THERMAL EVAPORATION

VACUO - Parma - Italy

Thermal and magnetron sputtering deposition system

Thermal source

January 2006

1.0 JOULE THERMAL EVAPORATION (JET)

1.1 GENERALITY

Evaporation in vacuum is a deposition technique of thin films made by vapour condensation of materials to be coated on substrate.
Current passing through a resistive element generates sufficient heat to melt and evaporate various coating materials.
Materials commonly evaporated using resistive heating include copper, silver,gold,platinum,tin,iron,nickel and aluminium.

Resistive evaporation can be used for industrial metallisations as well as demanding research applications.
Three basic resistive elements are generally used :filament coil,metal foil boat and oxide crucible types.

1.2 MODEL JET 300

JET 300 model has been designed to perform either the evaporation of metals and dielectrics in high vacuum,or to deposit simple layers and multilayers.
Basically the JET 300 model consist of :
- vacuum chamber
- evaporation sources
- power supply for evaporation
- pumping system
- gauges and control instruments
- support and rack

1.3 VACUUM CHAMBER

JET 300 vacuum chamber can be provided separately and can be fitted on a preexisting pumping group.The standard bell consist of a stainless steel main cylinder with a DN320 mm diameter,400mm height and two viton gasket to ensure the seal with the upper and lower flanges;on the body a DN100 viewport with magnetic shutter is mounted.In the bottom flange many holes are drilled to mount gauges ,high current feedthroughs ,shields and a pumping port.

On the upper flange four DN40 and one CF40 flanges are made :in the central CF40 flange the substrate holder is mounted ;this design allows to mount manipulators for linear and rotational movements.On a DN40 hole a movable shield with manual control is mounted :this shield protects the substrate during the preheating phase of the crucible and can also stop the evaporation when a preset thickness value is reached.The remaining holes are closed by blind flanges.

1.4 EVAPORATION SOURCES

Evaporation sources are locked in the center of the bottom flange.
Standard configuration is with 6 boat for an evaporation at a time(see CONFIGURATION B) in fig.3).Seven water cooled high current feedthroughs are screwed in the DN25 holes and wear the evaporation source (crucible,filament,boat).
Filaments are typically three stranded tungsten wires looped into coils :the evaporant charge is small ,but the evaporation is fast and efficient.

If material sublimes or do not wet the filament wire upon melting ,crucible are used.
Metal foil boat resistive elements are yet another choice for small evaporation applications.When the evaporant wet the boat metal,the electrical resistance is lowered ,causing a drop in temperature.This problem can be eliminated by using a boat which has been coated with a thin layer of aluminium oxide.

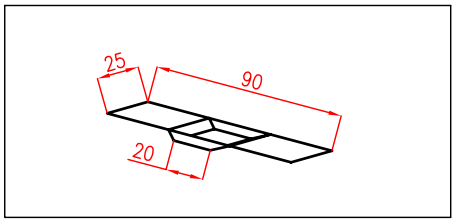


Fig 1 -Boat

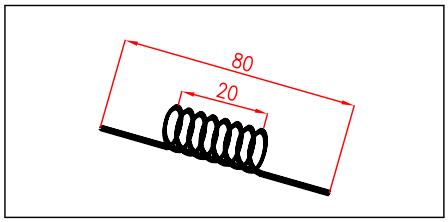


Fig 2 -Filament

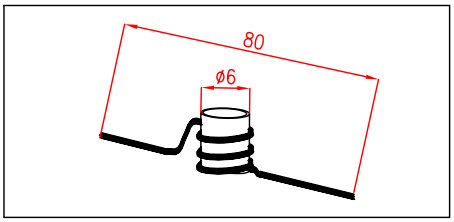
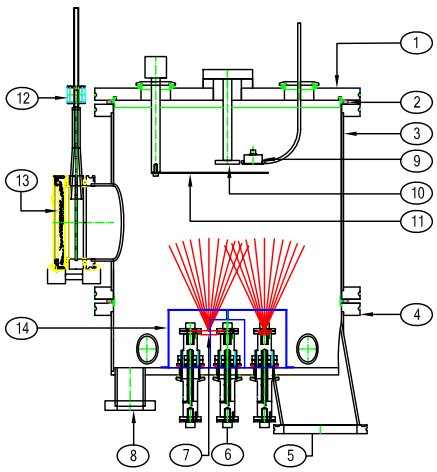
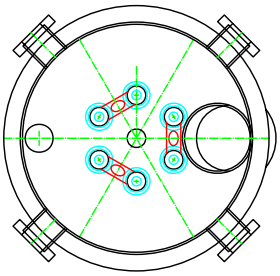


