ENHANCED PLASMA ABLATION (EPA)

- *EVAPORATION OF ALMOST EVERY MATERIAL POSSIBLE*
- *COST EFFECTIVE PRICING*
- *HIGH VACUUM DESIGN*
- *RUGGED IN CONSTRUCTION*

Essentially EPA is a new process in which a highly energized plasma beam sublimes some microns of a solid or liquid target in few nanoseconds.
EPA, because of its unique characteristics, is emerging as a popular physical vapor deposition (PVD) technique to grow a wide variety of chemically and structurally complex materials.
Because all the segment of the target is ablated in few nanoseconds into an energetic plume of material, the target stoichiometry is usually transferred readily to the substrate.
This process also has high kinetic and internal energy of the ablated species and the ability to operate in a variety of background gases over a very wide pressure range (from 3 to 10E-5mbar)

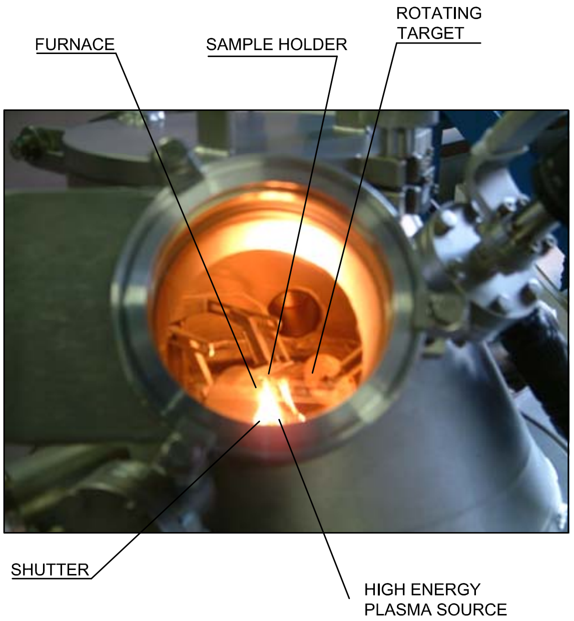
In the past similar techniques have been used for the production of high quality thin films of several complex materials that would be difficult or impossible by conventional PVD or chemical vapor deposition (CVD) techniques. Because of the high forward directionality of the ablated plume in EPA, scale-up of this process to coat substrates of useful size was once considered doubtful. However, different approach has been developed to uniformly cover large areas. Deposition over substrates up to 200mm have been demonstrated with a uniformity in thickness maintained below of ± 5%.

Practically all materials may be evaporated: the main feature of EPA is to produce high power density at the target surface (10^8 W/mm²) comparable to pulsed laser deposition (PLD), but the PLD process is critically dependent on the optical absorption coefficient of the target material.

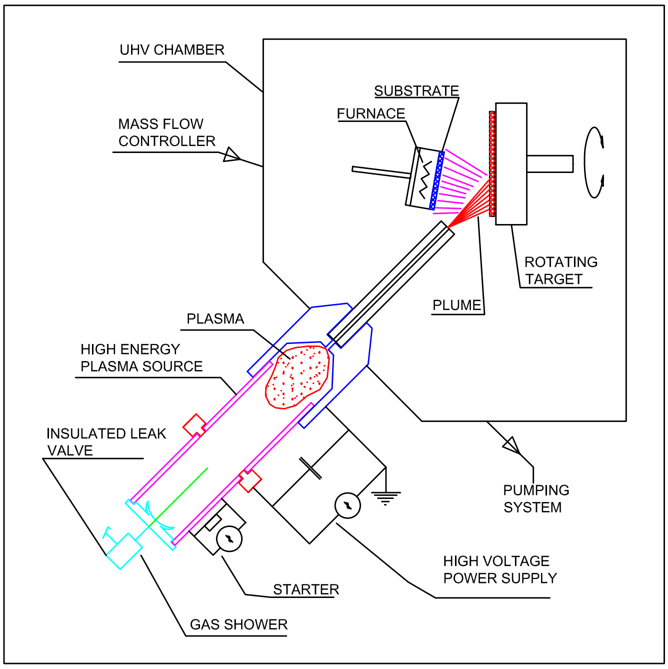
SiO_2 with a large band gap of 10eV for example, is transparent to the excimer laser radiation; in EPA technique, however, the high-power electrons may strongly couple to the SiO_2 target, leading to SiO_2 film deposition.

