PLD and PED Components

- Oxygen compatible Substrate Heaters for epitaxial oxide film depositions.
- Automated Target Carousels for preparing multilayer heterostructures.
- Custom-designed Deposition Chambers for PLD and PED.
- Manual and Automated Laser Window-change Accessories.
- Pulsed Electron Deposition (PED) sources for laser transparent materials.
- Ideal for retrofitting existing Systems or construction of new Systems.

NEOCERA

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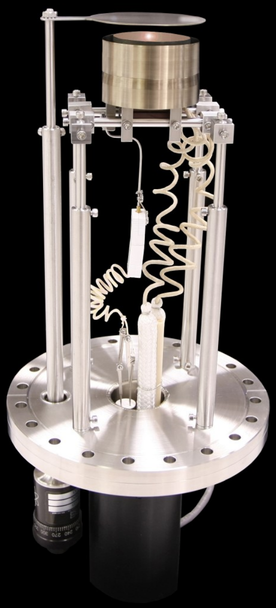
Conductive Substrate Heaters

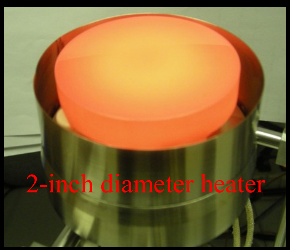
Substrate Heaters play an important role in achieving optimum film properties via growth kinetics. In the case of epitaxial oxide films, oxygen compatibility is also critical as the films are normally deposited in a high-partial pressure of Oxygen (up to 500mTorr) and at relatively high temperatures (around 1000˚C). With these requirements in the forefront, Neocera developed a variety of Substrate heaters. Research requirements demand flexibility in the features (maximum temperature, size, system compatibilities, cost etc) and hence the need for an assortment of heaters.

1. Conductive substrate heaters:

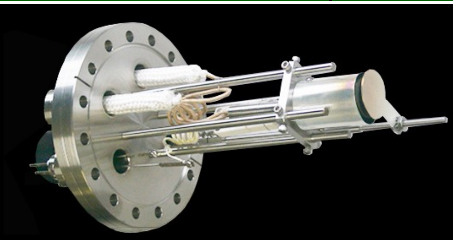
In this case, the substrate is in direct contact with the heater plate. The primary heat transfer mechanism is thermal conduction. The substrate is attached to the heater plate either by silver thermal paste or by mechanical clips. Silver paste bonding will provide the maximum substrate temperature possible (950˚C) where as mechanical clips can be used when lower temperatures are acceptable (650-700˚C and below). Following are the technical specifications of Neocera Conductive substrate heaters.

	Feature	Details
1.	Maximum Substrate Temperature	950˚C.
2	Heater sizes	2” diameter is standard. 1”, 3” and 4” diameter heaters are available on request.
3.	Oxygen compatibility	Up to 1 atmosphere (760Torr) of oxygen.
4.	Temperature control	Heater temperature is controlled by a programmable PID temperature controller. K-type thermocouple is integrated. Phase-angle fired power supply is included.
5.	Temperature stability	+/- 1˚C
6.	Temperature Uniformity	+/- 5˚C
7.	Mechanical adjustability	Heater is mounted on an XYZ support Structure; XYZ adjustments are *exsitu.*
8.	Other features	• Pre-ablation shutter is included. • The temperature controller can be integrated with Neocera system software (Labview 2013).





2-inch diameter heater



1-inch diameter heater, flange mounted

Temperature controller with phase fired power supply

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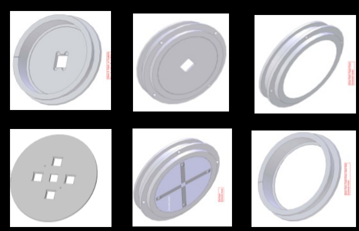
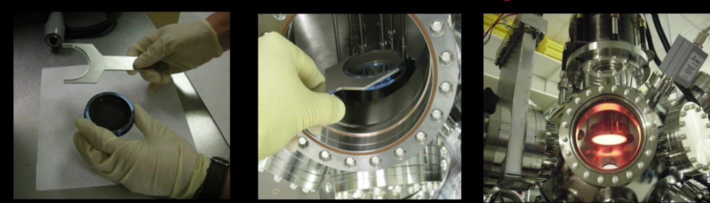
Radiative Substrate Heaters

