JLAB-TN-09-055
3 November 2009 Marcy Stutzman

400ºC heat treatments

400ºC heat treatment is used to lower hydrogen outgassing rates in vacuum chambers.

Motivation

Hydrogen outgassing is the predominant source of gas in UHV/XHV vacuum chambers. Heat treating a chamber as part of the preparation using a 400ºC heat treatment aims to reduce outgassing by using moderate heat and a long time to allow the hydrogen within the stainless steel walls and flanges to diffuse out. This should result in a lower room temperature outgassing rate.

Heat treating at 900ºC before final assembly also can be used to lower outgassign rate, but the subsequent welding of flanges can reintroduce hydrogen into the material, making the 400ºC heat treatment of the final chamber useful.

This tech note describes our methods and initial results for heat treating stainless steel chambers at 400ºC for 5-10 days to reduce outgassing for the UHV/XHV vacuum chambers for CEBAF and JLab FEL photoguns.

Equipment and Supplies Required

Blank flanges with jacking screws to ease disassembly

Insulated oven panels

Resistive heater assembly (either John's assembly or Bubba's heater bars)

Bake controller

Ground strap

Procedure

- All flanges used during 400ºC bake need tapped jacking screw holes to help release flanges during disassembly.
- Assemble the chamber with blank flanges in place of any delicate equipment (gauges, RGAs) not able to be heated to 400ºC.
- Set up pumping for the system:
    - Ion pumps within the oven must have magnets removed
    - Turbo system outside the oven.
- An ion pump outside the oven can be used, but pressure will likely be high.

- Assemble the heater system, making sure to have isolated current paths and secure ground. Get qualified person (see list of qualified personnel at end of tech note) to verify that the heater assembly is properly installed.

- Build oven, insulating cracks with sheet fiberglass insulation. Tape will not stick inside the oven at these temperatures. Make sure to have thermocouples for control and monitor.

- Ensure that all items within the enclosure are secured in a manner to prevent contact with the heaters. No tape allowed. Twisted welding wire or stainless steel pipe clamps should be used.

- Get qualified person (list of qualified people at end) to unlock the LOTO device on the heater, and plug it into the heater controller.

- Program the bake cycle. Bake controller parameters (PID) are the same as for a heater blower bake.

Initial Results

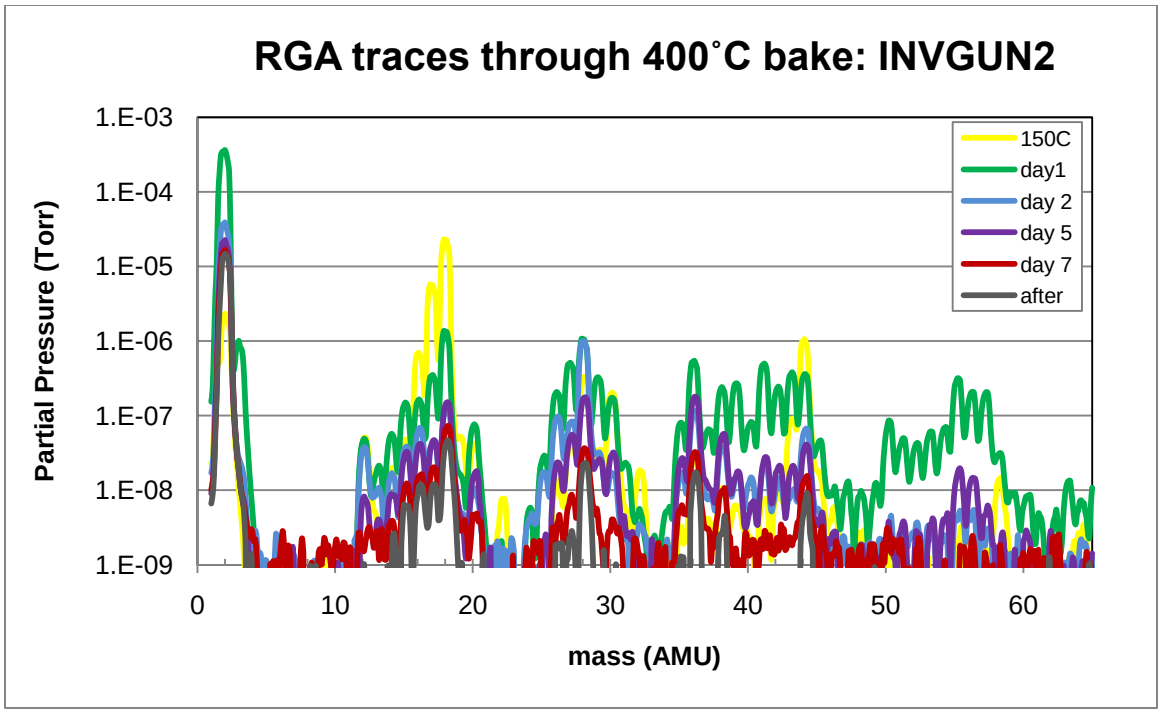
Four chambers have been heat treated thus far:

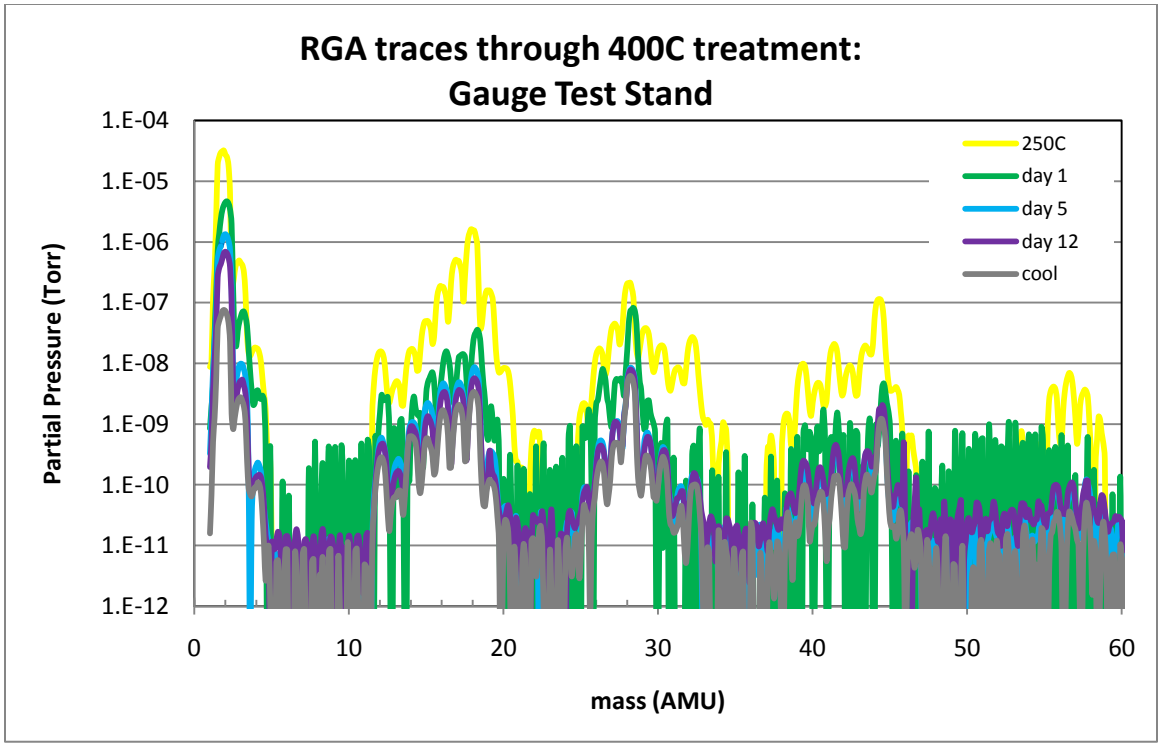
- FEL gun chamber
  - Bubba's bar heaters
  - 316LN stainless steel
  - Electropolished
  - $Q=2x10^{-13}$ Torr·L/s·cm^2
  -
- INVGUN1
  - NorCal fabrication
  - 316L stainless steel
  - Electropolished
  - John's dryer heaters
  - Bubba's pump cart
  - Installed in CEBAF Gun2 position Summer 2009
  - $Q=1.25x10^{-13}$ TorrL/scm^2
- INVGUN2
  - MDC fabrication
  - 316L stainless steel
  - Electropolished
  - awaiting electrode for installation in test lab
  - No outgassing number due to Ti contamination/pumping
- Gauge test stand
  - 304 Stainless Steel
  - No electropolish
  - Used Hydrogen cleaning chamber as the pump station during bake
  - $Q=3.5x10^{-14}$ TorrL/scm^2

Standard outgassing rates for comparison:
- EP 304 initial bake: 3 to $4.5x10^{-12}$ TorrL/scm^2
- 304, 13 bakes: $9x10^{-13}$ TorrL/scm^2

Bake Parameters

- Ramp rate
  - ~8 hours to 120ºC, soak 4 hours at 120ºC, 12 hours to 400ºC
  - At least 7 days at 400ºC (make sure to program the controller to “cont” or keep an eye on the time to avoid ramping down)
  - Cool to 200ºC in 8 hours, hold 4 hours, cool to 20ºC in 6-8 hours
- Using ion pump only, the pressure will get very high. Turbo system (Alcatel, Pfeiffer turbo) allows the ramp to go up at a reasonable pace.
- Once pressure starts falling at temperature, ion pump can be turned on. Turbo may be valved out overnight or in case of power outages once ion pump is stable below 3 mA.


RGA traces through 400˚C bake: INVGUN2
Partial Pressure (Torr)
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
0
10
20
30
40
50
60
mass (AMU)
150C
day1
day 2
day 5
day 7
after


RGA traces through 400C treatment:
Gauge Test Stand
Partial Pressure (Torr)
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
1.E-12
0
10
20
30
40
50
60
mass (AMU)
250C
day 1
day 5
day 12
cool

Conclusion

400ºC heat treatment is proving to be a useful technique to reduce outgassing rates of chambers for UHV/XHV photoguns with the goal of reducing ultimate pressure.

Qualified personnel: heater assembly inspection

Before unlocking admin LOTO on power cord for heater assembly:

1. Ground oven panels securely
2. Isolate current path for heaters.
3. Measure heater circuit continuity and ground path continuity.
4. Ensure all electrical connections are secure
5. Close bake oven to eliminate possibility of contact with heaters
6. Unlock power cord and connect to bake controller

After bake, lock out heater power cord before opening bake oven

Qualified Heater Inspector	Signature	Authorizing Signature	Date
John Hansknecht			