EPA system is able to deposit conducting and not conducting materials with deposition rates ranging from 0.01 Å/pulse up to about 100 Å/pulse.
Additional modification, like cathode and target cooling and others could significantly increase the deposition/ablation rates by, perhaps, order of magnitude.
With EPA, reduction of energy consumption cost of 2 order of magnitude is verified while the installation costs are more than 5 times cheaper than commercial PLD setups.

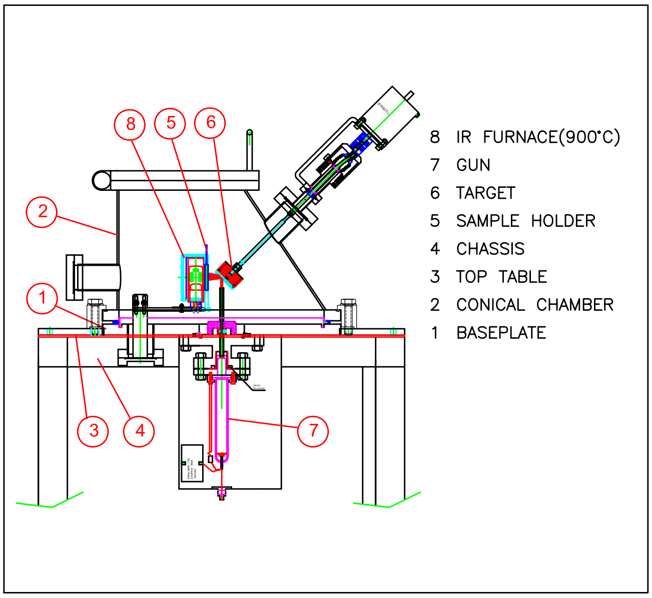
View through DN100 hublot



Principle scheme



IBCO Deposition chamber



APPLICATIONS

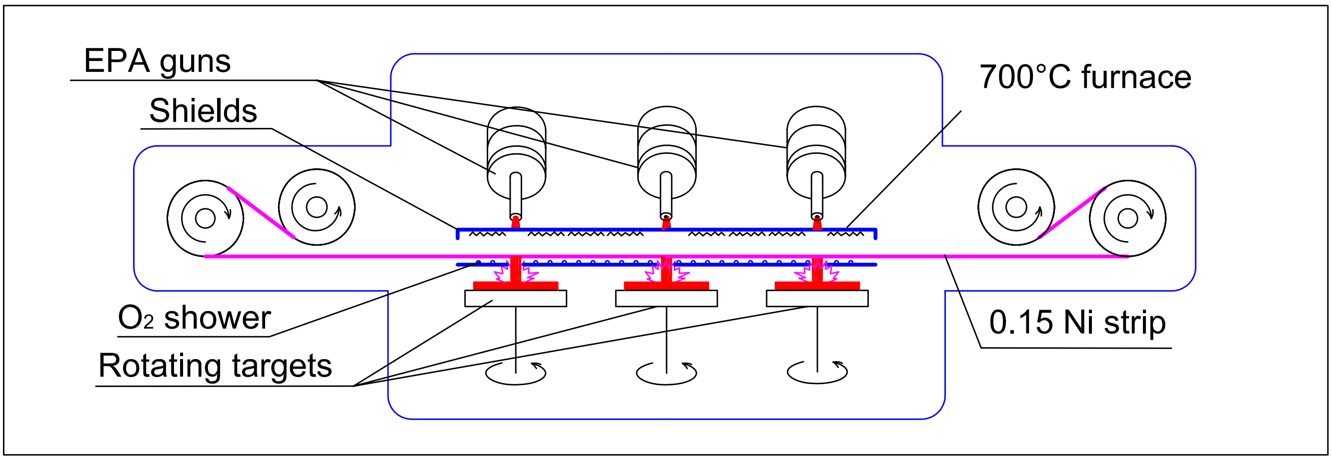
Colossal Magnetoresistence Manganites are an example of good results in deposition of epitaxial superconducting or ferromagnetic films with EPA technique.

Buffer oxide layers in a wide variety have been obtained, replacing laser ablation in thin film technology.

