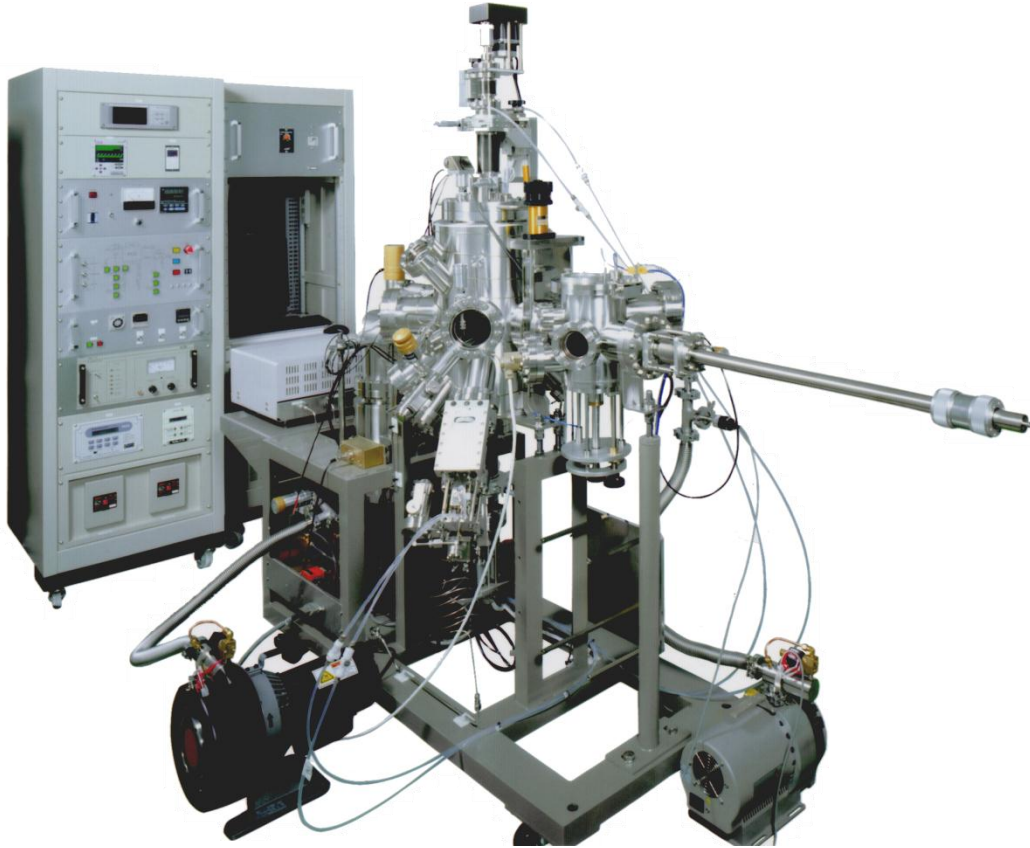


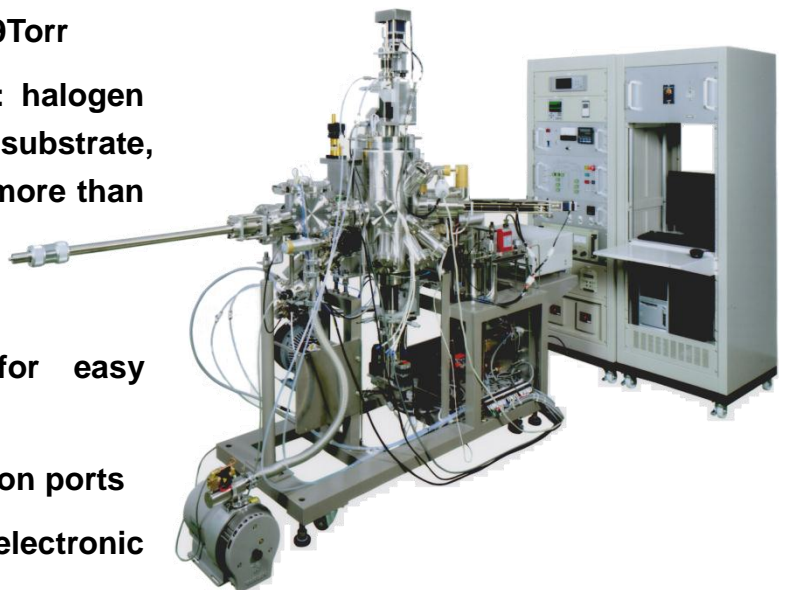
# Compact Laser MBE system

## Model name : **PAC-LMBE**



### [ Feature ]

- High scalability Laser MBE (PLD) system
- An ultimate vacuum pressure of 5E-9Torr
- Advanced substrate heating units : halogen lamp type for up to 1.5 inch (2 inch) substrate, and laser diode type for heating to more than 1,000 degrees C