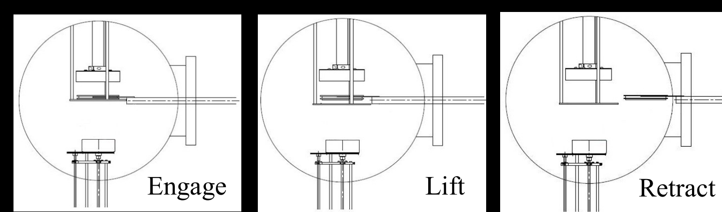
Neocera Radiative Substrate Heaters provide a maximum substrate temperature of 850°C. The heaters are UHV compatible and also Oxygen compatible up to a maximum of 1 atmosphere of Oxygen. The radiative heating element is a resistive coil with a maximum working temperature of 1050˚C, facilitating a maximum substrate temperature of 850˚C. The primary heating of the substrates is through radiation from the heating coil. K-type thermocouple laser-welded to the heating coil provides input to the PID temperature controller. The actual substrate temperature is measured by a calibrated external pyrometer. The radiative heaters are available in various substrate sizes (2-inch, 4-inch, 6-inch and 8-inch), 2-inch being the most common. When smaller substrate sizes are used, various types of substrate carriers/inserts can be provided as shown below. The wafer carriers used in radiative heaters are load-lock compatible.



Manual substrate loading



With load-lock arm: engage, lift and retract



	Feature	Details
1.	Substrate Temperature	850˚C Maximum.
2	Substrate size	2" diameter is standard. 5 mm x 5mm or 10 mm x 10 mm substrates will need inserts. 4", 6" and 8" diameter heaters are available.
3.	Oxygen Compatibility	Up to 1 atmosphere (760Torr) of Oxygen.
4.	Substrate Rotation	360˚ Continuous, 30 RPM maximum.
5.	Temperature Control	K-type thermocouple, PID control loop. Phase angle-controlled power supply is included.
6.	Temperature Stability	+/- 1˚C
7.	Temperature Uniformity	+/- 5˚C
8.	Substrate position adjustability	Substrate position can be Z-adjusted with an optional Z-stage.
9.	Other features	• Pre-ablation shutter is included. • High-pressure RHEED compatible • Can be integrated with Neocera system software (Labview 2013).

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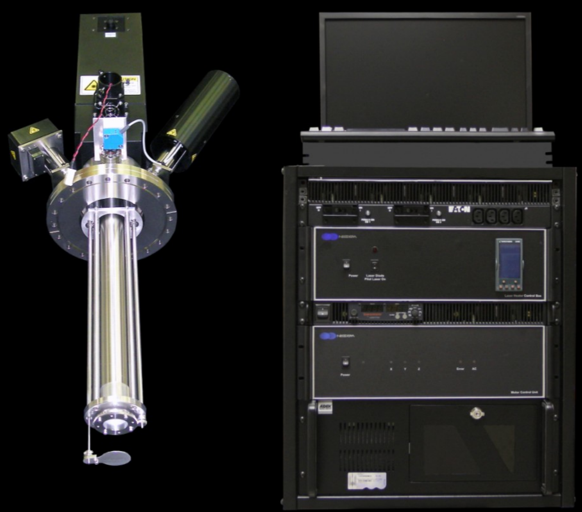
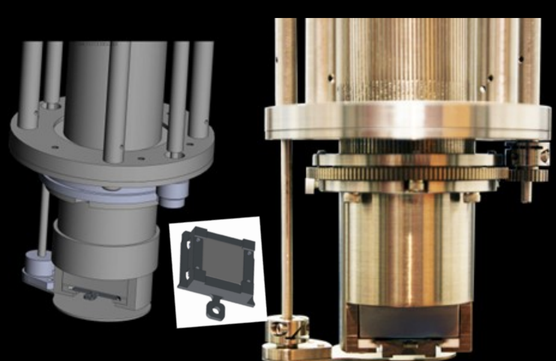
Laser Substrate Heaters

Neocera Laser Substrate Heaters provide substrate temperatures in excess of 1000°C on a variety of substrates. The substrates include optically transparent oxide substrates used for epitaxial oxide film growth. The back side of substrate is in direct thermal contact with an absorber heated by a 100 W (or 140W) fiber-coupled diode laser. Temperature of the absorber is constantly monitored by an integrated optical pyrometer which provides feedback to the PID temperature control loop. Neocera laser substrate heaters are fully compatible with custom wafer carriers used in a variety of UHV analytical systems such as XPS, AES, ARPES. ARUPS etc. The laser heater is UHV compatible.

