VACUO
engineering for research
www.vacuo.net

REP NEWSLETTER

Volume 04, No. 06 May 21, 2009

Energy saving in UHV

ENERGY SAVING IN ULTRA HIGH VACUUM SYSTEMS

Dalla Bella Luigi
VACUO S.r.l., Via Novara 6/A, 43122 Parma, Italy

1.0 Bakeout basic considerations

In UHV practice "bakeout" refers to elevating the temperature of a vacuum system during some portion of the pumpdown cycle and then returning to previous temperature. This process exploits the gas desorption increase from the vacuum heated surfaces at significantly higher rates than at ambient temperature.
The bakeout benefits are either a lower pressure reached within a given pumping time or a shorter total pumping time to reach a given pressure.
Compromise solutions such as degassing filaments of titanium pumps, ionization gauges, sample holders are applicable: fundamental advantage of bakeout remains, namely, that the lower binding energy components of the adsorbed gases are selectively removed from the surface of interest and the relevant portions of the vacuum environment are "cleaner".

2.0 Heating apparatuses

UHV systems are fabricated of a poor thermal conductor material and many separate pieces with wide thermal masses, so the temperature distribution is variable.
We have manufactured two chambers to compare two bakeout systems (fig.1, fig.2) and we have installed two different heating systems:

1. the first has two internal 1Kw-IR lamps with rotating screen and eight K thermocouples sticked on the inside wall
2. the second one has a 12 kW owen closed all around as a bag, with eight K thermocouples as above.

