THIN FILMS FOR PHOTOVOLTAICS AND OTHER APPLICATIONS

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BACKGROUND

2.8 meter coating plant at VBO, Kavalur

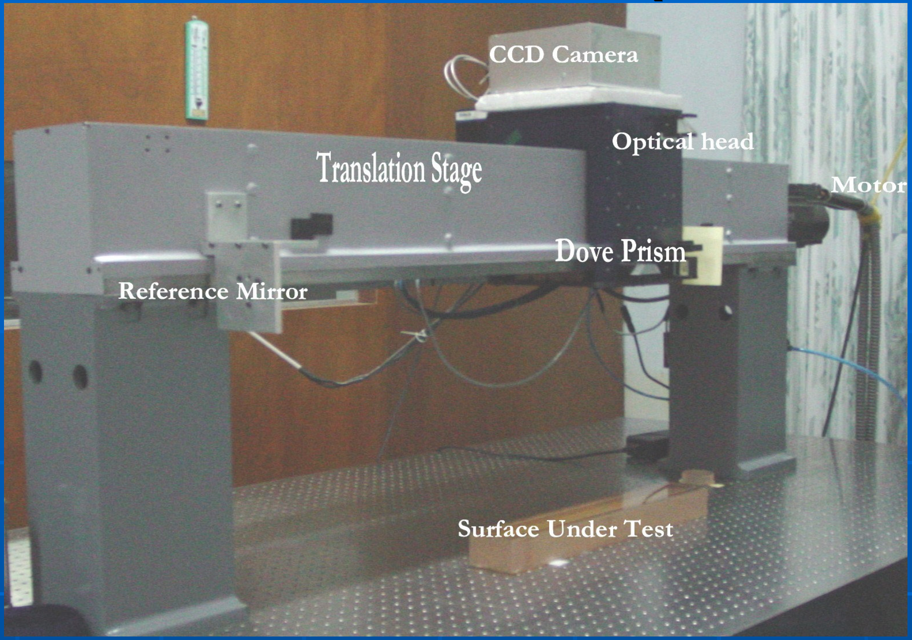
1.5 meter coating plant at VBO, Kavalur

Gold coating Unit for SRBL Strip Mirrors

2.5 meter coating plant at IAO, Hanle

Vacuum chamber fully assembled

LONG TRACE PROFILOMETER (VERSION I)



LONG TRACE PROFILOMETER VERSION I & II are developed under DAE/BRNS Project

LONG TRACE PROFILOMETER (VERSION II)

For Surface Metrology of long strip mirrors

Length= 1 meter .

Slope error measurement accuracy =0.2 arc sec

Scan mode operation

Fully Computer controlled

VHRR SUNSHIELD PANEL

Sun Shield Panel of high specular reflectance quality have been developed and were provided to ISRO for INSAT 2A, 2B, 3A and METSAT and INSAT 3D

INTRODUCTION

- Now as a part of our long term instrumentation centre plan R & D facility for thin film technology development has been initiated.

- Nano thin films for various astronomical applications including detector development is the area of present interest.

THIN FILM RESEARCH

Applications

- Optics
- Semiconductors
- Displays
- Acoustics
- Military
- Surveillance
- Security
- Industries
- Astronomy
- Aerospace

Devices

- Piezo Electric Devices
- Interference Filters
- Micro Electric Memory Devices (MEMD)
- Photo Voltaic Cells
- Field Effect Transistors (FET)
- Metal Oxide Semiconductor Field Effect Transistors
- Diode and Transistor Sensors
- Opto Electronic Devices
- Light Density Memory System for Computers

Thin film coating methods:

I) PVD (Physical Vapor Deposition)
II) CD (Chemical Deposition)

PVD can be categorized as:

1. Thermal evaporation
2. Electron beam evaporation
3. Sputtering
4. Molecular beam epitaxy
5. Ion plating
6. Activated reactive evaporation

CD can be categorized as:

1. Chemical Vapor Deposition
2. Spray pyrolysis (thermal deposition)
3. Electro Deposition
4. Electro less Deposition
5. Anodic oxidation

Our Facilities

We have already 2.8 m, 2.5 m and 1.5 m coating plant, which are exclusively useful for large mirror coating required at our field stations.

