elettrorava S.p.A.

MICROTEST
Equipment & Consumables for the semiconductors and hybrids

# THIN FILM DEPOSITION SYSTEMS

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# Who we are

## Elettrorava Company Profile

We design, develop, and manufacture Thin Films process equipment solutions for R&D, pilot and production applications. Our products include a complete array of turnkey solution, our competency help to develop also tailor made solutions based on our customers needs.

## People are our recipe

HIGH SPECIALIZED ENGINEERING

Engineering process is maintained in house in all phases.

Our customers need equipment that obtains high purity, conformal, dense and uniform coatings. To achieve this all engineering processes are monitored step by step, **from conception to commissioning**.

THIN FILM PROCESS KNOW-HOW

Thanks to our 35 years experience in thin film processes we support our client through all stages of development, testing and validation of the deposition processes. All machines supplied to our customers are accompanied by a process guarantee.

# Our Vision

Tomorrow will be a place where new technologies need a vertical integration of design, manufacturing, and process optimization. New materials and electronics will change people's life, and we will be part of this change.

#nanotec is the keyword!

# Our History

## Driving innovation since 1922

### 1922
**Company foundation**
Electromechanical workshop founded in Turin by Eng. Antonio Rava

### 1962
**Incorporated as S.p.A.**
Incorporated as S.p.A. and workshop transferred to Venaria, today's headquarter

### 1975
**Turbomolecular Pumps**
Introduction of High Vacuum Turbomolecular Pumps family ETP

### 1987
**Thin Film Systems**
First production of a complete thin film deposition system for R&D

### 1990
**Multi-chamber System**
Introduction of the first multi-process, multi-chamber fully automatic systems

### 2003
**Dual Ion Beam Sputtering**
Introduction of the first dual ion beam assisted sputtering deposition

### 2010
**Internal Lab**
Construction of new internal laboratory for process R&D and validation

### Today
**Large Size Wafer**
Introduction of a multi-chamber, multi-process system for up to 350 mm x 320 mm wafers

### Tomorrow

# Our Value Proposition

## More Value Less Complexity

### NEED

Our customers identify a need

### INVENTION

The solution of the identified need is clear

### R&D

The solution is implemented

### PILOT PRODUCTION

Testing the market response

### VOLUME PRODUCTION

Start producing high volumes

# Worldwide Customers

## Italian technology, international breath


40 years experience
15 countries
100+ systems active

# Our References

## Customers Satisfied Over the World

PECVD
France
Two PECVD Multichamber Cluster tool Systems for Photovoltaics applications

DIBSP
India
Dual Ion Beam Sputtering Deposition Systems for Laser Optics applications

EBD
France
Two Electron Beam Deposition Systems for R&D Applications

PECVD – CVD – RIE-SPUTTERING
Tunisia
Several systems for Energy Research

EBD
India
Two Electron Beam Deposition System and one Thermal Evaporation System for Aerospace

PECVD – ICPRIE System
Vietnam
Multi-chamber systems

PECVD
Netherlands
PECVD Multi-chamber Cluster tool System for Photovoltaics applications

PECVD
Netherlands
PECVD Multi-chamber Cluster tool Systems for Photovoltaics applications