fig 1

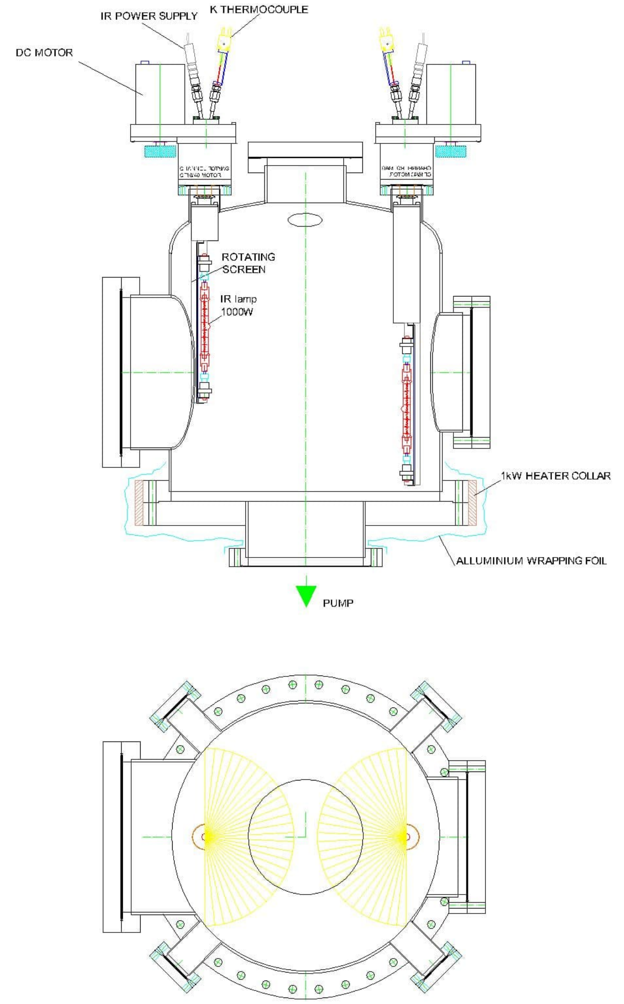
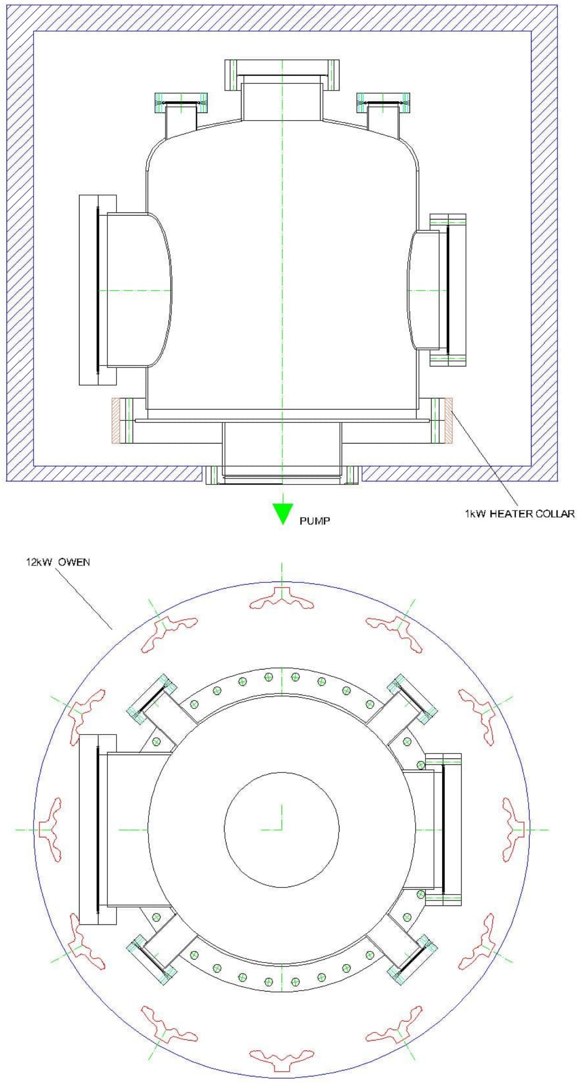
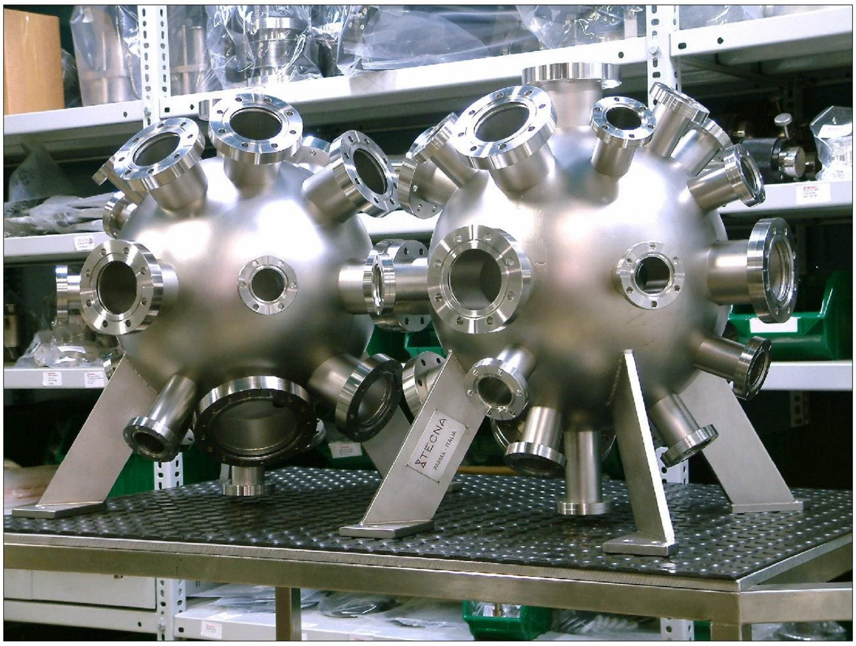

IR POWER SUPPLY
K THERMOCOUPLE
DC MOTOR
ROTATING SCREEN
IR lamp 1000W
1kW HEATER COLLAR
ALLUMINIUM WRAPPING FOIL
PUMP

fig 2


PUMP
1kW HEATER COLLAR
12kW OWEN


TECNA

3.0 Bakeout

Bakeout at 200 °C

Chamber	Method	Power	Temp raise	Running time	Temperature uniformity	Cool down	Ultimate vacuum	Note
Evap 1	I R	2 kW	2 min	16 h	Good	2 h	2x10E-9 mbar	
Evap 2	resistance	12 kW	2 h	16 h	Good	3 h	2x10E-9 mbar	