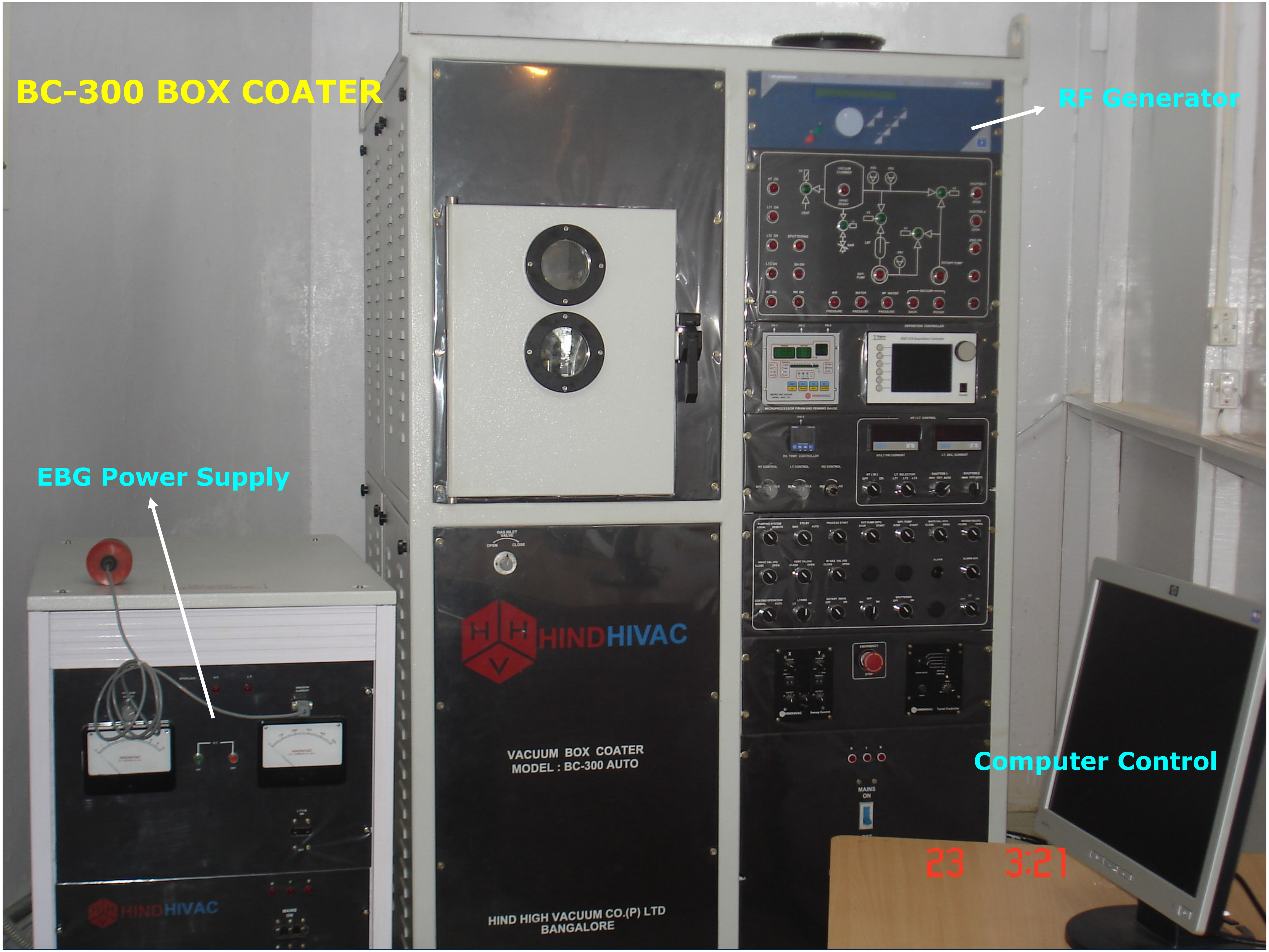
Recently we have added new fully computerized coating facility for R & D oriented work on smaller samples. Three types of physical vapor deposition methods known as thermal evaporation, electron beam gun evaporation and sputtering are available with this coating plant.

OUR FOCUS

Development of Photo Sensors including IR Detectors and Filters

The R & D would be possible with available facilities at our Institute.

S.No.	Name of Instrument	Application
1.	BC-300 Box Coater	Thin film deposition
2.	WYKO NT 1000 Profilometer	Roughness Measurements
3.	Spectrophotometer	Absorption Measurements
4.	Scanning Electron Microscope	Morphological Study
5.	Energy Dispersion Spectrometry	Elemental Analysis