- Up to 6 targets loadable
- Load-Lock transfer component for easy exchange of targets and substrates
- Various components mountable option ports
- Fully computer control and/or electronic manual control



**Pascal Co., Ltd.**

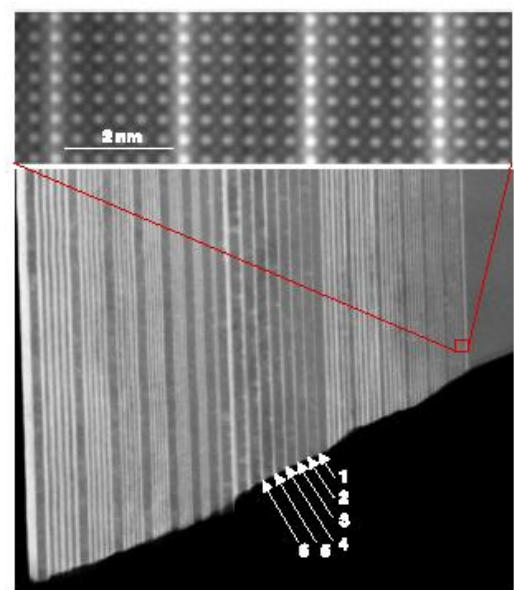
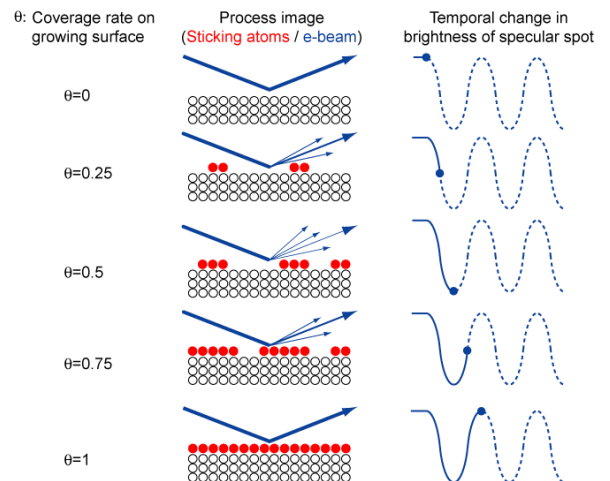
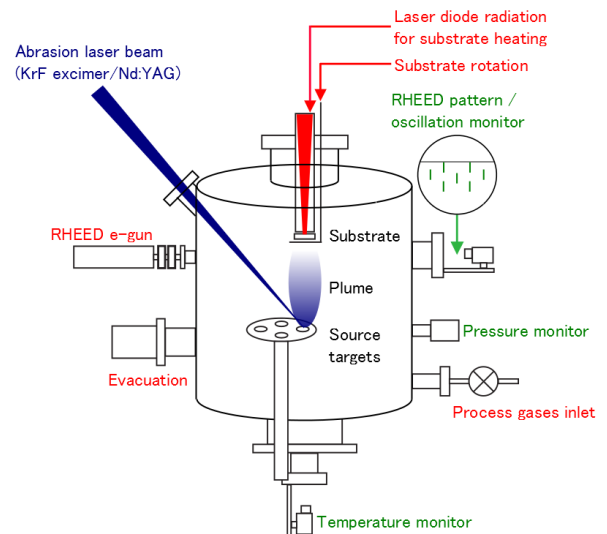
# Laser MBE : Laser Molecular Beam Epitaxy