Other examples of representative materials produced by EPA:

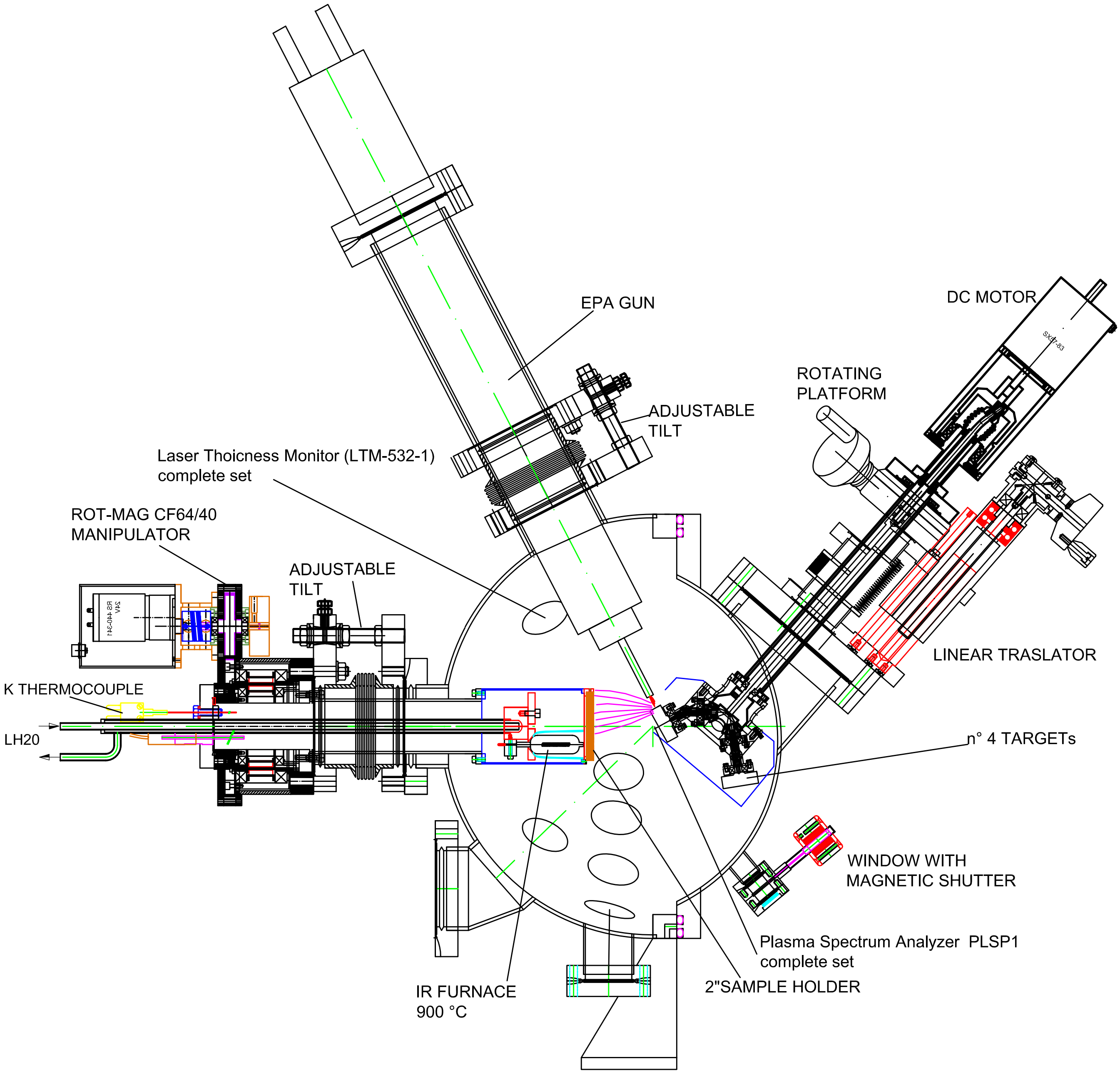
- YBCO, GdBCO high temperature superconducting films (operating temperatures at 90K are known)
- $BaSrTiO_3$ films
- SiO_2 compounds and Al_2O_3 ceramic oxide films

Thermovoltaic systems, SWCNT nanotubes, photonics materials are investigating this new technology.



