SLS-TME-TA-1998-0014
October, 1998

UHV Materials and Technologies for SLS Front End and Beamline

Chen Qianhong

Paul Scherrer Institut
CH-5232 Villigen PSI
Switzerland

Contents

1 Introduction

All Front ends and some Beamlines in SLS are ultra high vacuum (UHV) systems and therefore must be designed in a range of pressure lower than 5 10^{-8}. The following specifications will concern materials, technologies and components that must be used in UHV systems.

2 Materials

The following is a list of UHV compatible materials:
Stainless steel (AISI 304L or LN, AISI 316 L or LN, AISI 321)
Aluminum (6061-T6, 5454, 5058)
Alumina
Beryllium
Beryllia
Pyrolitic graphite Carbon foil, Diamond
Copper (OFHC or OF), Glidcop→
Inconel, Monel
Macor→
Noble metals (Gold, Silver…)
Nickel
Tungsten
Titanium (50A)
Glass.

If not otherwise specified, vacuum chambers and pipes must be made of stainless steel AISI 304L, the flanges must be made of AISI 316N-ESR, and the gaskets must be made of OFHC copper.

3 Welding

Welding quality is an important characteristic for the performance of UHV vessels. All welding operations must be carried out in a clean area.
Welds should be regular, continuous, non porous and every attempt should be made to reduce the width of the "transition" region along each side of the weld.
Sealing welds should be made from the vacuum side of the vessel. External discontinuous structural welds are suggested.
Whenever possible, single pass welds should be used.
If structural welds must be executed inside the vacuum, these welds should be made discontinuously and should not cross the sealing ones.
If it is impossible to make sealing welds from the vacuum side of the vessel, total penetration is essential in order to avoid the creation of "pockets", which may favour retention of gases, and to ensure a sound mechanical structure.

All parts to be welded must be cleaned prior to welding. To prevent undue oxidation of vacuum surfaces, all welds are to be performed under Tungsten inert gas (TIG). Vacuum sealing welds made externally must have full penetration, leaving a smooth surface on the vacuum interior (d < 0.3 mm). Any later brushing or other finish work on the welds is prohibited.

4 Brazing

The brazing strip must be composed of materials with saturation vapour pressure < 10^{-3} Pa at the brazing temperature; no organic content is allowed. The brazing strip must be cleaned according to the same procedure as used for other components.
The following alloys can be used:

Cusil	(Ag 72% - Cu 28%)	brazing temp. 820 °C
Incusil A.B.A	(Ag - Cu - In - Ti)	brazing temp. 750 °C

The vacuum brazing oven must have a temperature control system with a precision better than ±5°C; it must have installations providing safety against sudden pressure increases or leaks; the brazing jig and associated fixture devices must be appropriate.
The brazing temperature and the absolute residual pressure must be recorded for the complete brazing cycle. In addition, relevant comments must be entered in a log. The recorder paper tape and the log must be presented together with the finished components for provisional acceptance by PSI.
The brazing process must be performed at a temperature lower than 850°C. The brazing cycle must be programmable. Brazing must be carried out under < 10^{-3} Pa residual gas pressure. The total residual gas content due to hydrocarbon or any other diffusion pump vapour must not exceed 10 percent.

5 Cleaning and pre-baking

Before final assembly, all vacuum components must undergo a suitable cleaning and washing treatment in order to obtain a specific desorption rate, before bake out, lower than 10^{-6} Pa $dm^3/s\ cm^2$.
The following UHV cleaning treatment is suggested:
a) wiping off of large dirty patches;
b) perchlorethylene vapour treatment (121°C), followed by draining and drying;
c) washing in alkaline solution (pH 11) at 65°C, with ultrasonic treatment for 15 minutes. Alkaline detergent solution, type Diversey 708 or equivalent types:
   Potassium phosphate 20 g/dm^3,
   Sodium bisilicate 20 g/dm^3,
   Alpyanyl 568 0.25 cm^3/dm^3;
d) rinsing in de-mineralized water;
e) oven drying at 150°C;
f) cooling to ambient temperature in a ventilated, dust-free room or enclosure;
g) clean components must be wrapped in aluminum foil and sealed in clean polyethelene bags.

Acid etching followed by neutralization is not allowed in this cleaning process.

Before assembling, the UHV components must be pre-baked in a vacuum oven at a temperature of 450°C for 24 hours. The heating and cooling rate must be 50°C/hour. The pressure must be better than 10^{-5} Pa. The specific desorption rate must be lower than 10^{-10} Pa dm^3/cm^2 after the per-baking.

6 Assembly and storing

The main UHV components must be assembled in a laminar flow hood of class 100 or in a class 10000 cleanroom. The complete assembly of all the UHV components must be done in a class 100000 cleanroom or in a clean area suitable for UHV.
The working conditions must be:

a) no smoking or eating;
b) suitable clean gowns must be used, in particular overalls, caps, overshoes and gloves;
c) all tools must be cleaned and degreased;
d) all tools coming into contact with UHV surfaces must be made of stainless steel;
e) cranes or other mechanical devices must be protected in order to avoid leakage of lubricants;
f) after vacuum testing, the components must be stored in dry nitrogen.

7 Leak test

Leak test must be performed using a helium leak detector with the following characteristics:
-measuring range from 10^{-2} Pa dm^3/s to 10^{-9} Pa dm^3/s
-having an internal pumping system
-calibrated leak of helium in the range of 10^{-6} Pa dm3/s.
The leak test must be made on all A type components prior to final assembly and on the overall X04SFE assembly before bake-out. The helium leak rate must not exceed $2X10^{-8}$ Pa dm3/s.

8 Bake-out

The bake-out procedure should be as follows:
-verify that:

all supports are fixed to the floor by bolts
all unused flanges are closed by blank flanges
the gate valves in the center of FE and the fast valve are in the open position
the gate valve at the end of FE is in the closed position
one of the two right-angle all-metal valves is in the closed position
all bellows for linear motions are in their extended positions
remove or place protection on all non-bakeable parts

-connect an oil-free roughing pump system to the right-angle all-metal valve (which is in the open position) and start evacuation;
-when the pressure is lower than 10^{-4} Pa, the heating system should be switched on; a baking temperature of 200°C must be reached with a maximum heating rate of 50°C/hour;

-the temperature is maintained at 200°C ±5°C for 36 hours;
-the RGA ion source filament must be out-gassed according to manufacturer instructions;
-when the pressure is in the lower range of 10^{-5} Pa, ion pumps are switched on;
-The temperature is decreased to room temperature at a cooling rate of 50°C/hour;
-after reaching room temperature, the valve for roughing is closed and the system is pumped down. The pressure must reach a value lower than $2X10^{-8}$ Pa.
During the bake-out, the temperature and the pressure must be monitored and recorded on paper.

9 Vacuum test

After the system is cooled from bake-out down to room temperature and its pressure reaches a value lower than $2X10^{-8}$ Pa, the vacuum test will be performed by using a Residual Gas Analyzer (RGA). This test consists of two parts:

a) measuring the spectrum of the residual gases; the results must meet UHV requirements;
b) performing a leak test with helium, using the RGA.