PECVD
Romania
PECVD single chamber system

PECVD/HWCVD
Spain
Multi-chamber PECVD / HWCVD system

# Market Served

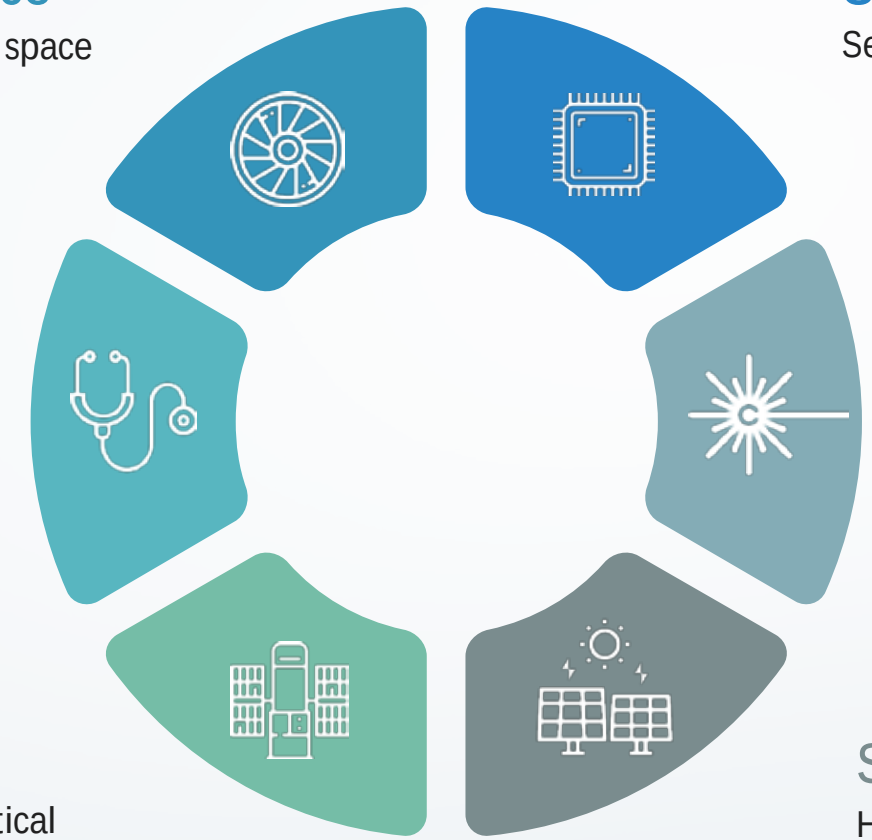
## Thin Film Application in Different Markets

### Aeronautic and Aerospace

Turbo engine blades coating, sensors, space components

### Semiconductors

Semiconductors, ICs, Mems and sensor



### Medical Equipment

Solutions for medical and orthodontic sectors

### Optoelectronics

Optoelectronic, LEDs, OLEDs and flexible displays

### Optical Coatings

Accurate and uniform coatings for optical applications

### Solar Photovoltaics

High performance and special applications

# Markets Solar Photovoltaics

## High efficiency and special applications

### Requirements

- High efficiency solar cells
- Large area solar cells
- Low weight, low cost per Watt produced

### Applications

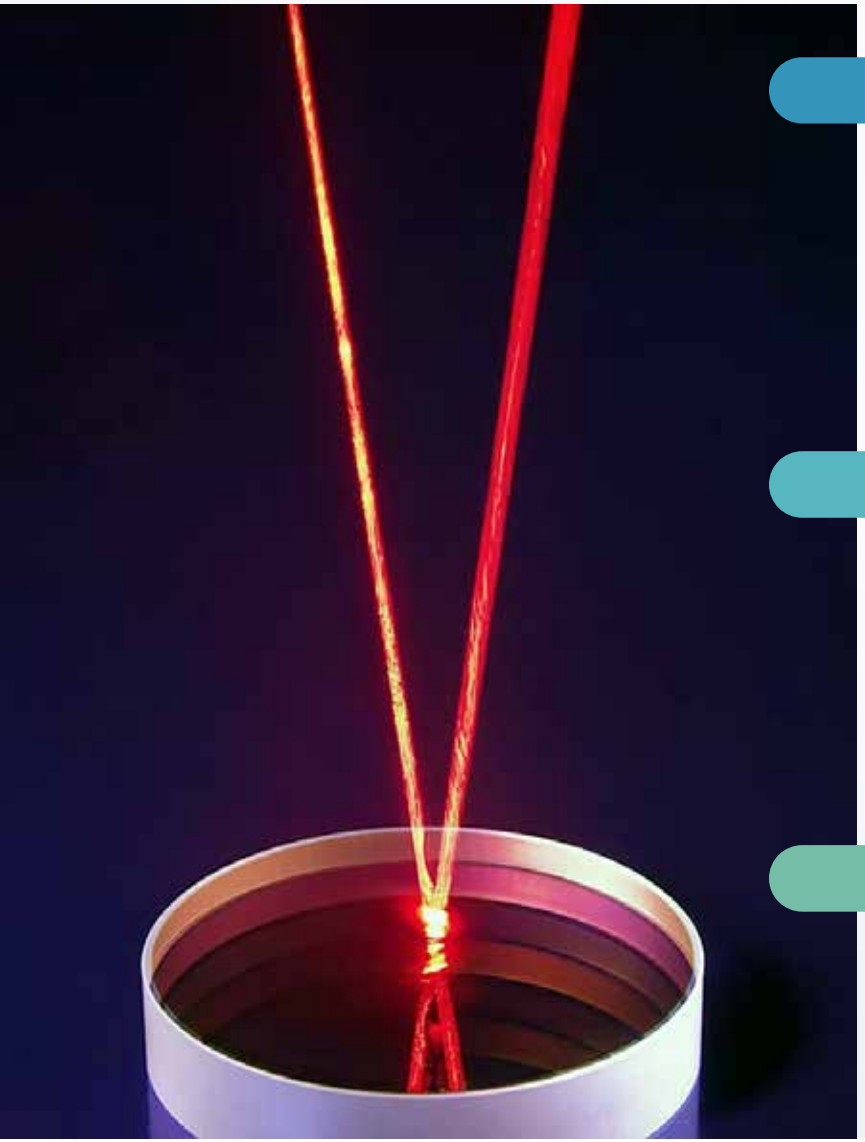
- Amorphous silicon solar cells with p-i-n structure
- Amorphous silicon alloys (SiC, SiGe) solar cells with tandem structure (2 x p-i-n)
- Heterojunction solar cells combining thin film silicon with polycristalline or crystalline Si wafers