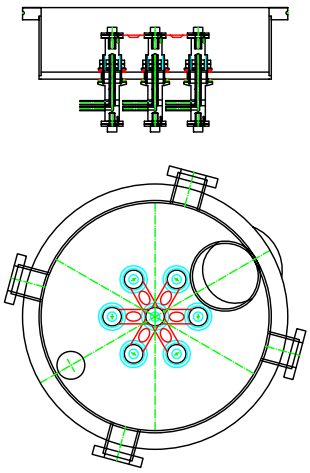
Fig 3 -Crucible



1 Upper DN320 flange
2 Centering ring with oring
3 Main cylinder
4 Lower flange
5 DN100 pumping port
6 Water cooled high current feedthrough
7 Evaporation boat
8 Auxiliary flange (5XCF40)
9 Thickness monitor head
10 Sample holder
11 Sample shutter
12 Magnetically operated shutter
13 DN100 viewport
14 Cover shield



CONFIGURATION A)
6 feedthrougs connected two by two with three boats allows to evaporate at the same time three different materials by mean of three power supplies



CONFIGURATION B)
a central feedthrough connected to 6 feedthroughs by 6 boats allows to evaporate six different materials at a time by mean of one power supply

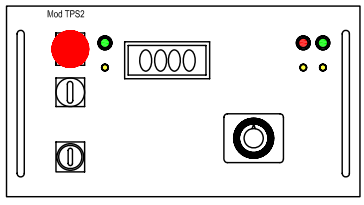
Fig 4 -Sketch of general layout of EVAPORATION CHAMBER

1.5 POWER SUPPLY FOR EVAPORATION

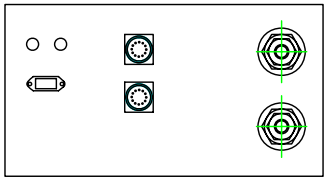
The thermal power supply Mod.TPS2 is designed to perform the evaporation process in vacuum.The main features of TPS2 are the roughness ,the versatility with which it can be fitted to the operative conditions and the simplicity of the operation.
In the front of panel an ammeter allows a thin regulation of the output current by mean of a multiround trimmer.

TECHNICAL DATA

Rated current	200A - 10Vac
Max power emitted	2 KVA
Continuous control of the output current	
Main	230V - 50Hz
Container for rack 19" x 6U ,depth 550mm	
Weight	Kg 45



Front panel



Back panel

Fig 5 -TPS2 front and back drawings

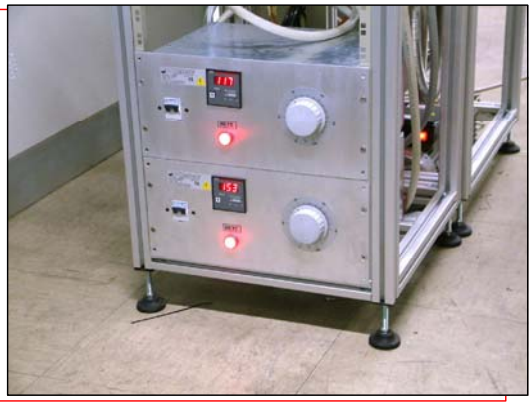


Fig 6 -TPS2 during the test

1.6 PUMPING SYSTEM

Plug and play is the design of this pumping system with a very flexible set up.
The high vacuum station is realised by two pumps :a rotary vane pump and a drag turbomolecular pump.
An automatic general controller checks each phase of bell emptying with concern to the safety of the system.
Pumping system is lodged into an Al frame made with Bosch profiles and plastic panels.Lever feet and casters accomplish the chassis.