Bakeout at 250 °C

Chamber	Method	Power	Temp raise	Running time	Temperature uniformity	Cool down	Ultimate vacuum	Note
Evap 1	I R	2 kW	6 min	16 h	Good	3 h	6,6x10E-10 mbar	
Evap 2	resistance	12 kW	3 h	16 h	Good	4 h	6,5x10E-10 mbar	

Bakeout at 300 °C

Chamber	Method	Power	Temp raise	Running time	Temperature uniformity	Cool down	Ultimate vacuum	Note
Evap 1	I R	2 kW	12 min	16 h	Good	3.5 h	3,1x10E-10 mbar	
Evap 2	resistance	12 kW	4.5 h	16 h	Good	5 h	2,9x10E-10 mbar	

Bakeout at 300 °C + heating collar on DN400 flange

Chamber	Method	Power	Temp raise	Running time	Temperature uniformity	Cool down	Ultimate vacuum	Note
Evap 1	IR / resistance	2+1 kW	12 min	16 h	Very good	3.5 h	2,2x10E-10 mbar	Increasing power on the big mass, temperature becomes more uniform
Evap 2	resistance	12+1 kW	4.5 h	16 h	Very good	5 h	2,2x10E-10 mbar	

Economical rating

Chamber	Method	Investment Cost		Energy Consumption	Note
Evap 1	IR	n° 2 IR lamps 1kW on CF40, T control, rotating shield	5 k€	32.4 kW	
Evap 2	resistance	12 Kw Faired owen, T control	24 k€	241.2 kW	Often is necessary to dismount motors and cables

The differences between the two UHV systems are evident, but the same cosiderations are not always valid for different systems; anyway the acquired experience helps to design new UHV plants with these facilities and the related energy saving.