### Technologies

- Plasma Enhanced Chemical Vapor Deposition for semiconductor thin layers
- Sputtering for deposition of Transparent Conductive Oxides as solar cell top and bottom contacts

# Markets Optical Coatings

## High reflectivity, uniformity and density thin films



### Requirements

- Extremely low absorption highly transparent materials
- High density materials with high laser damage threshold
- Very good uniformity over large surfaces
- Stoichiometric oxide materials
- Excellent adhesion

### Applications

- High reflectivity (>99.98%) dielectric multilayer mirrors at designed wavelengths (e.g. 633nm)
- Low absorption filters in a wide range of optical designs
- Optical devices with high laser damage threshold

### Technologies

- Dual Ion Beam Sputtering using one Sputtering Ion Beam Source and one Assist Ion beam Source
- Electron Beam Evaporation with assistance from one Ion Beam Source

# Markets Optoelectronics and Semiconductors

High efficiency systems, wide range of deposited materials

## Requirements

- Highly photoemissive materials
- High carrier lifetime materials
- Metals for contacts
- Transparent Conductive Oxides

## Applications

- Light Emitting Devices
- Thin Film Transistors for Large area Displays
- Small size Integrated Circuits

## Technologies

- PECVD
- Magnetron Sputtering
- PVD electron beam evaporation

# Markets Aeronautics and Aerospace

## Quality solutions for a complex market

### Requirements

- Reliability
- Repeatability
- Quality
- Endurance performances
- Work in extreme environment

### Applications

- Engine components
- Cockpit and Fuselage components
- Navigation systems
- Avionics

### Technologies

- CVD
- PECVD
- Sputtering
- PVD

# Markets Medical

## High performance and biocompatibility materials

### Requirements

- Reliability
- Repeatability
- Quality
- Endurance performances
- Biocompatibility

### Applications

- Orthopedic Implants
- Cardiovascular Devices
- Neurosurgical Devices
- Surgical Instruments
- In Vitro Diagnostic

### Technologies

- PVD
- Sputtering
- Ion implantation

# Our Scientific Committee

## R&D to meet tomorrow's challenges

Our scientific committee is the point of reference for our R&D projects, the resolution of complex problems and the validation of new processes. They represent our competencies at the service of our clients' challenges.

### Paolo Rava

Ph.D. @ MIT

R&D Director @ Elettrorava

He carried out research activities on the electrical and optical properties of crystalline semiconductors (silicon, gallium arsenide and indium phosphide) and on the conversion efficiency of photovoltaic solar cells.

### Pietro Mandracci

Ph.D. @ Trento University

Professor @ Politecnico di Torino

His main research interests deal with the study of the plasma-assisted modification of surfaces and the growth of thin-films and nanostructures. He is also involved in new applications of nanotechnology to biology, biomedicine, and to the energy savings/production industrial fields.