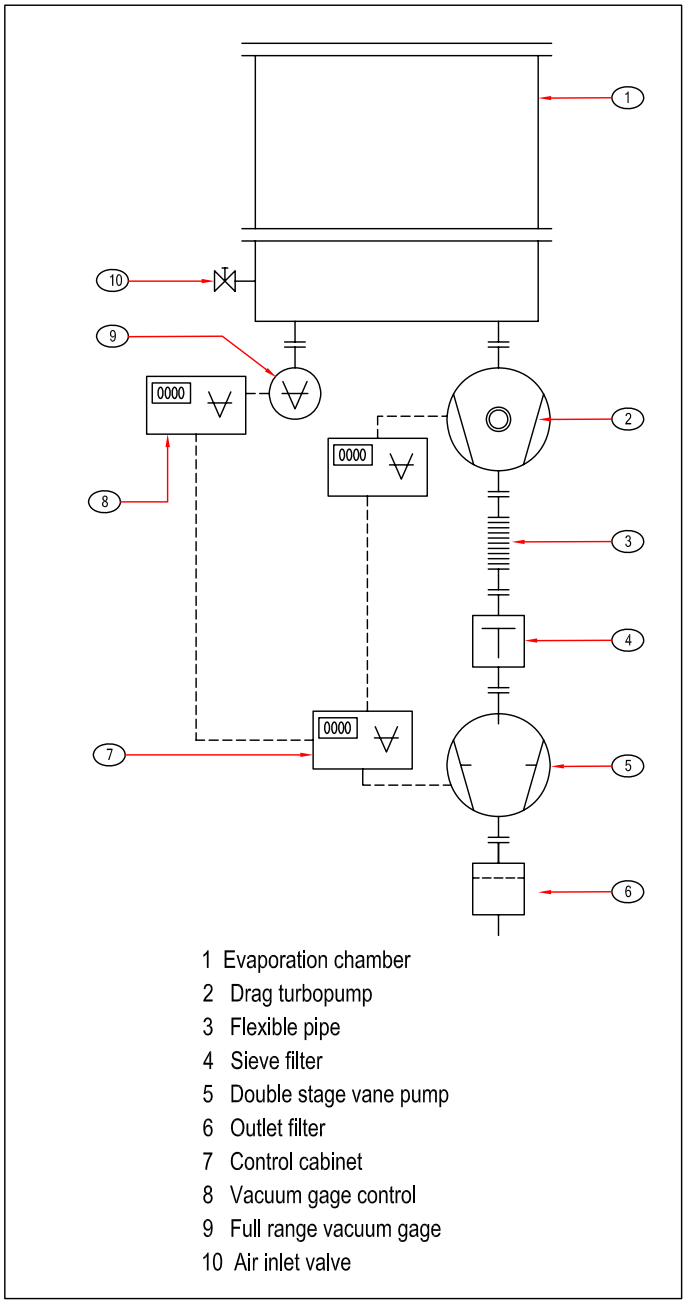
TECHNICAL DATA

Drag turbopump Mod TSH 521

-connection flange,input	DN100 ISO-K
-pumping spee for nitrogen	300 l/s
-ultimate pressure	<1.10*-8mbar
-run up time	5 min
-cooling method	water,air
-water consuption	1.5 l/min
-fore vacuum max	<12.5 mbar

Rotary vane pump Mod D016 M

-flange in and out	DN25 ISO-KF
-pump fluid filling	0.9 l
-rotational speed at 50 Hz	1400 r/min
-total ultimate pressure	<5.10*-3 mbar
-pumping speed at 50 Hz	16 m*3/h
-mains requirements	230V-50Hz+/-10%
-water vapor tolerance	15 mbar