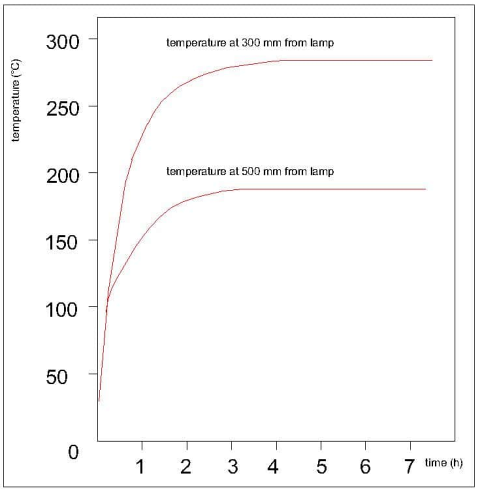


fig. 3: Temperature rise in a chamber irradiated by an IR 1000 lamp

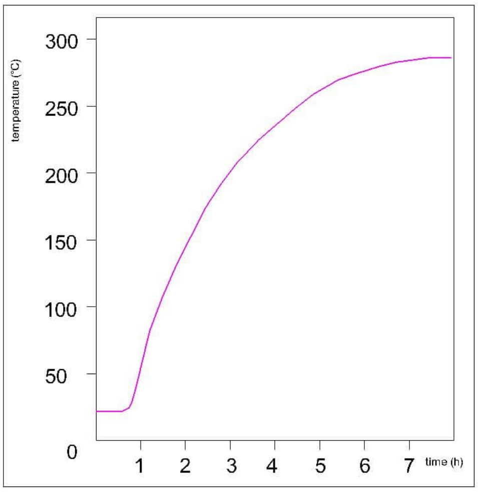


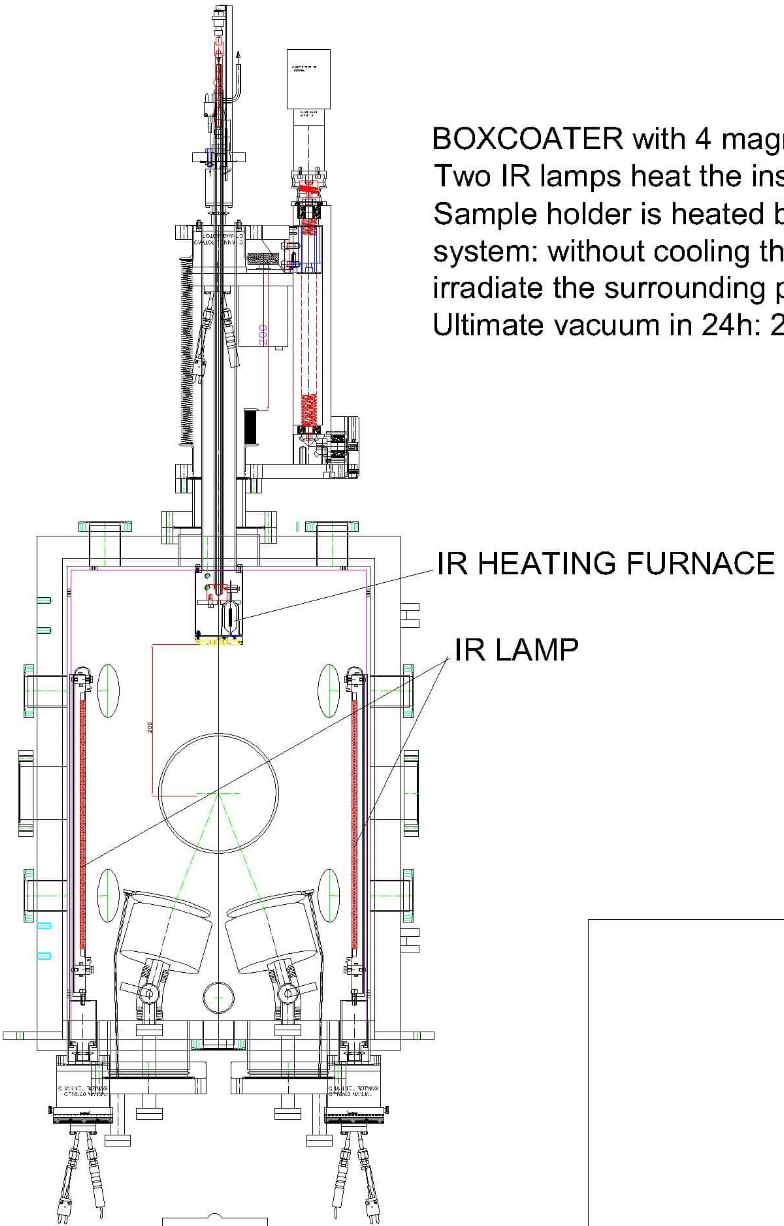
fig. 4: Temperature rise in a chamber heated by 12 kW owen