We, PASCAL Co., Ltd. have been developing and supplying many kinds of vacuum apparatus heretofore in Japan. Above all, we are paying a special attention to the pulsed laser deposition (PLD) and the development of systems for the PLD. The laser MBE is a refined method of PLD that realizes epitaxial growth of various oxide / nitride thin films on a substrate. In laser MBE a substrate and sintered targets are set in an ultra high vacuum (UHV) chamber. Epitaxial growth is caused by ablation of source target by irradiation of laser pulse and sticking / coverage to growing surface on the substrate. The laser pulse is introduced from outside UHV chamber through a quartz window. The growth process can be monitored in situ by RHEED of which intensity oscillation is interpreted by an elastic scattering model.

## Advantages of our system are;

- Easy evaporation despite materials with high melting point (ex. oxides).
- Little difference of chemical composition between source targets and deposited films.
- Quite few contamination due to laser abrasion as a light-induced process.
- Digital (or discrete) control of film thickness / growth rate by repetition number of the laser pulse.
- Growth under wide-vacuum-range condition with process gas flow is acceptable.
- Easy exchange of targets that leads to realize heteroepitaxy and multilayered structure.

The laser MBE is very suitable for the atomic layer controlled growth of oxides / nitrides, and also suits for a simple and inexpensive apparatus comparing with conventional MBE. Our laser MBE system pursues extremely to be compact, and contains many outstanding know-hows on, for instance, the substrate heating and the load-locked exchange of samples or targets. The laser MBE has advantages of both the conventional MBE and the pulsed laser deposition (PLD), simultaneously, because the deposition method means a pulsed laser abrasion growth in an ultra high vacuum circumference.



## Atomic layer controlled growth by laser MBE

Bright-field image of the LaTiO<sub>3</sub>/SrTiO<sub>3</sub> multilayer thin film section observed with a transmission electron microscope (TEM)

## Reference;

A. Ohtomo *et.al.*, NATURE, VOL 419, 378 (2002)

## [ Standard configuration of PAC-LMBE ]

1. Deposition chamber
2. Multi-target manipulator unit
3. Substrate heating unit (Laser diode type or Halogen lamp type)
4. Load-Lock (L/L) chamber with transfer mechanism
5. Common system (Frame, rack and control system)

## [ Options ]

- Variety RHEEDs and pattern processing system
- Combinatorial mask positioning unit
- Mass flow controller(s)
- Ozonizer, Radical beam source
- Optical component for laser beam introduction
- Excimer laser stand and laser optics with protection hood
- Pre-annealing heater in Load-Lock chamber
- Gate valve for laser beam introduction viewing port exchange

## ● Substrate heating unit

### Halogen lamp type



The halogen lamp type substrate heating unit makes the substrate heating possible to more than 800 degrees C, under the oxygen atmosphere more than 500mTorr.

- Up to 1.5 inch (38mm $\phi$ ) substrate size of standard holder, in addition up to 2 inch (50mm $\phi$ ) substrate size of optional holder
- More than 800 degrees C substrate heating
- Uniform temperature distribution
- Free rotation of substrate holder
- Under the oxygen atmosphere more than 500mTorr

### Laser diode type



The laser diode type substrate heating unit makes the substrate heating possible to more than 1,000 degrees C, under the oxygen atmosphere.