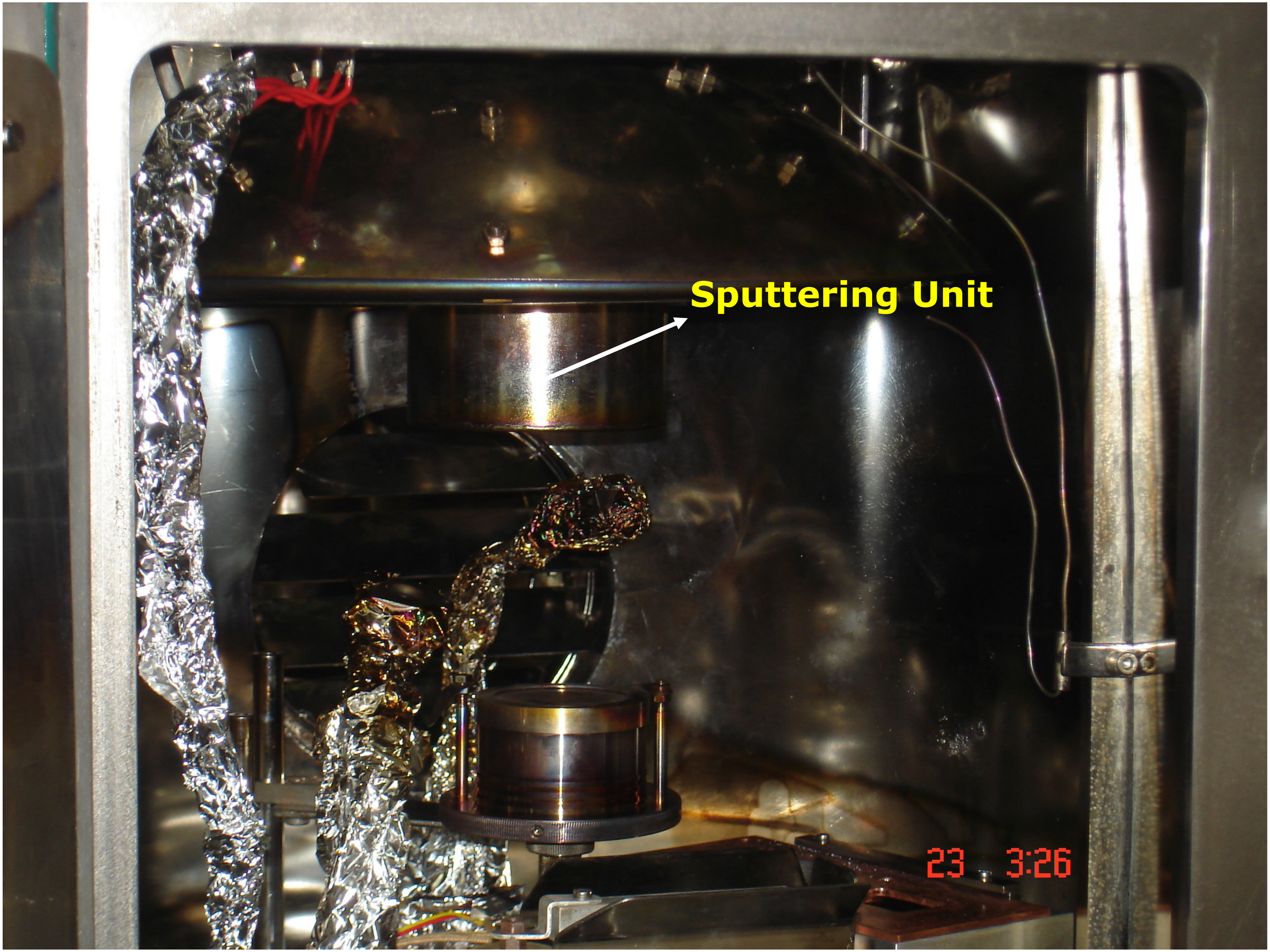
BC-300 BOX COATER

RF Generator

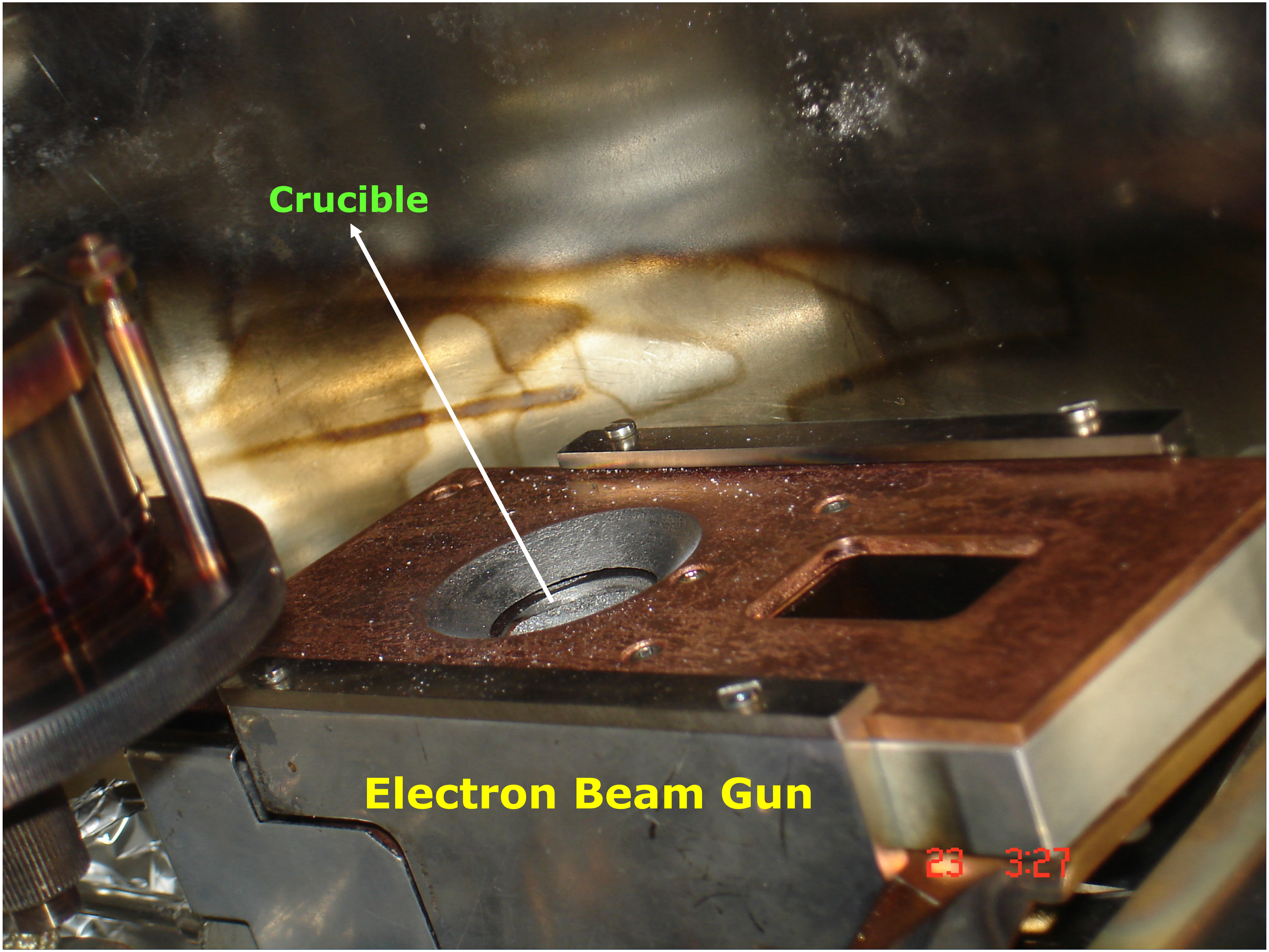
EBG Power Supply

Computer Control


HT ON
LT1 ON
VACUUM CHAMBER
HIVAC READY
VENT
ROTARY PUMP
GAS INLET VALVE