### Ruud E.I. Schropp

Ph.D. @ University of Groningen

Professor @ University of Western Cape

He authored more than 600 papers and 12 patents. Currently, his research interests are c-Si heterojunctions, next generation thin (nanostructured) films for photovoltaics, enhanced light coupling by plasmonics, nanophotonics, and photon conversion, and hybrid tandem solar cells.

### Caterina Summonte

MSc in Physics @ University of Bologna

Researcher @ IMM CNR

She has been responsible for her institution in two European research projects. She authored about 120 articles in international Journals. Her main interest is the optical characterization of thin film and nanostructured materials.

# Our CVD Technologies

## Production and R&D Systems Solutions

### PECVD
Plasma
Enhanced
Chemical
Vapor
Deposition
(RF, VHF, MW)

### MOCVD
Metal
Organic
Chemical
Vapor
Deposition

### ICP - PECVD
Inductive
Coupled
Plasma
PECVD

### HWCVD
Hot
Wire
Chemical
Vapor
Deposition

### ECR - PECVD
Electron
Cyclotron
Resonance
PECVD

### ALD
Atomic
Layer
Deposition

### HTCVD
High
Temperature
Chemical
Vapor
Deposition

# Our PVD Technologies

## Production and R&D Systems Solutions

### SPUTTERING
Magnetron
Sputtering
Deposition

### MULTI SPUTTERING
Multi
Magnetron
Sputtering
Deposition

### DIBSD
Dual
Ion
Beam
Sputtering
Deposition

### LASER SPUTTERING
Laser
Sputtering
Deposition

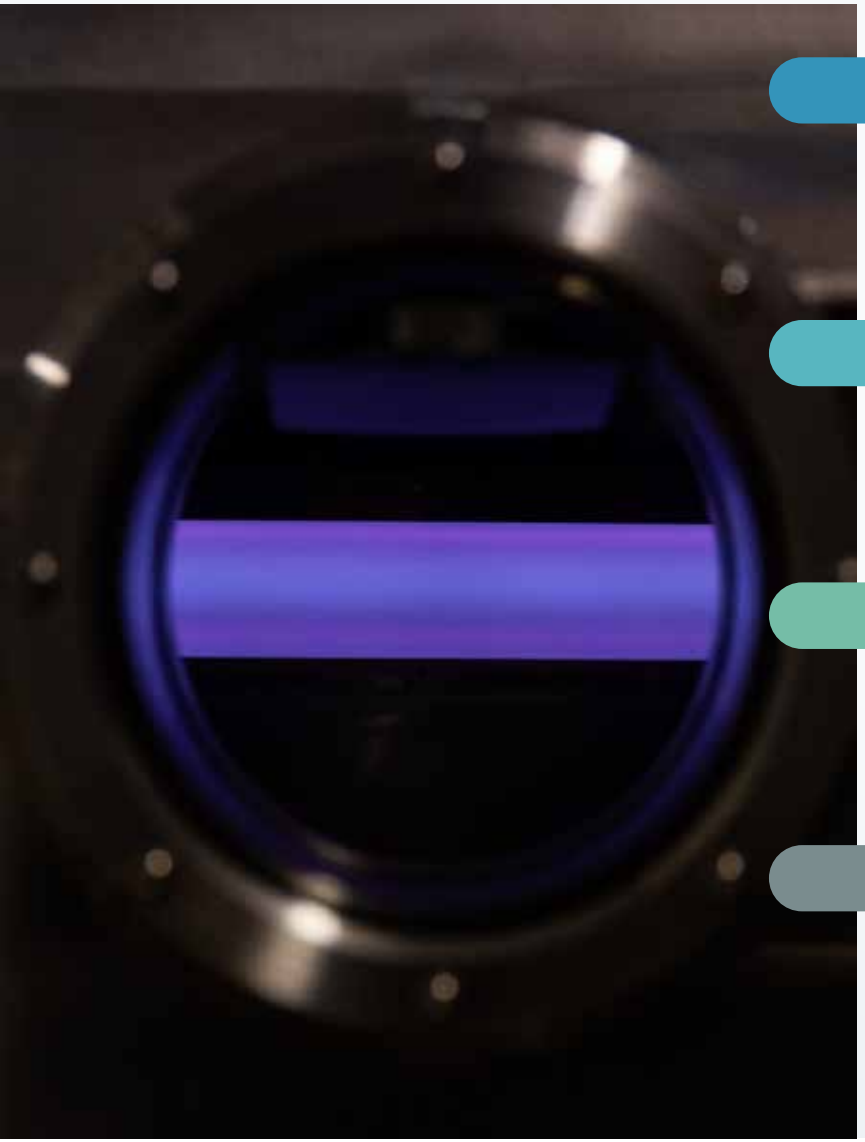
### EBD
Electron
Beam
Deposition

### TE
Thermal
Evaporation

### IBAD
Ion
Beam
Assisted
Deposition

# Our Products

## High reliable and top selling quality systems



### THIN FILM DEPOSITION STANDARD SYSTEMS

We supply a complete array of machines for Thin Films Deposition testing and production. Our products portfolio includes both PVD and CVD solutions from Sputtering, Ion Beam, Electron Beam to Plasma Enhanced CVD through Evaporation systems.