1 Evaporation chamber
2 Drag turbopump
3 Flexible pipe
4 Sieve filter
5 Double stage vane pump
6 Outlet filter
7 Control cabinet
8 Vacuum gage control
9 Full range vacuum gage
10 Air inlet valve

Fig 7 Pumping layout

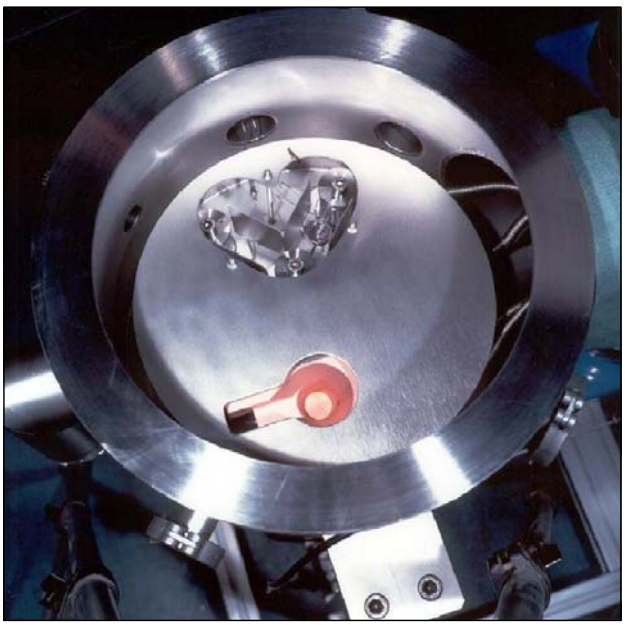


Fig 8 JET300 with one thermal source,one flash source and one 4kw e-gun source

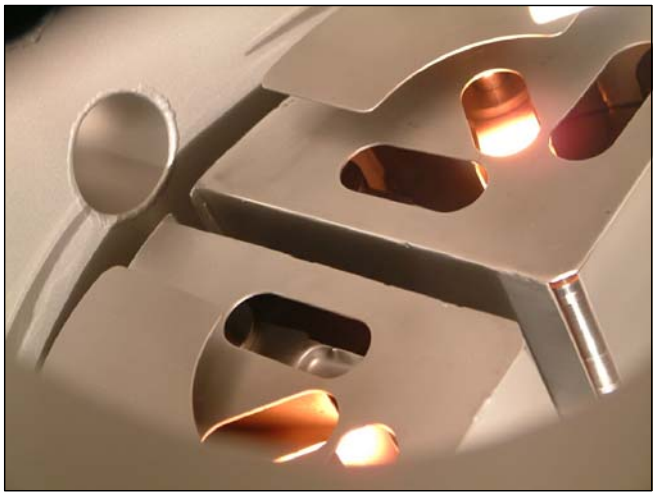


Fig 9 JET300 with two of the six thermal sources during a co-evaporation

1.7MULTIFILM THICKNESS RATE MONITOR

Mod.STM-100/MF Multifilm Thicness/Rate Monitor is a precision mass and film thickness measurement instrument for use in thin film deposition processes and other quartz crystal microbalance applications.
The unit utilizes the extremely sensitive and time proven 6MHz oscillating quartz crystal as the sensor device.The intrument is constructed with advanced LSI and microprocessor technology.

-Parameter storage for up to nine unique deposition materials
-4 set point relays
-4 remote input control lines
-RS-232C computer interface
-Bipolar high resolution analog recorder output for thickness or rate
-Configurable for negative rate mode
-Frequency display mode