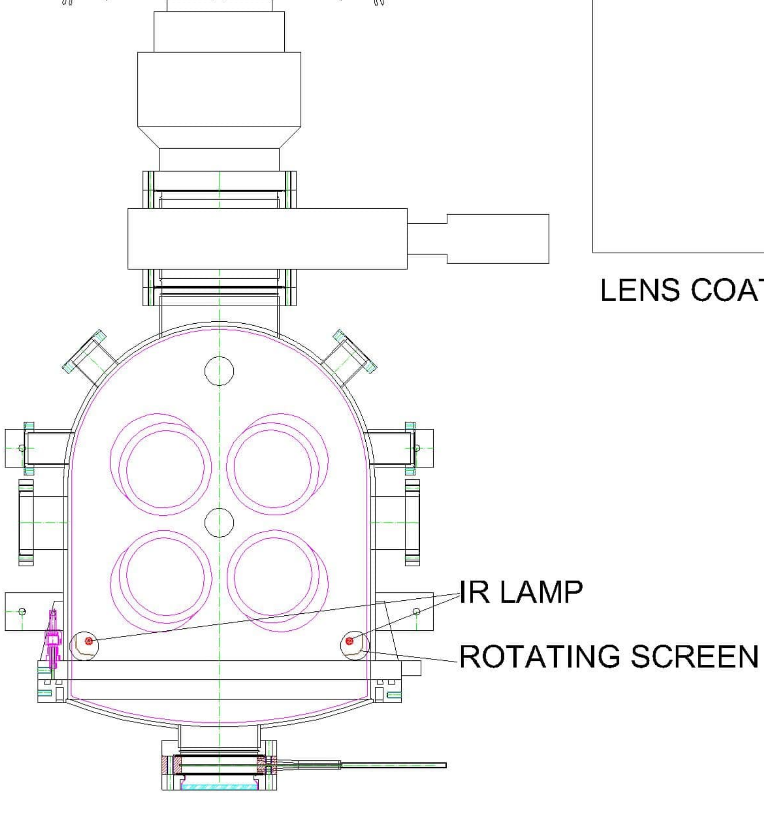
4.0 BOXCOATER operation

BOXCOATERs are systems to coat or grow materials in high vacuum (some exemple in fig.5).
To change the sample holder or the targets, the door is opened for some time, so the inside parts are restored to atmosferic pressure.The inner walls adsorb gases and the worst is the water vapour.
To increase the gas desorption during the pump down process, IR lamps have been used (see fig.6).
In many cases the cycle time has been lowered: for example 5 min less on a 40 minutes cycle means a 12.5% reduction in the production time.

fig 5

BOXCOATER with 4 magnetron sputtering sources
Two IR lamps heat the inside walls to 200°C for bakeout.
Sample holder is heated by IR lamps to 950°C with cooling system: without cooling this furnace can be used at 450°C to irradiate the surrounding parts.
Ultimate vacuum in 24h: 2x10E-8mbar

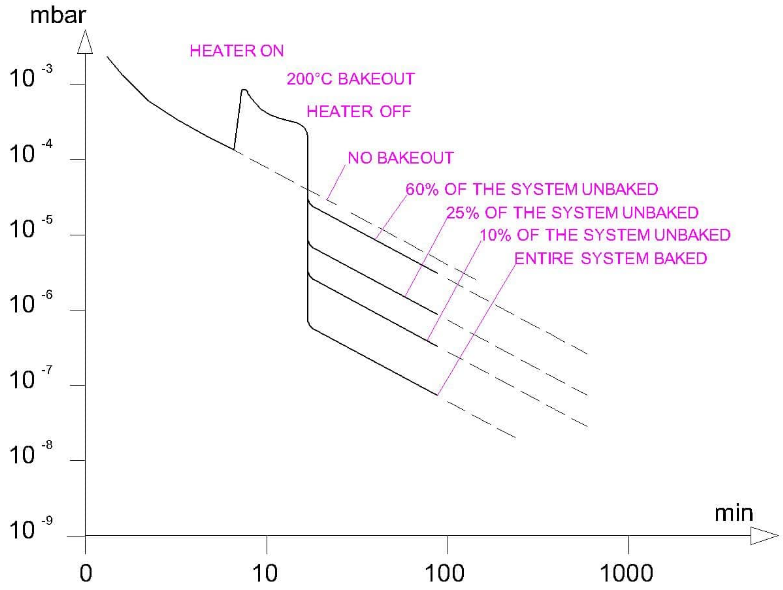




LENS COATING BOXCOATER

BOXCOATER operation

fig 6



This curve is only for general qualitative behavior of the BOXCOATER.

We have also observed that heating the inner walls of the BOXCOATER during the opening interval reduces the gas absorption too. Nevertheless, each process has its own problems that will be analyzed in the optics to save energy: in ultra vacuum processes are yet possible.

6.0 Developments

VACUO has designed many IR bakeout systems with different powers and configurations making improvements in time and energy saving in ultra high vacuum practice. This can be applied not only in new vacuum system design, but could be installed in old UHV systems.