### TAILOR MADE SYSTEMS

Although having a line of standard systems, we pay special attention to specific customer needs, offering complete tailor made systems designed to achieve the performance required by the customer and provided with a process guarantee.

### MULTI PROCESS, MULTI CHAMBER SYSTEMS

In order to satisfy the need to obtain products through deposition with different technologies, we are able to design and build multi-process machines able to operate automatically both in sequential and single mode.

### TURBOMOLECULAR PUMPS AND VACUUM UNITS

We produce turbomolecular pumps in a wide range of pumping speed that may be supplied both as stand alone components and as part of complete pumping units including primary pumps, valves, gauges, etc.

# Products Thin Film Standard Systems

## Three product lines to meet customer's needs

We have a range of standard machines capable of meeting all the most stringent requirements of our customers. Our equipment utilizes the best vacuum and electronic components for long-term reliable operation with minimal maintenance.

### PVD Series

- UHV capability ($10^{-9}$mbar) or HV capability ($10^{-8}$mbar)
- Substrate size from 5 cm up to 30 cm
- Process temperature: from room temperature up to 600°C
- Deposition sources (stand alone or in combination):
  - Single crucible or multi-crucible electron beam source (6,10 and 15 KW)
  - Thermal evaporation Joule effect sources
- Heated substrate rotation at variable speed
- Turbomolecular / cryogenic / TSP pumping
- Quartz Crystal Thickness Controller
- Optical Thickness Monitor