- More than 1,000 degrees C substrate heating
- Up to 10mm square substrate size
- Free rotation of substrate holder
- Quick substrate heating and cooling
- Best solution of substrate heating under oxygen atmosphere
- Substrate temperature monitor using pyrometer

## ● Multi-target manipulator unit



This multi-target manipulator works choosing appropriate source target for thin film deposition following the deposition sequence like as a revolver mechanism. In addition the unit has target spin mechanism for uniform irradiation of ablation laser. The unit can load up to 6 targets and has contamination protective shield. And the unit has clear position which is no target area to get through laser beam. It will give you easy monitor of laser beam power using laser power monitor (option) and synthesized quartz viewing port on laser power monitor port (option).

## ● Load-Lock (L/L) chamber with transfer mechanism

This L/L chamber has a vacuum pumping line which can exhaust in a short time in the UHV. Substrates and Targets are transferred between L/L chamber and deposition chamber without exposing to the atmosphere. The deposition chamber is always kept under the UHV because the deposition chamber is separated from this L/L chamber.

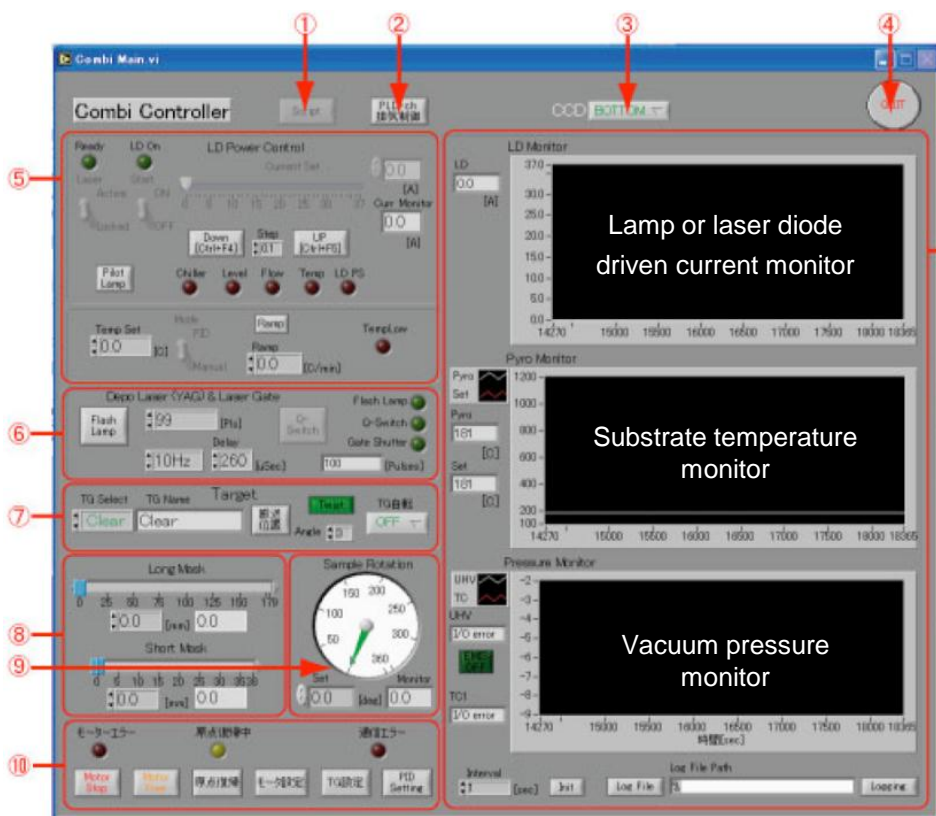




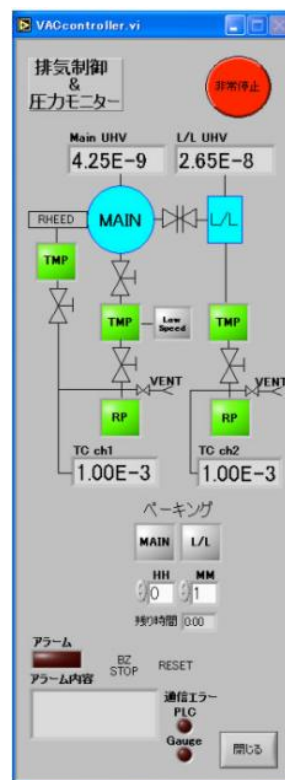
# Fully LMBE control software

Pascal's LMBE control software can control not only substrate heating, target selection, target spin and twist, combinatorial mask position (option), substrate rotation, but also oscillations of an ablation laser in the same period. In this way, this software can control each function with an electronic manual, and then automatically control thin film deposition processes to edit the script of its recipe and run.

