- HCl 50% en volume 1 à 2 mn
- Rinçage en eau demi-courante
- Nickel Wood
 - Composition:
 - o NiCl_2 220 à 280 g/l
 - o HCl 35% 75 à 95 cm^3/l
 - o température : ambiante
 - o d.d.c 5 à 10 A/dm^2
 - o durée 5 à 6 mn
- Rinçage eau déminéralisée courante
- Cuivrage-mat
- Composition
 - o CuCN 50 g/l
 - o KCN libre 12 à 25 g/l
 - o K_2CO_3 0 à 110 g/l
 - o Eau déminéralisée $\rho > 10^5 \Omega$
 - o Sel de Rachille 45 g/l
 - o Température : 30 à 40°C
 - o D.d.c 1 A/dm^2
 - o Durée suivant épaisseur. Vitesse dépôt $\approx 0,2 \mu\text{m}/\text{mn}$
- Contrôle épaisseur
- Rinçage eau déminéralisée - démasquage
- Rinçage eau chaude 60 à 65°C 1 à 2 mn
- Séchage air sec
- Contrôle aspect masquage épaisseur
- Emballage

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APPENDIX 2

UNOFFICIAL TRANSLATION

GALION SA

6, avenue des Frères Lumière
92188 ANTONY
Tél. : 01.46.66.81.87
Fax : 01.46.66.16.00

COPPER PLATING OF STAINLESS STEEL

- Grease cleaning with chlorated solvents: 38 to 45°C « METHYLENE CHLORIDE »
- Masking
- Ultrasonic grease cleaning with detergent HENKEL NOVOCLEAN 909
 - 45 to 55°C
 - time: 3 minutes
 - composition: NOVOCLEAN 909 20g/l
- Demineralized running water rinsing
- Oxides conditioning
 - composition: $\text{KMnO}_4 + \text{NaOH}$
 - time: 30 mn.
 - Temperature: 80 to 100°C
- Still water rinsing
- Demineralized running water rinsing
- HCl 50% in volume 1 to 2 mn
- Half-running water rinsing
- Nickel Wood
 - Composition:
 - o NiCl_2 220 to 280 g/l
 - o HCl 35% 75 to 95 cm³/l
 - o Room temperature
 - o d.d.c 5 to 10 A/dm²
 - o time: 5 to 6 mn
- Demineralized running water rinsing
- Unpolished copper coating
- Composition
 - o CuCN 50 g/l
 - o Free KCN 12 to 25 g/l
 - o K_2CO_3 0 to 110 g/l
 - o Demineralized water $\rho > 10^5 \Omega$
 - o « Rachille Salt » 45 g/l
 - o Temperature : 30 to 40°C
 - o D.d.c 1A/dm²
 - o Time based on thickness. Coating rate $\approx 0,2 \mu\text{m}/\text{mn}$
- Thickness control
- Demineralized water rinsing - damasking
- Hot water rinsing 60 to 65°C 1 to 2 mn
- Dry air-drying
- Appearance, masking, thickness check
- Packaging

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