### S Series

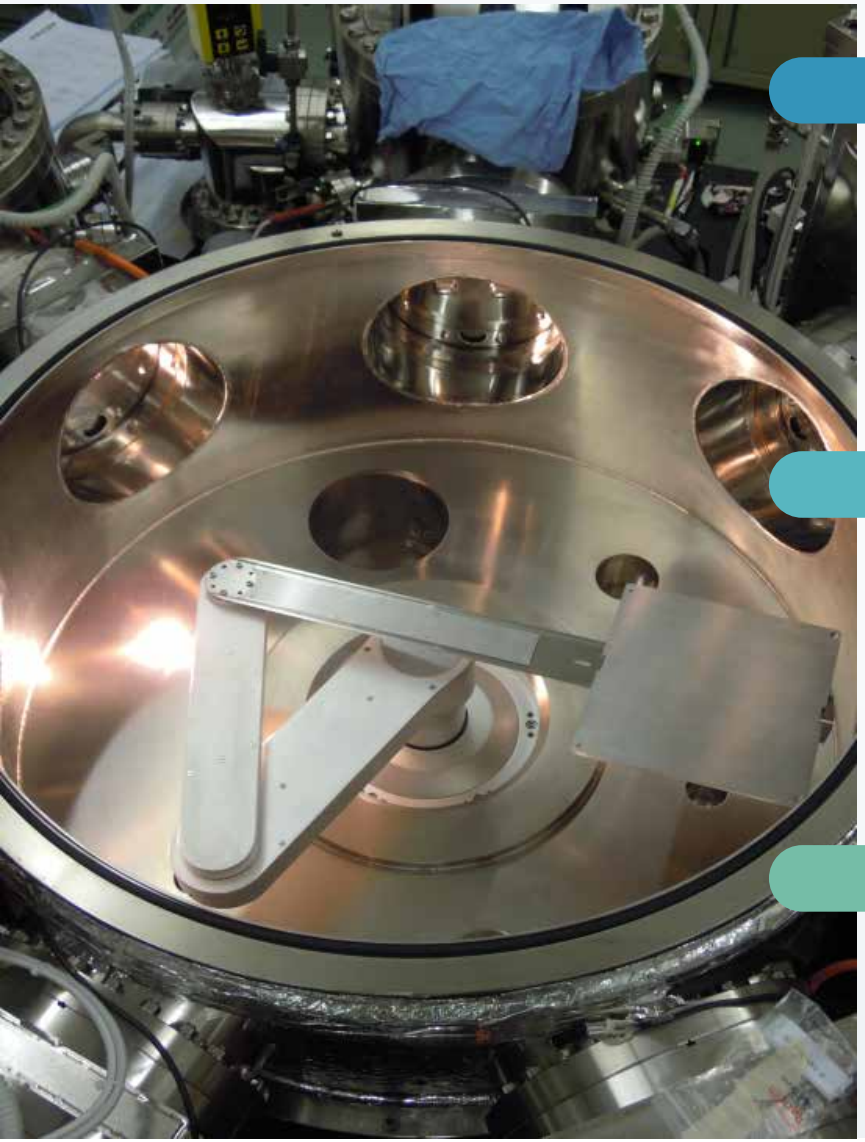
- UHV capability ($10^{-9}$ mbar) or HV capability ($10^{-8}$mbar)
- Substrate size from 5 cm up to 30 cm
- Process temperature: from room temperature up to 600°C
- Deposition sources (stand alone or in combination):
  - Magnetron sputtering cathodes
  - Ion beam sources for sputtering, assisting and substrate etching
- Heated and tilted substrate rotation at variable speed
- Turbomolecular / cryogenic / TSP pumping
- Quartz Crystal Thickness Controller
- Optical Thickness Monitor

### CVD Series

- UHV capability (10-9 mbar) or HV capability ($10^{-8}$mbar)
- Direct or remote plasma excitation by RF, VHF, MW or ECR
- Dedicated or additional Hot Wire CVD
- Substrate size from 10 cm x 10 cm up to 32 cm x 35 cm
- Process temperature: standard up to 400°C, optional up to 1000° C
- Modular process gas manifold with mass flow controllers
- Automatic process pressure control by throttle valve and capacitance manometer
- Turbomolecular pumping for ultimate vacuum and during process
- Deposited material quality and homogeneity guarantees

# Products Multi Process Systems

Configured by customers



## Main Features

- Several process chambers (up to seven) based on one or more techniques (PECVD, HWCVD, Sputtering, etc.)
- Transfer of substrate under high vacuum from one process chamber to another in any sequence
- Load Lock chamber for substrate loading under vacuum, with automatic multi substrate feeder cassette
- Separate pumping units and gas manifolds for each process chamber to avoid cross contamination

## Applications

- Applications: thin film multilayer devices based on a-Si:H, µc-Si:H, a-$Si_xC_y$:H, µc-$Si_xC_y$:H, a-$Si_xN_y$:H, µc-$Si_xN_y$:H (solar cells, sensors, LED's, TFT's etc.)
- Substrate size from 10 cm x 10 cm up to 35 cm x 32 cm

## Process Guarantees

- Process guarantees for optimum specific device properties (semiconductor materials and electronic devices, metals, optical materials, etc.) can be offered

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# Products Turbomolecular Pumps

## From 1975 high quality vacuum components

High pumping speed combined with relatively low rotation speed give our turbomolecular pumps high efficiency and operability, reducing the risk of breakage. All models can also be produced in corrosion resistant version.