You will be able to choose two modes of substrate heating control; lamp or laser diode power manual control and substrate temperature PID control. You will be able to select target or clear position and to ablate target surfaces uniformly by target spin and twist control. You will be able to control not only pumps ON / OFF but also valves Open / Close. And then You will be able to get more many functions for advanced Laser MBE.

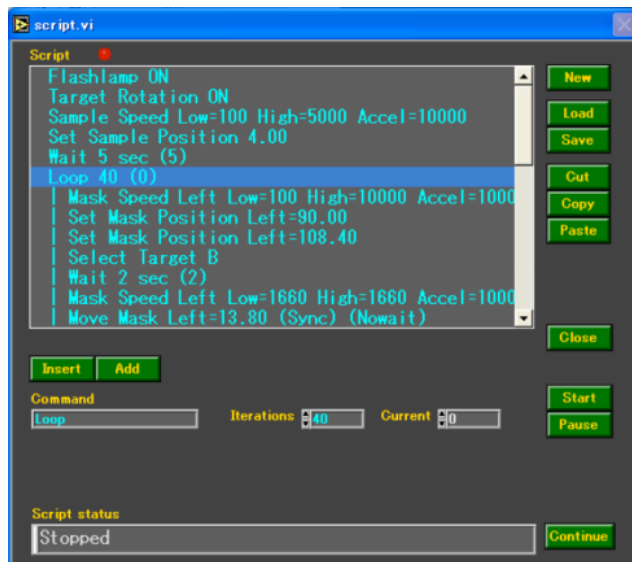


Main window of LMBE control software



Vacuum control window

1. Run button for script edit and run window
2. Run button for vacuum control window
3. Run button for CCD display window
4. Exit button
5. Substrate heating control
6. Ablation laser oscillation control
7. Target selection, target spin and twist control
8. Combinatorial mask position control (option)
9. Substrate rotation control
10. Auxiliary operation
11. Monitor and log display



Script edit and run window

# Electronic manual controller



Control rack

## ■ Substrate temperature control

You will be able to choose two modes of substrate heating control; lamp or laser diode power manual control and substrate temperature PID control by temperature controller.

## ■ Substrate rotation control and target rotation control

You will be able to control rotation speed of substrate and target by rotation speed controller.

## ■ Target revolution control

You will be able to select target or clear position and to align target position by remote target controller.

## ■ Vacuum control

You will be able to control not only pumps ON / OFF but also valves Open / Close by vacuum control panel. That interlock will protect against the miss operation of push button.