Laser Substrate Heater package



Laser Heater with custom wafer carrier



Laser Heater at 1000˚C

	Feature	Details
1.	Substrate Temperature	1000˚C maximum.
2	Substrate size	10 mm x 10 mm maximum.
3.	Oxygen Compatibility	Up to 1 atmosphere (760Torr) of Oxygen.
4.	Substrate Rotation	360˚ Continuous, 30 RPM maximum.
5.	Temperature Control	Integrated pyrometer, PID control-loop.
6.	Temperature Stability	+/- 1˚C.
7.	Temperature Uniformity	+/- 5˚C.
8.	Substrate Z- adjustability	50 mm adjustability with standard Neocera wafer carrier.
9.	Pre-ablation shutter	Included.
10.	High-pressure RHEED compatibility	Yes.
11.	*Insitu* UHV wafer transfer Compatibility	Yes. From PLD system to Analytical Systems (ARPES, ARUPS, XPS Auger).
12.	Other features	Can be operated in pulsed mode. Rapid temperature (100 C/sec) rise /cool features are available.

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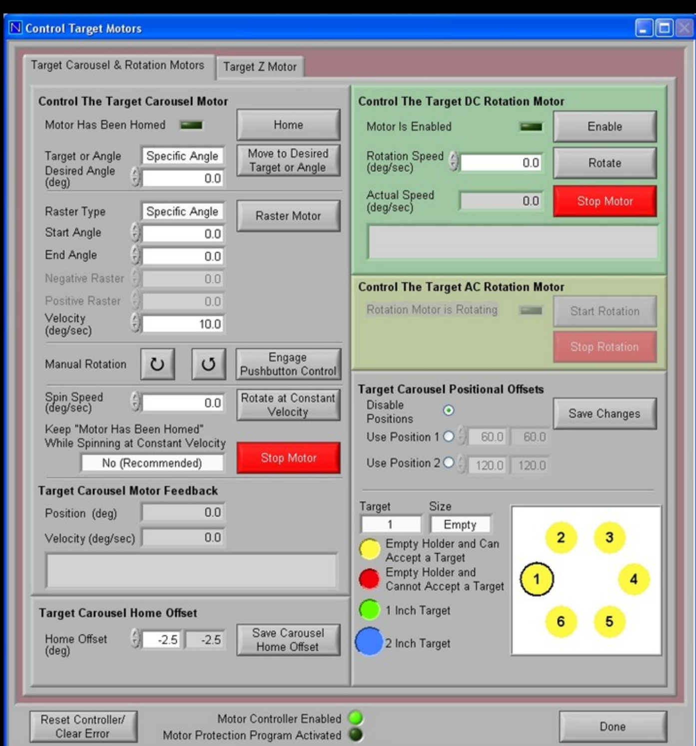
Multi-target carousels

Neocera Multi-target carousels are designed to provide optimum film properties through improved target erosion characteristics. The targets rotate about their axes and also raster about the axis of the carousel, exposing fresh surface to each pulse of the laser. Rotation alone will lead to non-homogeneous erosion of the target surface and this is avoided by a combined rotation and rastering of the targets. For depositing epitaxial films and multilayer heterostructures with reproducible and optimum film properties, these target carousel features are critical. The targets do not need sanding or resurfacing.



Multi-target Carousel – Specifications

1.	Number of Targets	Six x 1-inch diameter or Three x 2-inch diameter.
2.	Target rotation	360 degrees continuous (1-20 RPM).
3.	Target rastering	Max 100 degrees/sec for uniform ablation over the entire target surface.
4.	Target indexing	Yes
5.	Target height	Adjustable (manual for non-UHV Systems), insitu for UHV systems with Z stages.
6.	Target shield	Yes. Protects targets from cross-contamination
7.	Capabilities	Epitaxial films, multilayers and superlattices
8.	Target rastering protocol	Non-linear velocity protocol
9.	CCS capability	Yes, without the need for masks

Software features:

- Target indexing, target rastering and target rotation are controlled by LabVIEW 2013 software, facilitating multilayers and superlattice depositions.
- Software controls external triggering of the laser- facilitates nano-scale thin film growth control.
- Software provides continuous composition spread of binary and ternary phase spreads (optional).