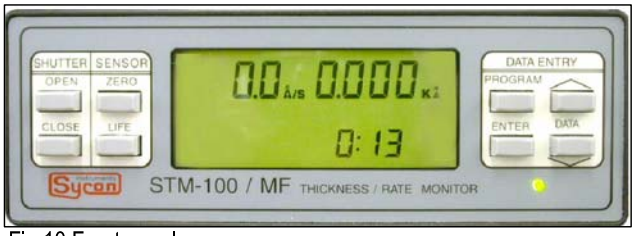


Fig 10 Front panel

Fig 11 Back panel

VSO-100
IN VACUUM SENSOR OSCILLATOR PACKAGE

Low cost ,hybrid circuit technology allows the design of a compact in vacuum oscillator/sensor package,to solve the large system application for QCM's.Sycon has developed a hybrid oscillator in a compact sensor holder for use in large systems where standard sensing heads cannot be used.The oscillator is closely coupled to the sensing crystal for higher reliability and longer sensor life.For large system applications the maximum in vacuum cable lengths are specified in feet instead of inches.A single water cools both the sensing crystal and the electronicspackage.
For large system applications the Sycon In-Vac oscillator/sensor package is the solution.

Features
-extends in vacuum cable length up to 10 feet
-hybrid design oscillator/sensor
-small package,easy retrofit of existing installations
-easy crystall replacement
-large 3/16" water cooling lines
-single +5V power/signal coax cable connection
-quality vacuum tigh construction
-shuttered oscillator/sensor available