The pumps are controlled by ETC series electronic control unit, that can be configured with RS-232, RS-485 or ProfibusDP connection.

| MODEL | | ETP 300 | ETP 450 | ETP 1000 | ETP 6000 |
|---|---|---|---|---|---|
| Pumping Speed $N_2$ | (l/s) | 330 | 460 | 1000 | 5500 |
| Pumping Speed $H_e$ | (l/s) | 340 | 520 | 1150 | 6000 |
| Pumping Speed $H_2$ | (l/s) | 300 | 480 | 1100 | 5000 |
| Ultimate pressure | (mbar) | $5 \times 10^{-10}$ | $5 \times 10^{-10}$ | $5 \times 10^{-10}$ | $5 \times 10^{-10}$ |
| Rotational Speed | (rpm) | 42000 | 36000 | 36000 | 14000 |
| Inlet Flange | | DN160ISO DN160CF | DN160ISO DN160CF | DN200ISO DN200CF | DN500ISO |
| Lubrication Type | | Grease | Grease | Grease | Oil |
| Operating Position | | Any | Any | Vertical up or down | Vertical up |

# Our Services

## Customer Centered Solutions

### INTERNAL APPLICATION LABORATORY

Our staff are trained to identify all key aspects of new process study and validation. Our engineers can help to optimize the system performance whether you are developing a new deposition process, or re-engineering an existing one.

### CUSTOMER SUPPORT

Our customer support department take care of all our systems from commissioning to end of life, ensuring constant and continuous operation. We offer ready on stock spare parts with fast delivery, staff training and technical operation all over the world.

### RETROFIT AND TECHNICAL SERVICIES

Our technical knowledge also enables us to operate on existing systems by engineering their technological upgrade and adapting them to the process required by the customer.

### COLLABORATION AND R&D

We offer collaboration for national and international research projects with University or other private companies, participating to European fund raising.

# Services Our Laboratory Facilities

## Internal R&D capability

Our laboratory is equipped with systems that cover the major technologies and is used by our technicians for research projects, customer servicing and validation of new processes.




### PECVD

- Deposition area up to 1 x 1,3 mt
- Substrate height up to 5 mm
- Gas type: SiH4, H2, CH4, PH3, B2H6 , N2O
- Temperature: 100-400 °C

### SPUTTERING

- Deposition area up to 50 x 50 cm
- Substrate height up to 5 mm
- Gas type: Ar, O2
- Temperature: 100-300 °C

### THERMAL EVAPORATION

- Deposition area up to multiple substrates 15cm x 15cm
- Substrate height up to 5 cm

### ELECTRON BEAM

- Deposition area up to multiple substrates 15 x 15 cm or 200 mm diameter
- Substrate height up to 5 mm
- Gas type: Ar, O2
- Temperature: 100-300 °C

# Services Co-R&D

## Enabling Innovations

### R&D for innovation

We believe in innovation, through continuous research and development projects carried out with our partners.

As technologies advance, challenges lead us to solve increasingly complex problems that can be tackled through experience and an open innovation approach.

In past years we carried out more than ten research project with our customers and partners.

### Partnership

Over the years we have built a network of partners of primary importance and specialized in scientific research in the field of thin film deposition. This network includes leading Italian and European universities and institutional research centers.

### More value

Thanks to our R&D service we add value to our customers' solutions, supporting them during the initial process testing, certification and optimization during the entire machine production life.

# Services Process Validation & Guarantee

## Our Competencies at your Service

We have the expertise to guarantee the results required by our customers, both in the field of production and scientific research. Before our systems leave the factory they have been tested and validated and are delivered with a guarantee of the process for which they were built.

### PRE OFFER TEST

Realization of samples during the bidding phase to validate the proposed solution

### SYSTEM ENGINEERING

Design, manufacturing and assembly of the systems in our mechanical workshop

### OPERATING TEST

Deposition of samples for customer validation and process certification

### GUARANTEE

The equipment is shipped and assembled at the customer's facility with process guarantee

# Competence and quality for our solutions

How to win the market leadership

## R&D partners

POLITECNICO DI TORINO
MATERIALS SCIENCE DEPT.

IMM Institute for Microelectronics and Microsystems
National Research Council of Italy

## Automation

MITSUBISHI ELECTRIC
Changes for the Better

SMC
Expertise – Passion – Automation

## Primary vacuum

PFEIFFER VACUUM

## Other systems

mks

SEREN Industrial Power Systems

InstruTech® Inc.