Space simulator with internal 6kW IR lamps
Ultimate vacuum: 2x10E-9mbar

Ref.: B. Ferrario, Introduzione alla Tecnologia del Vuoto

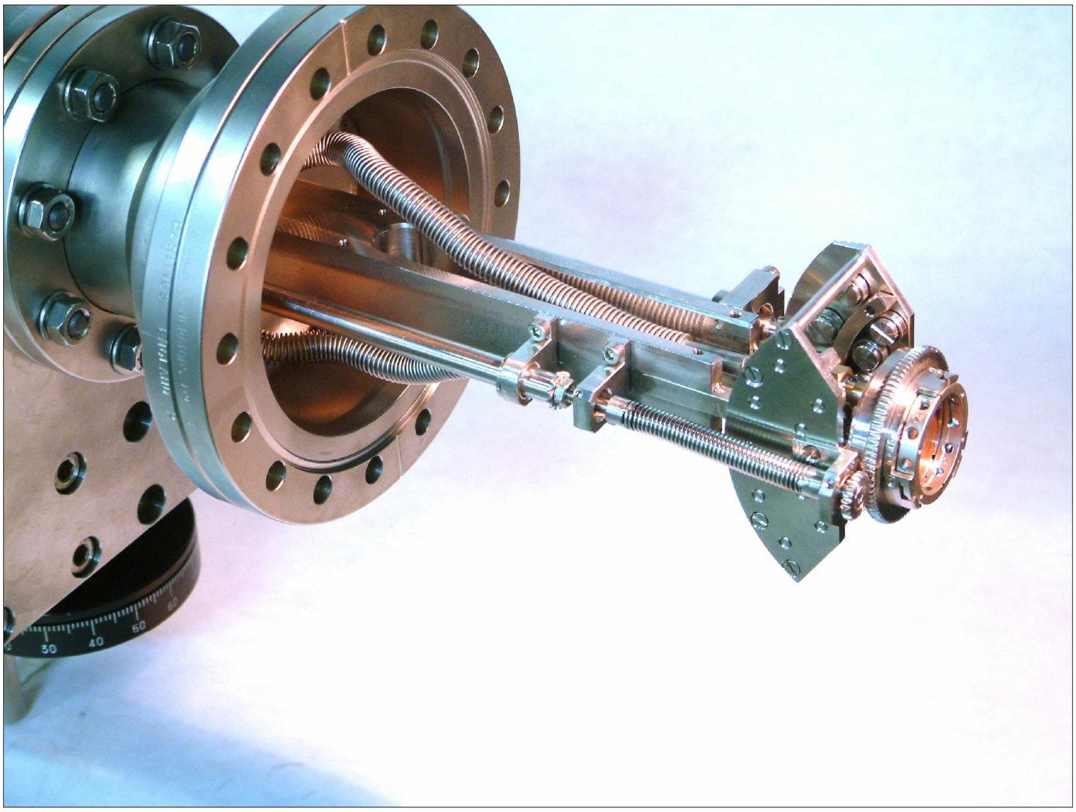
VACUO
engineering for research
www.vacuo.net

REP NEWSLETTER

Volume 05, No. 02 May 24, 2009

CRADLE MANIPULATOR

To have a 180° steradiant free surface a cradle system has been designed.This manipulator has two rotation axis passing in the center of the sample.The Z axis rotation is continuous 360°, the second rotation has +/- 40°perpendicularly to Z axis.
Sample holder is trasferable both laterally ,both frontally by bayonet.
In the back of sample a LN2 reservoir cool down the sample.
Mounting WS2 coated ball bearing with ceramic spheres, manipulator is bakeable to 300°C in vacuum.