OPEN
CLOSE
23 3:26



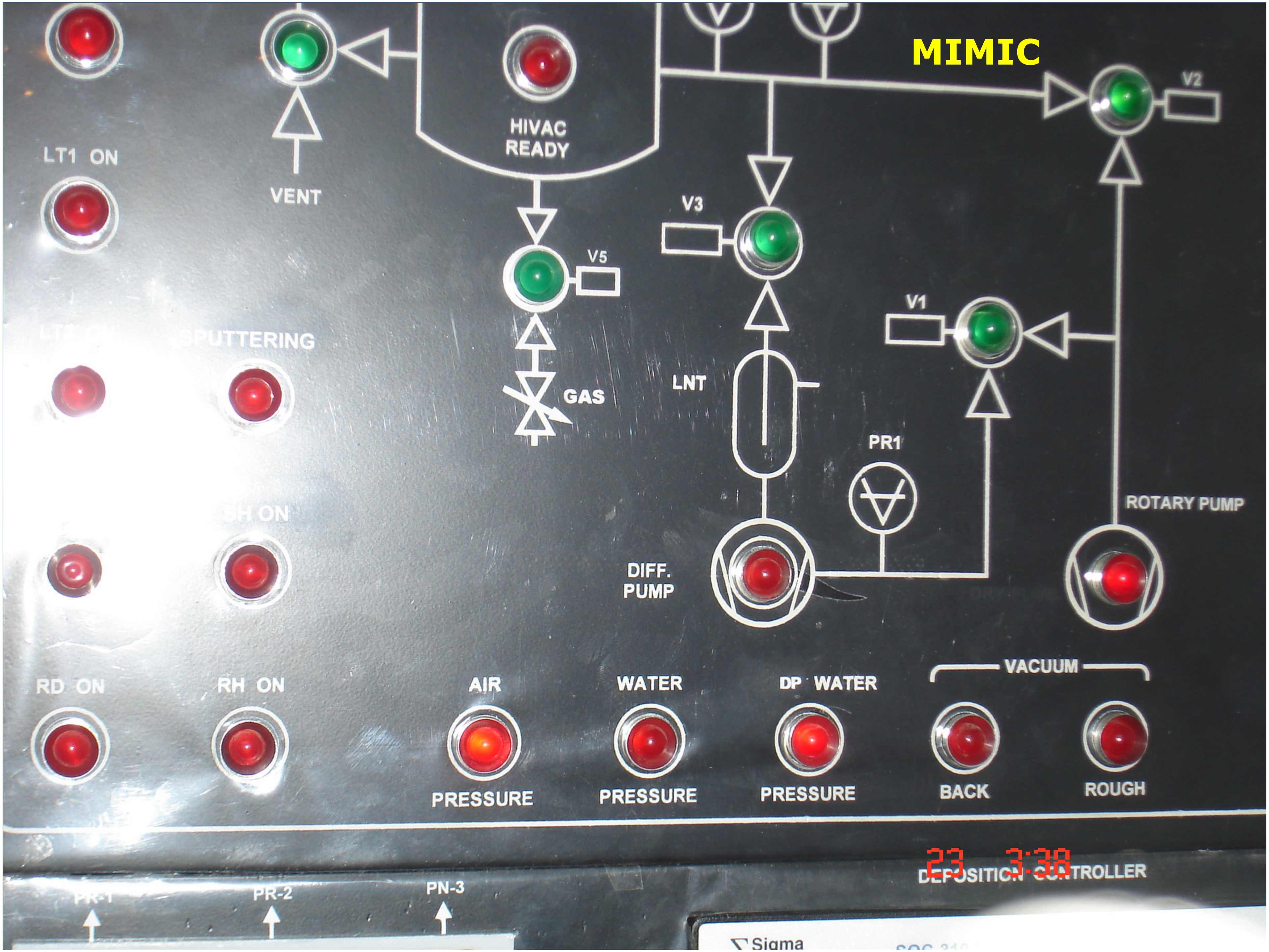
Sputtering Unit
23 3:26


Crucible
Electron Beam Gun
23 3:27

Vacuum Gauge

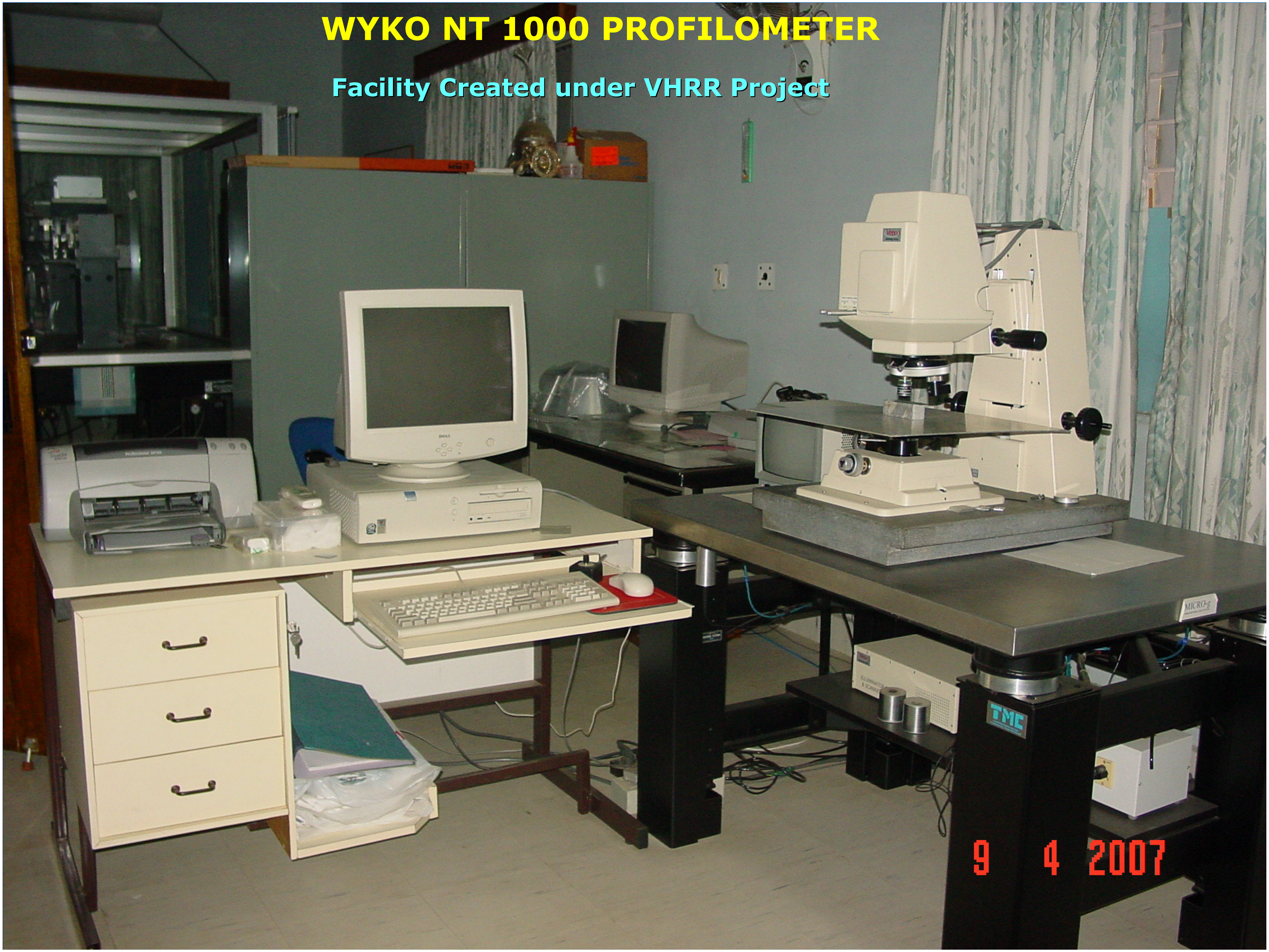
Deposition Controller

MIMIC


LT1 ON
VENT
HIVAC READY
V2
V3
V5
V1
SPUTTERING
GAS
LNT
PR1
ROTARY PUMP
SH ON
DIFF. PUMP
RD ON
RH ON
AIR PRESSURE
WATER PRESSURE
DP WATER PRESSURE
VACUUM
BACK
ROUGH
23 3:38
DEPOSITION CONTROLLER
PR-1
PR-2
PN-3
Sigma