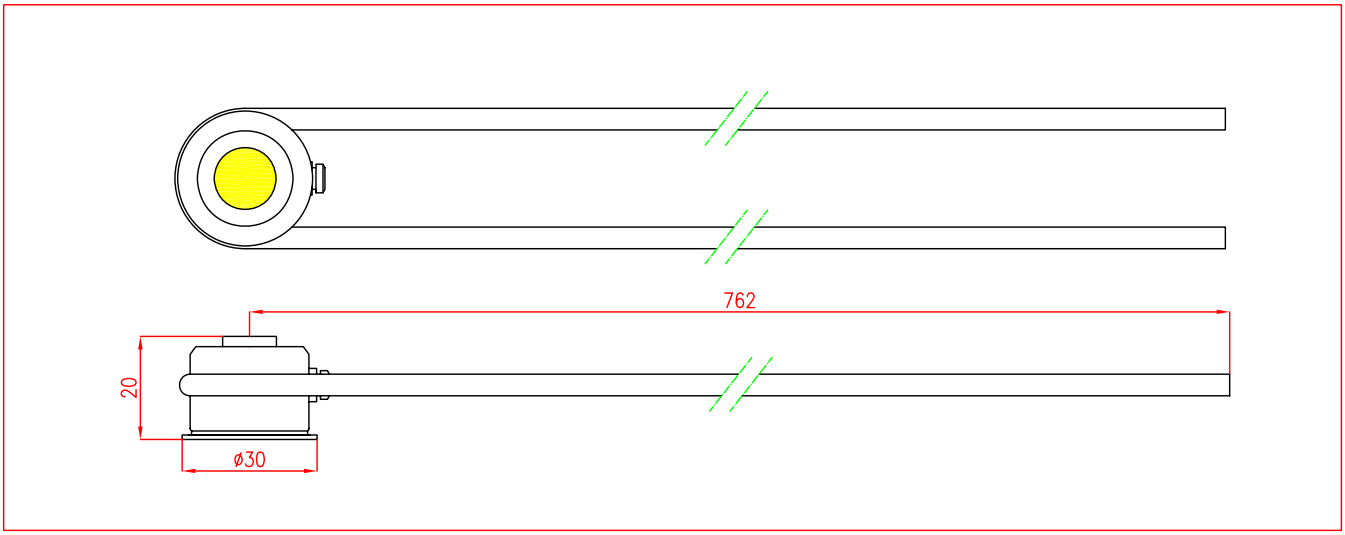
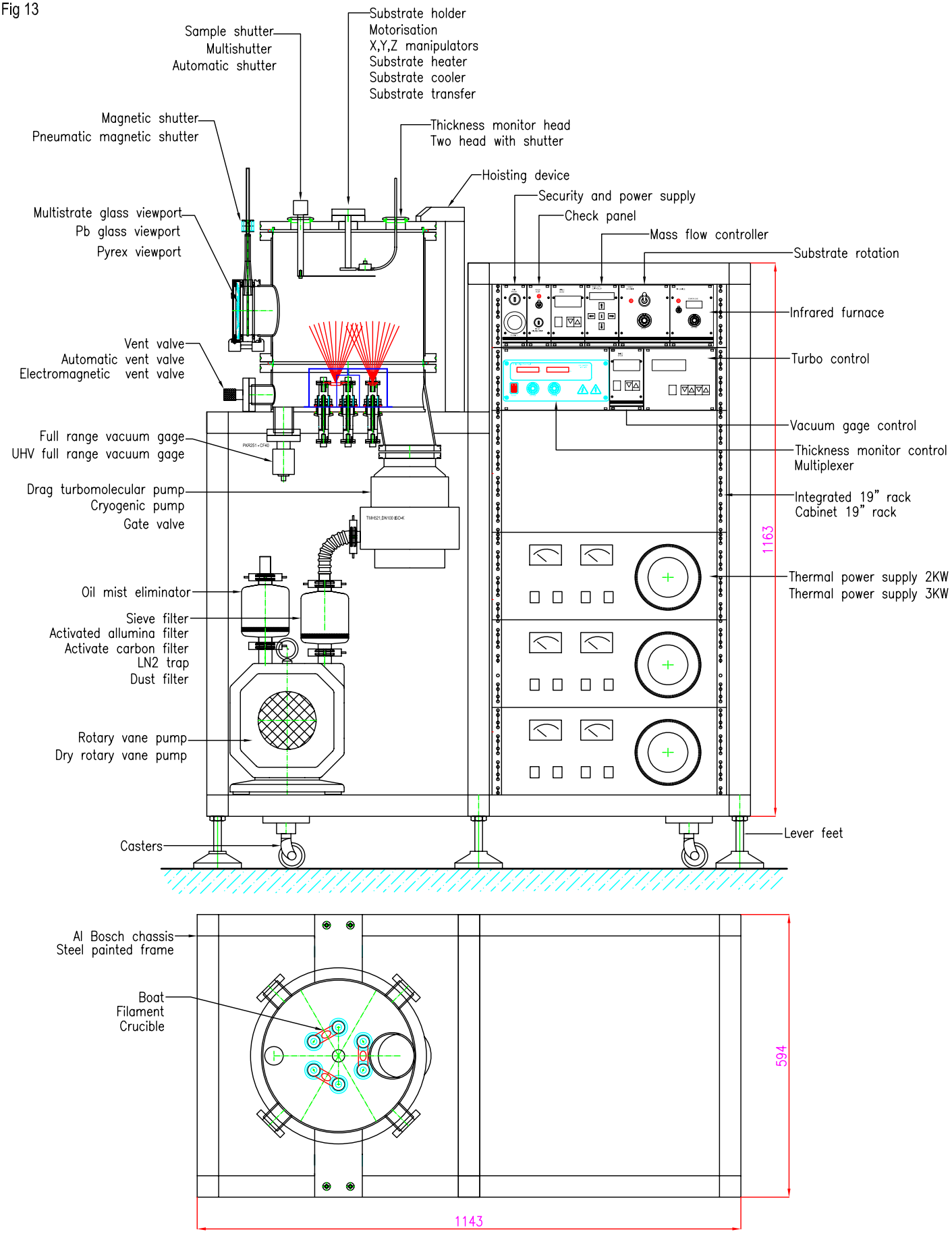


Fig 12 Low profile sensor head

Fig 13



1.8 LAYOUT AND OPTIONS

VACUO designs and develops new evaporation systems for research and industrial laboratories ,so a high number of options are possible.

The most commonly used options are reported in the above sketch:anyway our technical staff can suggest other solutions following your requirements.

2.0 GAUGES AND CONTROL INSTRUMENTS

In the main frame a key switch starts the power supplies.
Compact full range Mod PKR251 vacuum gage measures the vacuum from atmospheric pressure to 5.10*-9mbar.A thresold prevents whatever not in vacuum operations.
The choosen thickness monitor is the model STM-100/MF described in prg 1.7.

As option a controlled gas introduction is made by means of a mass flow controller to produce a reactive deposition.
All the instruments are inserted in frames and cabled in a 19" rack.