Sponsored by : **INRIM-Torino**

VACUO
engineering for research
www.vacuo.net

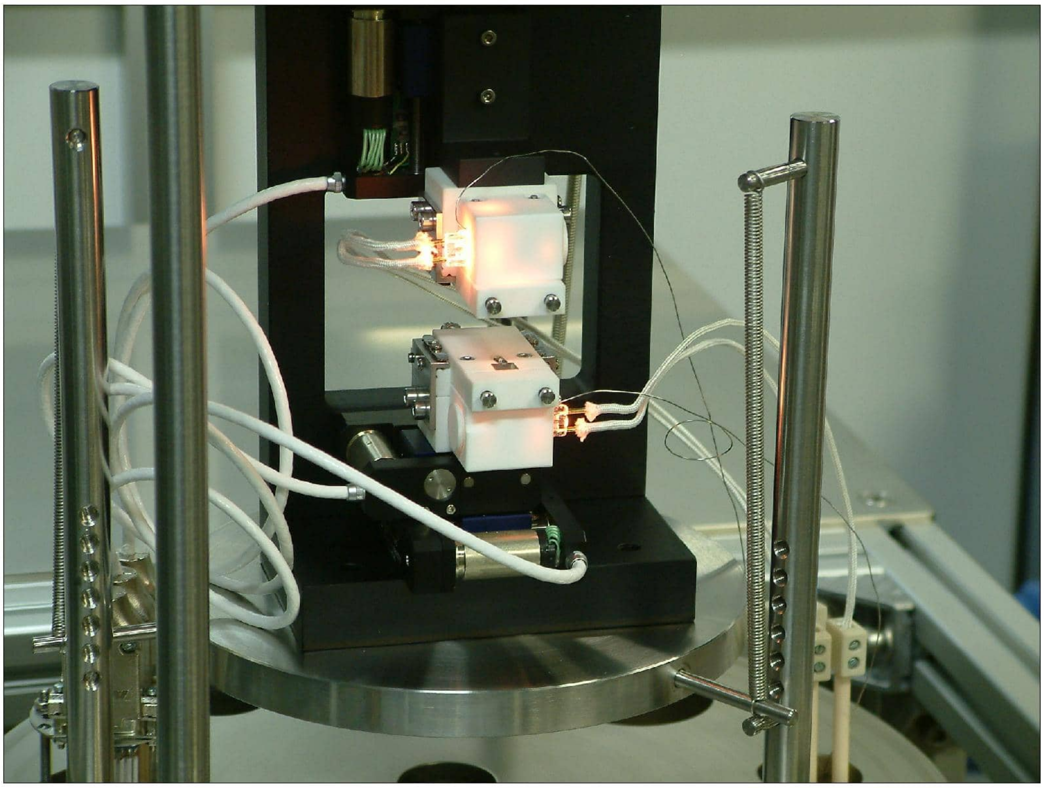
REP NEWSLETTER

Volume 05, No. 05

May 24, 2009

FIELD EFFECT SYSTEM

To measure the field effect two SWNT samples are mounted on two slides drived by microstepping motors in high vacuum.
For high voltage insulation sample holders are made in MACOR and lodges the samples in planar shape to move side by side their surfaces.
Three coaxial polarisations simulate an electronic triode. In the back of samples, two IR furnaces are mounted with related K thermocouples to reach 300°C.
5 mm vertical stroke is run in step of nanometer.
System is mounted on a platform suspended by three identical springs to avoid vibrations.
Operating vacuum 1.10*-7 mbar.