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Deposition Chambers

Neocera Deposition Chambers are specifically designed for Pulsed Laser Deposition and Pulsed Electron Deposition. These chambers are compatible with Neocera Substrate Heaters, Neocera Target Carousels and several other components offered by Neocera. The Chambers are made of SS304 and are UHV compatible and will have numerous ports ideally designed and configured for PLD, PED, load-locks, RF/DC Sputter sources, DC ion sources and process control diagnostics such as such as high-pressure RHEED, Ion Energy Spectroscopy etc.

Neocera offers two standard size spherical chambers (12” and 18” diameter) with an access door. The access door can be sealed off if load-locks are planned as in the case for UHV Systems. Custom size chambers can be provided in cases where the substrate size exceed 6-inches in diameter. In special cases, Neocera works with customers in designing a chamber that matches the customer needs.

Deposition Chamber -12

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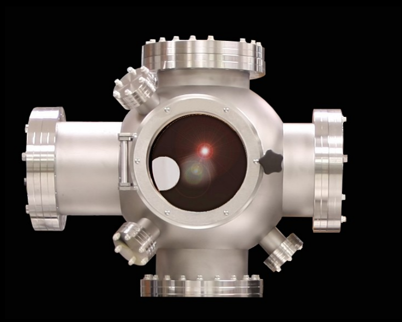

Specifications

12-inch diameter SS 304 Chamber for side-mounted target carousel and side-mounted conductive heater as in Pioneer 120 PLD System.

- 8” CF Pumping port.
- 8” CF Substrate heater port.
- 8” CF Target carousel port.
- 8” CF port with access door (also serves as a view port).
- 8” CF view port (top of the system)
- 4.5” CF excimer laser port and / or 6.75” CF PED port.
- 2.75” CF ports (for accessories).
- Deposition capabilities: PLD, PED, RF/DC Sputter source.

Deposition Chamber -18

Specifications

18-inch diameter SS304 Chamber for top-mounted radiative heater and bottom-mounted target carousel as in Pioneer 180 PLD System.18” diameter spherical chamber.

- 8” CF port with hinged door.
- 8” CF substrate heater port.
- 8” CF target carousel port.
- 6” CF laser port.
- 6” CF RHEED gun port.
- 6” CF RHEED screen port.
- 6” CF pumping port.
- 3x 6” CF ports (RF, DC Sputtering and /or DC Ion guns/View ports).
- 6.75” CF PED port.
- 6” CF load-lock port
- Additional 2.75” and 1.33” CF ports.
- Insitu diagnostic ports.

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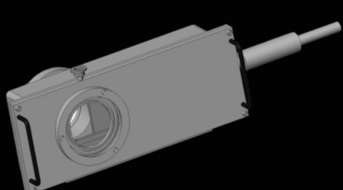
Laser Window-change Accessories - Automated and Manual options

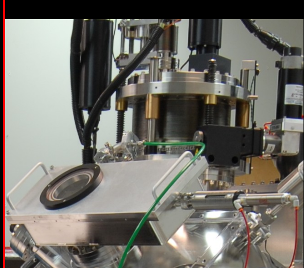
In PLD, the laser is external to the deposition chamber. The laser pulse enters the deposition chamber through a UV-grade laser window and is coupled to the target. During deposition, the chamber-side of the laser window that is in direct line-of-sight to the plasma plume receives a small percentage of the ablated material that forms a thin layer on the window. Depending on the optical properties of this deposited layer and the amount of the material deposited, the laser energy entering into the deposition chamber will get attenuated correspondingly. For reproducible film properties, it is critical to maintain the fluence (J/cm^2) on the target within a narrow and optimum range. The laser window therefore needs to be cleaned or replaced periodically in order to maintain this optimum fluence range on the target. This requires venting the chamber to atmosphere which is undesirable in certain cases such as UHV systems.

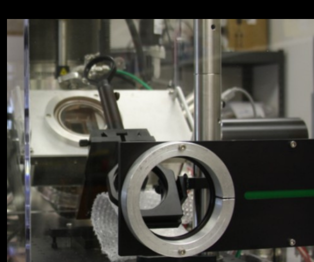
Neocera laser window-change accessories provide a solution to the laser window coating problem and provides clean optical beam path for extended periods of operation. A UV grade silica liner is placed inside the main laser window and only a small part of the liner is exposed to the deposit. As the exposed portion of the silica liner is coated, an uncoated portion can be moved into it's place, maintaining a clean optical beam path.