WYKO NT 1000 PROFILOMETER

Facility Created under VHRR Project



SCANNING ELECTRON MICROSCOPE EVO 40,Carl ZEISS

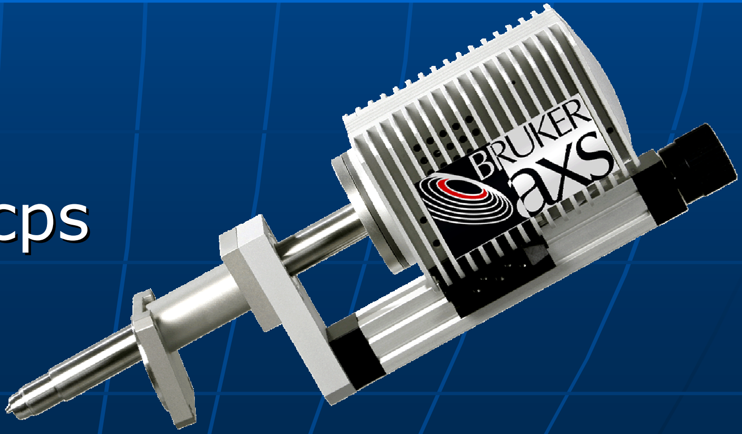
SPECIFICATIONS OF SEM – EVO 40

Resolution	**3.0 nm @ 30 kV (SE and W)** **4.5 nm @ 30 kV (BSD - XVP® mode)**
Acceleration Voltage	0.2 to 30 kV
Magnification	7 to 1,000,000x
Field of View	6 mm at the Analytical Working Distance (AWD)
X-ray Analysis	8.5 mm AWD and 35° take-off angle
OptiBeam® Modes	Resolution, Depth, Analysis, Large Field
XVP® Pressure Range EP Pressure Range	5 - 750Pa with air, or optionally water vapor 5 - 3000Pa with air 5 - 2000Pa with water vapor
Available Detectors	**SE in HV - Everhart-Thornley** **SE in XVP® - VPSE** **SE in EP - EPSE** **BSD in all modes - quadrant semiconductor diode**
Chamber	310 mm (Ø) x 220 mm (h)
5-Axes Motorized Specimen Stage	X = 80 mm Y = 80 mm Z = 35 mm T = 0° -90° R = 360° (continuous) Stage control by mouse or optional joystick and control panel
Future Assured upgrade paths	HV -> XVP® -> EP
Image Processing	Resolution: Up to 3072 x 2304 pixel Signal acquisition by integrating and averaging
Image Display	Single flicker-free XVGA monitor with SEM image displayed at 1024 x 768 pixel
System Control	SmartSEM™** GUI operated by mouse and keyboard Multilingual CONCISE GUI Windows® XP operating system
Utility requirements	100 - 240V, 50 or 60 Hz single phase No water cooling requirement

BRUKER EDS SYSTEM

SPECIFICATIONS

- **10 mm² active area**
- **Best Energy resolution: ≤** 127 eV @ **MnKα,**
- Flat resolution **up to** 100 000 cps
- **Detection from** Boron (5) **onwards**
- **Max. pulse rate** 1,000 000 cps
- **2 stage Peltier cooling**



CURRENT RESEARCH

PHOTOVOLTAIC SENSORS OPTICAL FILTERS

There are three essential elements associated to the experimental work:

(i) Deposition Method: Extensive use of electron beam evaporation method of deposition will be done along with Radio frequency magnetron sputtering in order to develop a proper sequence of efficient thin films.

(ii) Photovoltaics Near Infrared Sensor grade material development: Development of large grain sized (0.5-2 microns) thin films with minimum point defects, dislocations, grain boundaries and impurities etc.

(iii) Characterization of newly deposited thin films: To characterize the films we use following sequence

- ❖ We do surface roughness measurements with the help of WYKO 1000 NT profilometer.
- ❖ Absorption and reflection measurement of visible and infrared region of electromagnetic spectrum is to be done with spectrophotometer.
- ❖ Morphological study of thin films will be done with the help of SEM.
- ❖ Elemental analysis to detect impurities in the thin films will be done with EDS

POINTS OF IMPACT

- By optimizing doping constituents and deposition parameters development of larger grains to achieve higher mobility will be investigated, which is an important factor to increase the efficiency and reducing the cost

- The current stage of the research is on processing, characterization and modeling of large grain polycrystalline Silicon and Lead telluride based thin films deposited by multi-source electron beam gun (PVD).