***Sponsored by :* Dpt of electronic engineering , Rome University**

VACUO
engineering for research
www.vacuo.net

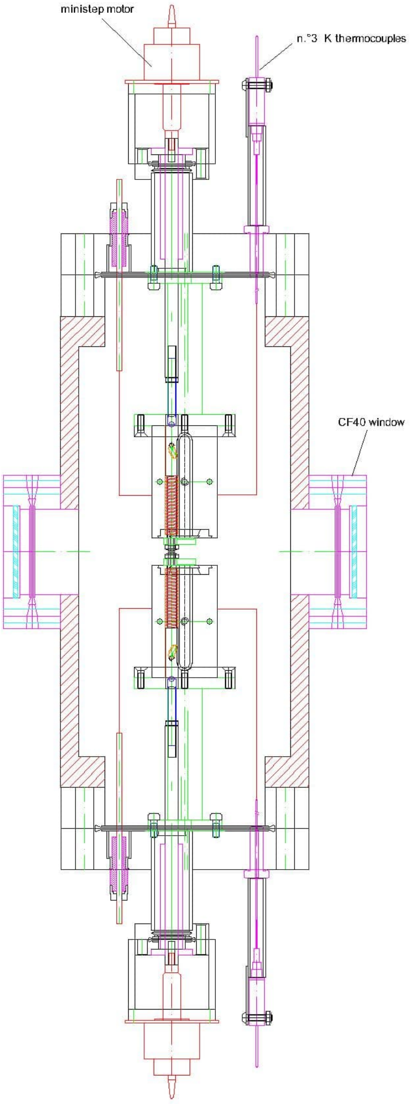
REP NEWSLETTER

Volume 05, No. 06

May 24, 2009

TOCK cells

TOKCs are the last generation of Tranferable Organic Knudsen Cells produced by Tecna.
The three temperature areas are allocated along the axis of the crucible and are realized by three filaments confinated by inconel screens.
Standard crucibles are in quartz with capacity of 0.33, 0.9, 3.5 cc.
Around the filaments three shields are installed to avoid the heat loss; their shape is designed by computer in order to optimize the efficiency of the heating.
Three inconel sheated K thermocouples are in contact with the crucible wall at three different levels: in this way the temperature plannig is realized through the power supply (PID).
When the tip of linear step motor is drawn back, the TOKC shutter is holded closed by spring.

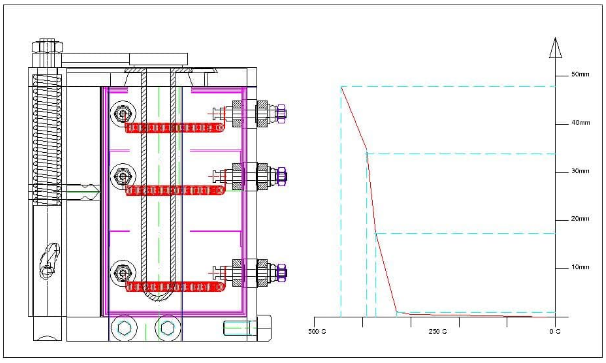


CF64 MOUNTING

In UHV growing chamber, two TOKC have been mounted one on top of the other.
Heating the lower TOCK,fullfilled with organic material,and mantaining cold the upper cell, a dry fractional distillation has been performed to improve the purity of the initial material.


THREE TEMPERATURE POWER SUPPLY AND CONTROLLER

Temperature control



Example of programmed temperature along the cell axis

VACUO
engineering for research
www.vacuo.net

REP NEWSLETTER

Volume 05, No. 07 May 24, 2009

ORGANIC GROWING SYSTEMS

Organic Molecolar Beam Epitaxy (OMBE) is a chemical process used to produce high purity, high performance solid materials. The process is often used in semiconductor industry to produce thin films. In a typical OMBE process, the wafer (substrate) is exposed to one or more volatile compounds, which react and/or settle on the substrate surface to produce the desired epitaxial layer. Organic Knudsen Cells (OKCs) are designed for these processes.
The presence of high volatile substances in the Ultra High Vacuum vessel can generate environmental pollution, so Transferable Organic Knudsen Cell (TOKC) can be the solution.
The drawing shows an example of a growing system with 6 TOKCs.
Connected to the growing chamber, a fast entry lock serves as cell stock. The storage trolley has 4 places and is moved by a programmable step motor or manually to excange the TOKC by means of a MMLR magnetic manipulator.
Inside the growing chamber, six TOKCs are mounted on a rotating platform moved by a step motor to place the cells in front of the MMLR manipulator. All around a copper screen is cooled by a tank filled with LN2 to maintain the vacuum in the range of 10E-10mbar.
On the top of the growing chamber a sample manipulator with transferable sample holder is installed with a furnace (600°C).

OMBE on test

REP NEWSLETTER

Volume 05, No. 07

May 24, 2009