ROLL TO ROLL SYSTEM for superconducting coating on nichel strip

CHAMBER OF SiC SYSTEM



EPA-5   2"sample holder-1kW IR furnace

Power supplies and controls for target

EPA-1 SYSTEM

EPA-1 System has been designed to indagate and produce a wide range of materials as high temperature oxides, complex alloys ,organic compounds. This ablation process generates a good stoichiometric deposition.

SPECIFICATIONS

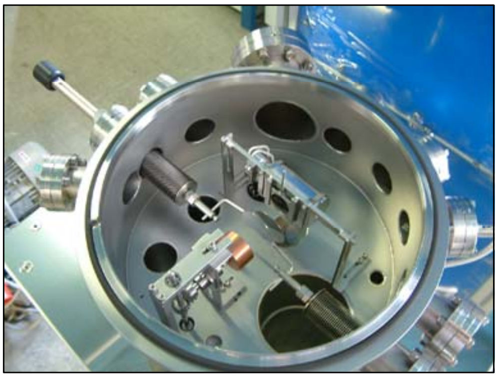
Chamber
size: spheical shape, DN350 base flange
quick port for sample operations
operating pressure: 2x10^-2 to2x10^-5mbar
lead glass DN100 viewport with magnetic shutter
sample shutter with push-pull translator

Substrate
heater: max temperature 800°C
temperature uniformity: better than 2°C
diam surface: 25/50mm
adjustable support structure
temp measurement: thermocouple K
temp controller: programmable auto-tuning PID temperature controller

Plasma source
power supply: 230V-50Hz-single phase
DC voltage: 8 - 25kV
operating pressure: 2x10*-2 to 2x10*-5mbar
power pulse density: 4 - 600MW/cm^2
max repetition rate: 100Hz
ablation depth: 0.5 - 2 micron
gas inlet: 2 - 100 scc/min

Target
1" diam rotating target
option: 4 x 1" diam targets
rotation speed: 0-30rpm
deposition rate:100/2000Angstrom/minute

Gas manifold
mass flow controller: 2 - 100 scc/min
single channel display and control



Superconductor film chamber

Vacuum system
70 l/s turbodrag pump
16 m^3/h rough pump with trap
vent valve for purge
pirani/penning vacuum gauge

System frame
Bosch Al profiled with levelers
sizes: length 1166mm
width 578mm
height 1160±50mm
power: single phase 230VAC - 50Hz - 20A

SPECIAL DESIGN

VACUO in collaboration with CNR laboratories and OS continues to expand the application of EPA to improve production of advanced materials as superconductors, SiC, peroskvites, SWCNT, oxides, organic materials.
Please contact VACUO for specific infomations on new processes and research machines.

Tilt-rotating target-magnetically coupled

COMPARISON BETWEEN EPA AND OTHER METHODS

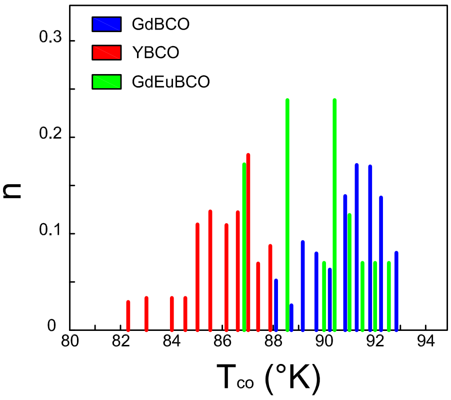
	Stoichiometric transfer	Chemical purity	Deposition rate variability	Flexibility to target material choice
EPA Enhanced Plasma Ablation	good	good	good	good
Magnetron sputtering	bad	good	good	good
PLD Pressure Liquid Deposition	good	good	bad	bad
CVD Chemical Vapor Deposition	good	bad	bad	very bad

MATERIALS DEPOSITED BY ENHANCED PLASMA ABLATION

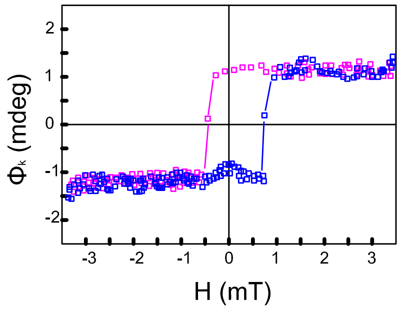
1. High - T_c superconductors: $YBa_2Cu_3O_7$,$SmBa_2Cu_3O_7$,$GdBa_2Cu_3O_7$