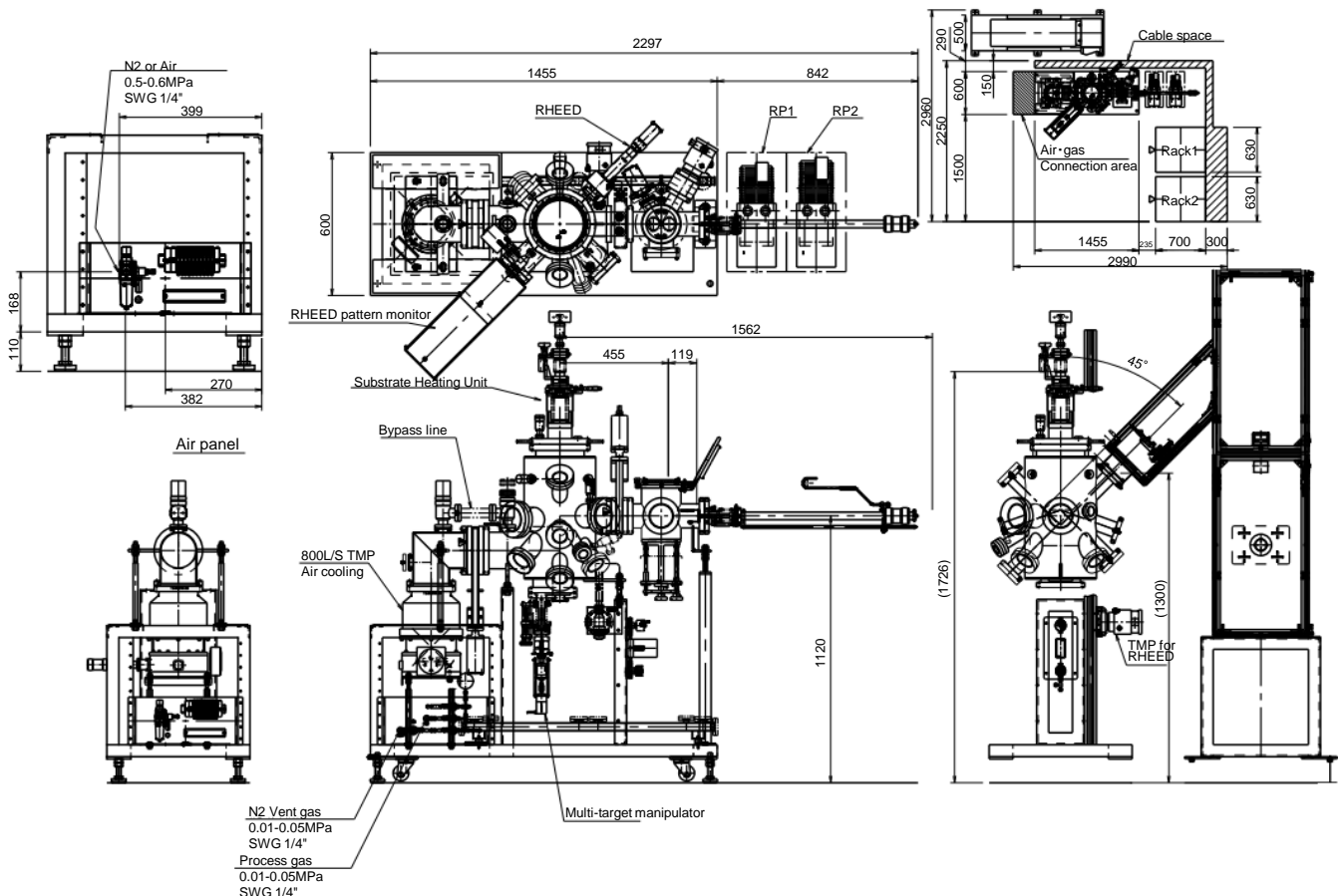
Temperature controller



Rotation speed controller






Remote target controller



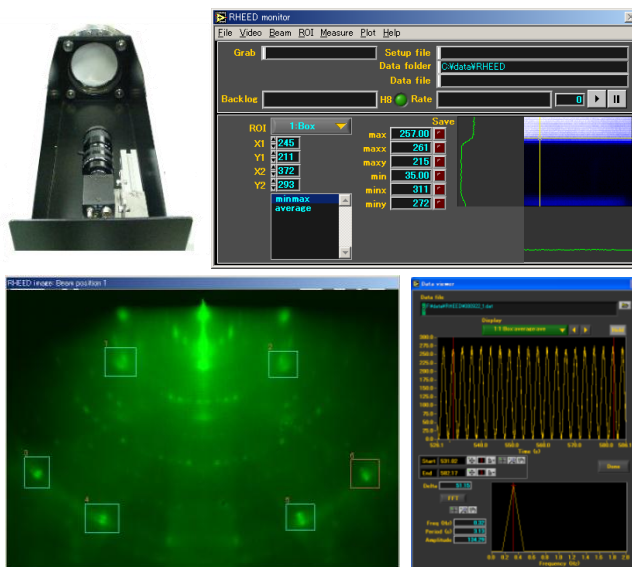
# Optional units

## ● RHEED unit

Fundamental unit of PASCAL Reflection High-Energy Electron Diffraction (RHEED) consists a compact size electron-gun with mounting via CF1.33" (ICF34) flange. The compact size e-gun brings easy mount to a vacuum chamber or easy maintenance. You can select RHEED unit from following 3 types.

Models Items	RHEED with single-stage differential pumping unit	RHEED with double-stage differential pumping unit	Parallel scanning RHEED
View			
Feature	<ul style="list-style-type: none"> <li>■ Max 30kV acceleration voltage (25kV rated)</li> <li>■ Workable up to 1.3Pa (1E-2 Torr) by Single-stage differential pumping</li> <li>■ Reasonable price</li> </ul>	<ul style="list-style-type: none"> <li>■ Max 30kV acceleration voltage (25kV rated)</li> <li>■ Workable up to 133Pa (1 Torr) by Double-stage differential pumping</li> <li>■ Variable positioning fluorescent screen</li> <li>■ XY-axes and tilt motion of electron-beam guide</li> </ul>	<ul style="list-style-type: none"> <li>■ Max 30kV acceleration voltage (25kV rated)</li> <li>■ Workable up to 1.3Pa (1E-2 Torr) by Single-stage differential pumping</li> <li>■ Scanning coil and driver for electron-beam parallel scanning</li> </ul>

## ● RHEED pattern processing system

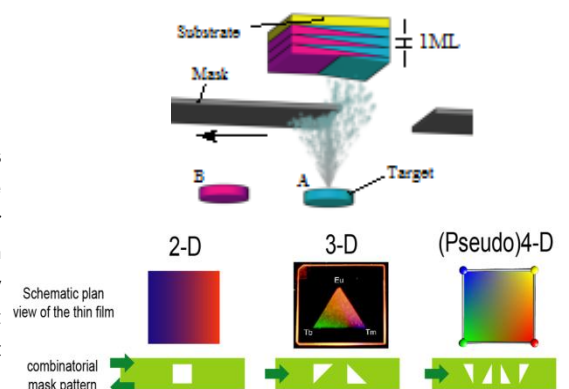


This system without using a special device realizes high-performance RHEED pattern processing by taking the RHEED pattern observed with a CCD camera in a computer. You can easily deposit at high-definition thin film growing process by using this system.