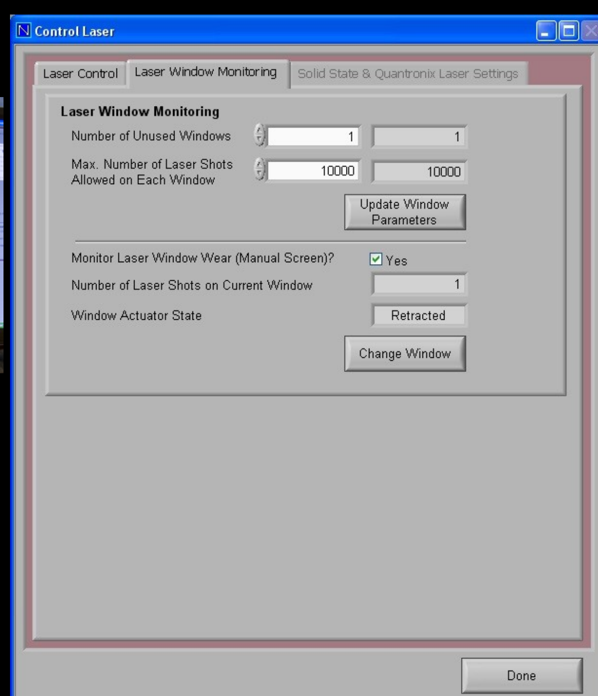
Automated and manual options are available for Neocera laser window-change accessories. In the automated case, a cassette of 6 silica slides are provided which can be changed automatically using System software. A software controlled actuator carries out the window change operation, as per the deposition protocol chosen by the operator. In manual cases, the silica liner is rotated to an uncoated portion. One automated option and two manual options are available based on the vacuum requirements.

Automated laser window-change accessory

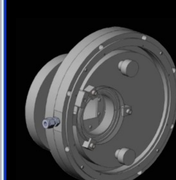


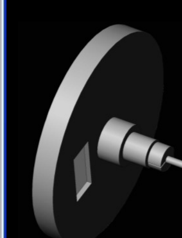






Manual options





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Pulsed Electron Deposition (PED) Source

Pulsed Electron Deposition (PED) is a relatively unexplored thin film deposition technique and is complementary to the well known Pulsed Laser Deposition (PLD). In PED, a pulsed (100 ns pulse width) high power electron beam (approximately 1000 A, 15 keV) , generated in a gas discharge, penetrates approximately 1 µm into the target resulting in a rapid evaporation of the target material. The non-equilibrium heating of the target facilitates stoichiometric evaporation (ablation) of the target material. Under optimum conditions, the target stoichiometry is preserved in the deposited films as it is in the case of PLD.

Unlike PLD, where the ablation process is critically dependent on the optical absorption coefficient of the target material, in PED, the ablation is independent of optical properties of the target material. It depends on the range of electrons and other materials properties (such thermal conductivity, heat capacity etc) of the target. For most of the target materials, this range of electrons is of the order of a few microns. SiO_2 with a large optical band-gap of 10eV for example, is transparent to 248 nm of Kr-F excimer laser radiation commonly used in PLD. In PED however, the high-power electrons can strongly couple to the target material (SiO_2), leading to SiO_2 film deposition. The beam-solid interaction mechanism and the plume enrgetics are quite different in PED in comparison to PLD. YBCO for example, a well know superconducting material, can be deposited by PED around 10mTorr of Oxygen partial pressure and 750˚C substrate temperature, where as the same material (YBCO) would need an Oxygen partial pressure of about 200mTorr in PLD at about the same deposition temperature. This 'phase space' difference between PLD and PED provides a unique opportunity to materials researchers to extend the range of materials that can be deposited as thin films by pulsed techniques.

For retrofitting existing PLD systems with a PED source, a 6.75" CF flange looking towards the target carousel at about 55 degrees will be needed.

Specifications

	Feature	Details
1.	Energy of Electrons	8-20 keV
2.	Maximum energy per pulse	800 mJ
3.	Minimum energy per pulse	100 mJ
4.	Process Gas Pressure:	3-20 mTorr
5.	Process Gases:	Oxygen, Nitrogen, Argon
6.	Pulse energy variations:	$\pm$10%
7.	Maximum Repetition Rate	10 Hz @ 15kV, 5 Hz @ 20kV
8.	Pulse width:	100 ns
9.	Beam cross section (min)	8×10^{-2} cm^2
10.	Maximum power density	1.3×10^8 W/cm^2
11.	Z-alignment range	50 mm
12.	XY alignment range	+- 20 mm
13.	Cathode lifetime	> 3×10^7 pulses

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