# Showcase 1 Multi-Process, Multi-Chamber

## Different Processes – One Solution

Multi-chamber system with one load-lock chamber for substrate holding, one transfer chamber with cluster tool robot for substrate transfer. Three to Seven Deposition Process Chambers based on RF-PECVD, ICP-PECVD, ECR-PECVD, RIE, Sputtering.

### MULTIPLE WAFERS

Automatic wafer feeder with Upward or Downward deposition of thin films.

### PURITY GUARANTEE

Turbomolecular pumping for ultimate vacuum and dry pumping for clean process


### HIGH THROUGHTPUT

Gas Cabinet with multiple panels with up to 50 MFCs and independent operations for each chamber (pumps, MFCs, RF generators)

### FULLY AUTOMATED

Complete automation control with recipe and real time operation

# Showcase 2 Dual Ion Beam Sputtering

## High quality and flexibility equipment for optical coatings

The basic DIBS (Dual Ion Beam Sputtering) system has two independent ion sources, one ion source for sputtering (IBS) the material from the target and another ion source for pre-cleaning of the substrate and ion-assisted deposition (IAD). The assist/etch source can fulfil various functions: it can be used to etch the substrate; it can provide “assistance” to the deposition process by bombarding the depositing film with energetic ions which can improve or modify the film properties or stoichiometry by physical and/or chemical effects; it can also be used as a low-energy pre-clean of the substrate prior to deposition.

### DEPOSITED MATERIALS

Oxides: Al2O3, Ta2O5, SiO2 and TiO2

Nitrides: Si3N4, etc.

Other: MgF2, LaF3, Nb2O5, ZrO3, Y2O3, HfO2, YF3 etc.

### OPTIMIZED TARGET EXPOSURE

Rotating target for a better etch result with an automatic variable position and incidence by rotation. Plus a continuous automatic oscillation of angle while depositing.

### FILM THICKNESS

Planetary substrate holder with automatic rotation function during deposition.

### BEAM CONTROL

The beam is controlled by a three grid system that helps beam collimation, suppresses electron back-streaming and reduce redeposition of sputtered material back inside the source.

# Showcase 3 Electron Beam Deposition

## Multiple crucibles electron beam evaporation systems

Electron beam deposition systems can be stand alone or assisted by ion beam for optical coatings. In this application the electron beam is the main deposition source and the ion beam source is used both for preclean and assist during deposition process. This combination, including the possibility of high vacuum in the chamber, allows a uniform deposition with a guarantee of high purity and absence of inclusions between layers. This technology is used for optical coatings in industrial, aerospace and military applications.

### CONFIGURABLE SOURCES

Single or Dual Electron Beam source, assisted by an Ion Beam Source for assist and preclean.

Optionally Thermal Sources and Magnetron Sputtering Cathodes.

### MULTIPLE MATERIAL EVAPORATION

Crucible indexer for selection and deposition of multiple materials


### FILM THICKNESS

Planetary substrate holder with automatic rotation function during deposition.

### DEPOSITION CONTROL

The deposition rate from the electron beam source is controlled by the Quartz Crystal Thickness Controller with a PID loop on the emission current of the beam

# Showcase 4 PECVD

## Plasma Enhanced Chemical Vapor Deposition Multi-chamber systems for large substrates size

A modular multi-chamber PECVD system for deposition on substrates with size from 10cm x 10cm up to 35 x 32 cm , separate Load Lock with pre heating with thermal radiation lamps, automatic robot for substrate handling between process chambers. The system is designed to prevent incorporation of residual impurities and cross contamination between different layers. The possible applications are R&D and small production of flexible OLED display, photovoltaics cells, LEDS, semiconductors and more.

### CONFIGURABLE HEIGHT

Configurable electrode height from 15 to 50 mm to the substrate holder in each chamber

### WIDE MATERIALS RANGE

Wide range of deposited materials as follows:

- Intrinsic and doped a-Si:H
- Intrinsic and doped µ-Si:H
- Silicon alloys such as SixCy:H, SixNy:H, SixOy:H


### FILM UNIFORMITY

The design of the electrode and the purity allowed by the HV system guarantee state of the art deposited layers with a thickness standard deviation uniformity < ± 2,5 %

### FLEXIBLE WORK FLOW

Each chamber can work independently or in a batch recipe for multilayer depositions

# Contact us

## Headquarter and Representatives


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