2.1 FRAME WORK

The frame is realized with Al structural shape from Bosch.These mechanical modules are very modular and elegant,so it is very easy to make changes.

The four feet have a 50mm height regulation and can be replaced by trailer casters.

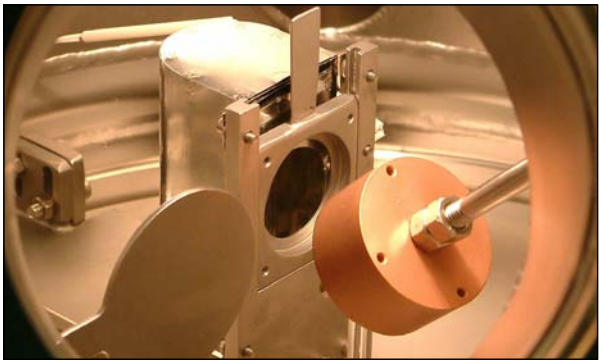


Fig 14 IR furnace

2.2 INFRARED FURNACE

The sample holder can be furnished with an infrared furnace to bake the substrate till to 900°C .
A Thermocouple K controls the temperature through a PID regulator.

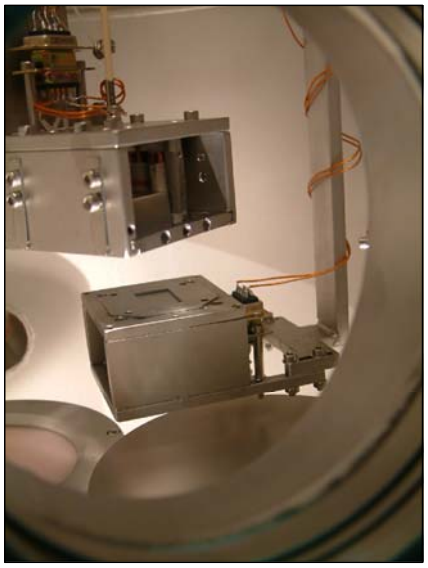


Fig 15 Mask

2.3 MASKS

To produce shaped depositions a mask is applied on the substrate surface.To avoid the mask sliding on the coating,Tecna has adopted a special in vacuum system to lift straight the mask on the sample surface during the deposition, avoiding the shadow effect.

2.4 MOD JET 600

Mod JET 600 evaporator has been designed for small production of coated glass window for domestic furnaces.
The inside 650mm diameter accomodates 410X410X4mm sample got in rotation by a dc-motor.
A thickness monitor measures the deposition rate.
An electrical lift pulls up the dome to facilitate the change of the glass window and the charge of material into the evaporation boats.
An automatic UHV dry pumping system is lodged under the evaporation chamber and its ultimate vacuum is 2.10*-9mbar
Power supplies and controls are mounted in 19" rack.
Four thermal sources are installed in the bottom flanges and two TPS2 power supplies operate simultaneuosly to coat quickly the antireflectance material on the glass window.
As option four DN25 holes allows to insert two other thermal source ;the design foresees to lodge a monocrucible electron beam (8KW).

Fig 16 JET600

2.5 MINI E-GUN EVAPORATOR MEG1

MEG-1 produce an oriented flux of evaporating material and limits the gross contamination in the vacuum chamber as produced by thermal evaporation.

The material either in rod form or into a crucible,is heated by the electrons coming from the filament.
The capacity for electrons to be directed to deliver up their energy in a confined area,leads to extremely high power density and local heating,allowing temperature in excess of 2800°C to be reached.