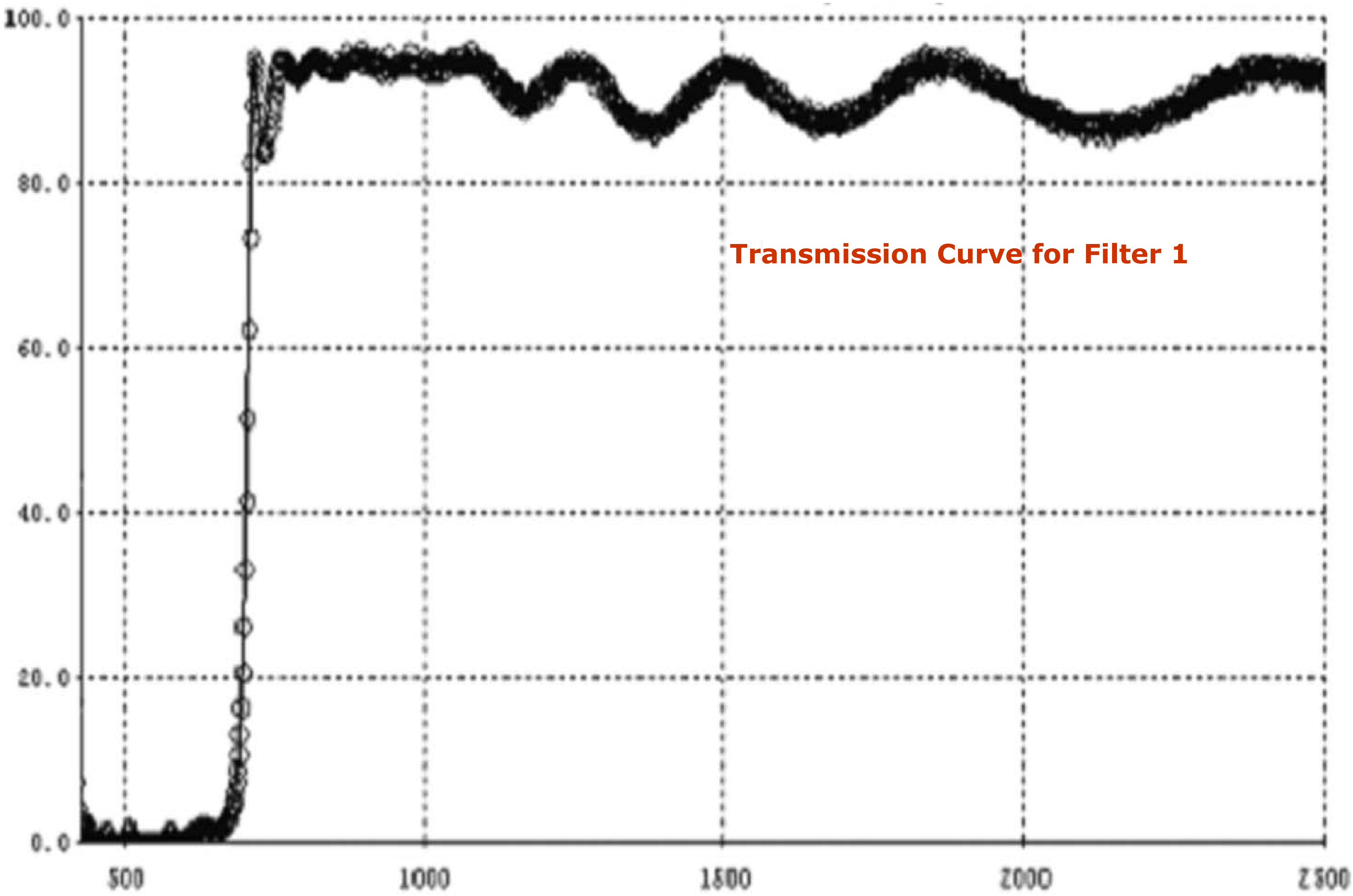
- The sputtering technique will be used at various stages of deposition to get technically improved multi-layers for higher efficiency.

A TYPICAL EXAMPLES OF OPTICAL FILTERS

Table 1 Design data for filter 1.

Long pass Filter reflects the visible spectrum from 450 to 650 nm and transmits IR heat from 750 to 2500 nm

Layer	Material	QWOT	Physical thickness (nm)
1	TiO2	0.5348	47.5
2	SiO2	0.5677	77.13
3	TiO2	0.9349	83.04
4	SiO2	0.6413	87.13
5	TiO2	0.7888	70.06
6	SiO2	0.721	97.96
7	TiO2	0.7586	67.38
8	SiO2	0.801	108.82
9	TiO2	0.7172	63.7
10	SiO2	0.7679	104.33
11	TiO2	0.7309	64.92
12	SiO2	0.7403	100.58
13	TiO2	0.7661	68.04
14	SiO2	0.7161	97.3
15	TiO2	0.6885	61.16
16	SiO2	0.6614	89.86
17	TiO2	0.5175	45.97
18	SiO2	0.5445	73.97
19	TiO2	0.4666	41.44
20	SiO2	0.6494	88.23
21	TiO2	0.6372	56.6
22	SiO2	0.6346	86.23
23	TiO2	0.6264	55.64
24	SiO2	0.557	75.67
25	TiO2	0.4865	43.21
26	SiO2	0.521	70.79
27	TiO2	0.6181	54.9
28	SiO2	0.9217	125.23
29	TiO2	0.2339	20.77