   Main achievements:
   $T_{co} > 92°K$, $I_c = 2 - 4 \times 10^6$ A/cm²
   Ultrafast deposition rate: 60 Å/s
   Direct growth of superconducting films on Ni tapes

   Distribution of the zero resistence Tc over a statistical sample of 106 films deposited in one month. *n* is the number of films showing
   -0.5K <Tc < +0.5K divided by 106



2. Colossal Magnetoresistance Manganite films ($La_xSr_{1-x}MnO_3$, $La_xCa_{1-x}MnO_3$, $Pr_xCa_{1-x}MnO_3$) on various substrates: $NdGaO_3$, $SrTiO_3$, Si ,SiO_x ,and GaAs
   Main achievements:
   T_{Curie} = 350K,100% Spin Polarisation at room temperature in $La_xSr_{1-x}MnO_3$
   $La_xSr_{1-x}MnO_3$ and $La_xCa_{1-x}MnO_3$ successfully used in OLEDs
   Prototype of memory elements $La_xSr_{1-x}MnO_3$ - organic - $La_xSr_{1-x}MnO_3$ fabricated



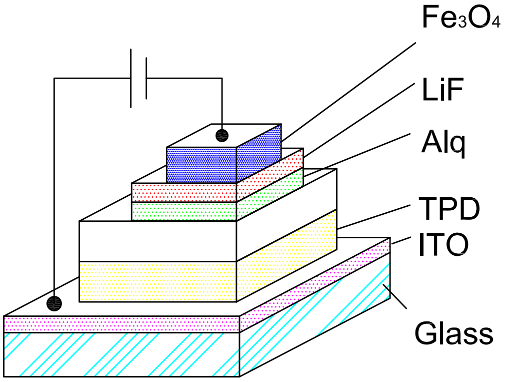
MOKE - Room Ferromagnetism

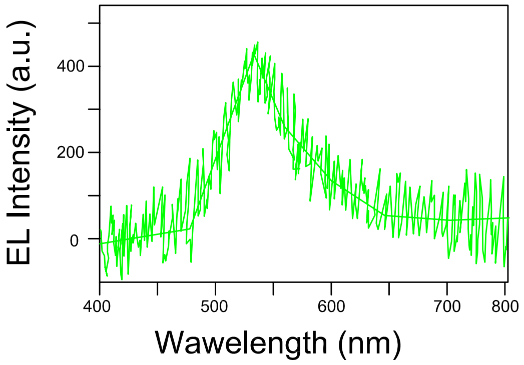
LN2 sample holder and 4 target

3. Magnetite FeO_4 films on both inorganic and organic substrates

   Main achievements:
   First time deposition of high quality magnetite films directly on layers of organic semiconductors for spintronics applications

First demonstration of working OLED with top magnetite electrode





4. Variouse simple and double oxides (AlO_x, TiO_x, CeO_x, $SrTiO_3$, $NdGaO_3$)

   Main achievements:

   Epitaxial growth of $SrTiO_3$ and $NdGaO_3$ on perovskite substrates
   High density for AlO_x ultra thin films for FET applications:
   leak currents less than 10^{-9} A at 100 V for 10 nm thick layers

5. Hard coating SiC

   Main achievements:

   High ablation rate
   Surface hardness of about 50% of the single crystal values

6. Transparent conducting oxides (TCO), IMO, ...
7. Organic materials: Teflon, Polyethylene, ...
8. Thin film depositions performed by EPA
   - CdS
   - CdTe
   - ZnO
   - WC
   - HfO_2
   - GaN
   - In_2O_3
   - ZrO_2
   - SiO_2
   - AlO_2
   - TiO_2
   - ZnO;Al_2O_3
   - Al
   - W
   - Cu
   - Ti
   - Stainless Steel
   - Polyethylene

DEVELOPED EPA SYSTEM FOR INDUSTRIAL APPLICATION

Extremely high deposition rate
High film thickness homogeneity
Low temperature deposition capability on plastic or "heat degradating" materials
Wide area implementation deposition system
Easy integration of EPA-GUNs module in thin films industrial production line
Safe and sustainable fabrication process