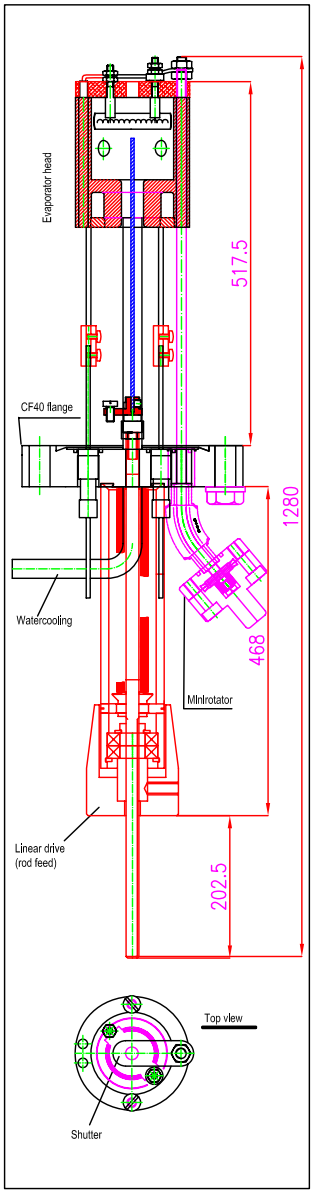
All the components, chosen for UHV,are mounted on a CF40 flange.The power supply may be switched to supply the power for evaporation :
-low power (50W) should be used for high vapor pressure materials,
-or up to 500W for crucible or thicker rods(2 or 3 mm) depending on the application and the deposition rate required.

APPLICATION

Two ways of evaporation are applied :
-*e-beam mode* : material in rod form is fed in the evaporation zone and polarized at high voltage to collect the electrons coming from the filament;the temperature rises rapidly to evaporation temperature and a pure films is deposited. Those materials with high thermal conductivity and low melting points need crucible evaporation.
-*crucible mode* :material is filled in a crucible made in refractory material which is heated by the electron flux causing the contents to evaporate.Crucible mode is advised for insulator or other poor electrical conductors and low vapor pressure materials such as silver ,gold and aluminum which melt before reaching useful vapor pressures.
So evaporation is possible for materials such as W,Ta,Mo,C,Pt,Cr,Ti,Fe from rod and Ag,Au,Al,Ni from crucibles.Rods from 1mm up to 4mm in diameter may be accomodated for requested applications. Crucibles from 50 to 200mm*3 can also be installed using the included rod holder. Deposition rates may be controlled from sub-monolayer/minute for refractory materials up to~2nm/sec for higher vapor pressure materials at 100mm working distance,matching the 500W power supply. Doping in MBE,electron microscopy,growth,surface science,atomic surface preparation are only some examples of applications of this technology.

Thickness monitors are often used to measure the evaporation rate through the deposited material;in this way is possible in feedback to program a defined thickness deposited in few mono-layers of material.Closed loop control as option can be obtained mounting an integrated flux monitor to measure the ion current of the partially ionized evaporanting beam.In feedback a PID controller regulates the power supply of the e-gun.

Fig 17 MEG-1 with shutter



Sizes

SPECIFICATIONS

°MECHANICAL

Flange	2.75"(CF40)
In vacuum length	110mm(other sizes on/r)
In vacuum diam.	33mm
Bakeout temp.	350°C
Rod feed	40mm
Rod diameters	1÷4 (or crucible)
Crucible volumes	50÷200cm*3
Crucible materials	Mo,Ti,PG,BN

°BEAM

Deposition rate	from <0,01Å/s to 2nm/s
Beam divergence	±15°

°POWER SUPPLY

Size	19" rack mount,7U high, 380Vtri/50Hz
E-beam power	Max 500W

°OPTIONS

Flux monitor
Flux controller
Crucibles
Thermocouple
Motorised rod feed

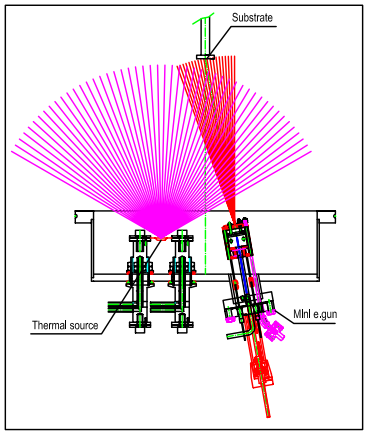


Fig 18 Thermal / E-gun sources

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