Transmission Curve for Filter 1

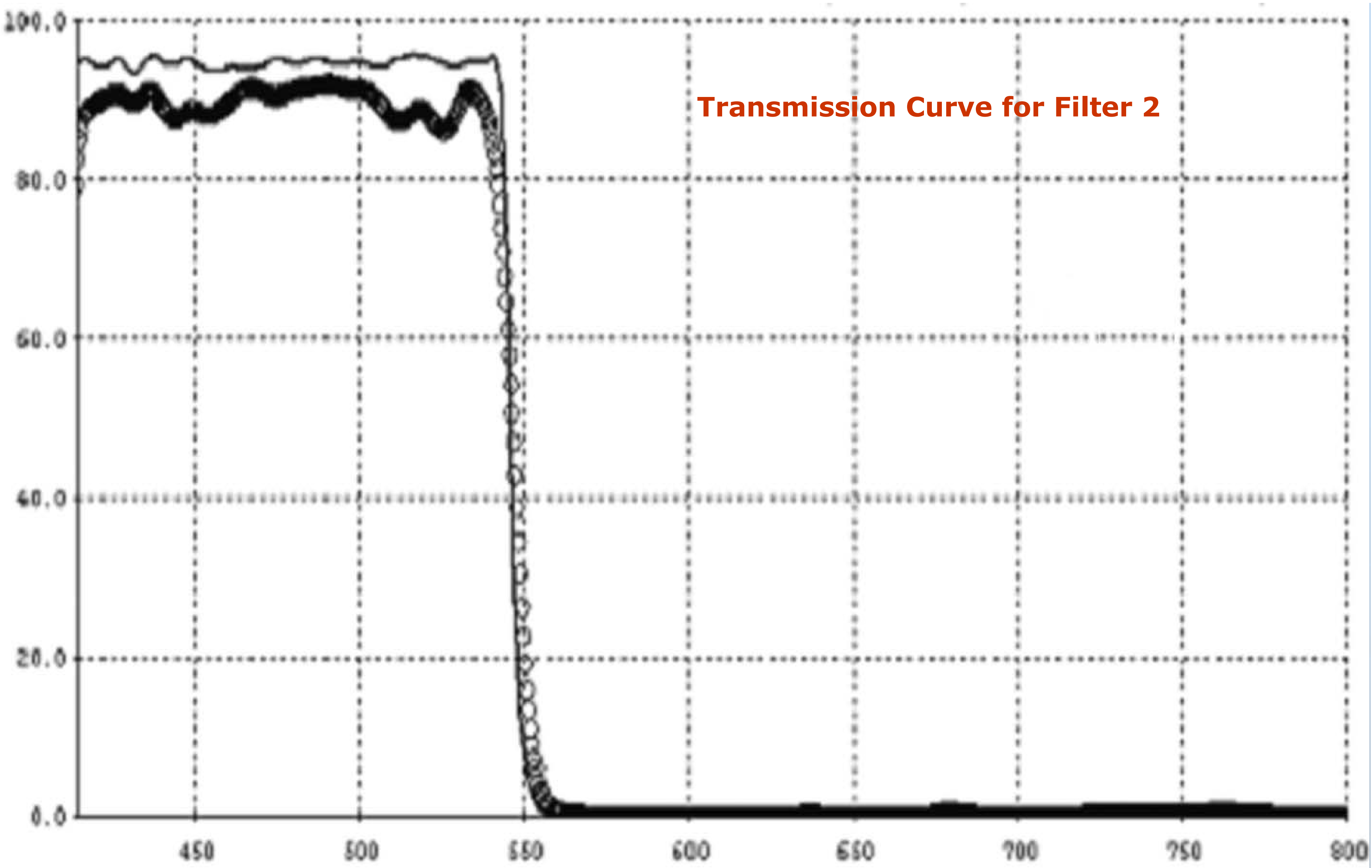
T% Vs Wavelength (nm)

Table 2 Design data for filter 2.

Short pass Filter allowing transmission from 415 to 540 nm up to 75% rejecting all other wavelength

Layer	Material	QWOT	Physical thickness (nm)
1	TiO2	0.3456	20.46
2	SiO2	1.8594	179.33
3	TiO2	0.6106	36.16
4	SiO2	1.689	162.89
5	TiO2	0.5804	34.37
6	SiO2	1.6978	163.74
7	TiO2	0.4026	23.84
8	SiO2	1.4065	135.65
9	TiO2	0.3456	20.46
10	SiO2	0.3174	30.61
11	TiO2	0.3456	20.46
12	SiO2	0.8945	86.27
13	TiO2	1.1462	67.87
14	SiO2	1.3873	133.79
15	TiO2	0.9062	53.66
16	SiO2	3.0163	290.9
17	TiO2	1.145	67.8
18	SiO2	1.1151	107.54
19	TiO2	1.2155	71.98
20	SiO2	1.2862	124.05
21	TiO2	0.4983	29.51
22	SiO2	1.7788	171.55
23	TiO2	0.3456	20.46
24	SiO2	1.2571	121.23
25	TiO2	1.2279	72.71
26	SiO2	1.1336	109.33
27	TiO2	1.1668	69.09
28	SiO2	1.2159	117.27
29	TiO2	1.2703	75.22
30	SiO2	1.44	138.87
31	TiO2	1.4702	87.06
32	SiO2	1.2907	124.48
33	TiO2	1.3257	78.5
34	SiO2	1.138	109.76
35	TiO2	1.3256	78.49
36	SiO2	1.3331	128.57
37	TiO2	1.437	85.09
38	SiO2	1.3968	134.71
39	TiO2	1.2907	76.43
40	SiO2	1.2368	119.29
41	TiO2	1.2345	73.1
42	SiO2	1.2961	125
43	TiO2	1.1982	70.95
44	SiO2	0.6796	65.54

Transmission Curve for Filter 2



T% Vs Wavelength (nm)

THANK YOU