- Real-time RHEED pattern observation, intensity oscillation monitoring, and saving their data
- Reloading saved data, processing and saving as a text file
- Easy analysis using commercial spreadsheet software
- Even beginners can immediately use by a user-friendly operation.

## ● Combinatorial mask positioning unit

Synthesizing at one time specimens representing all combination of synthesis conditions concerned followed by screening the products features the "combinatorial chemistry", which becomes indispensable now in medicine or pharmaceutical development. As a result of the combinatorial chemistry, an "exponential" acceleration of development speed has been proven. By precise movement of the mask board patterned with rectangles or triangles at close position of substrate during thin film deposition, composition gradient thin film patterns are formed on one piece of substrate.





## ● Mass flow controller(s)

Variable leak valve of process gas inlet can control leak rate at wide range pressure precisely, but it can't control automatically. If you want to control automatically, you should order mass flow controller(s) changed for variable leak valve, or added aside from variable leak valve. And then if you order it / them with optional mass flow control function of PLD control software, you will be able to control not only flow rate but also vacuum pressure by feedback program.

## ● Ozonizer, Radical beam source

If you want to inlet active gas for process gas, we can offer ozonizer and radical beam source. Ozonizer will ozonize pure O<sub>2</sub> and form several percent ozone gas, and radical beam source will form Oxygen atoms, Nitrogen atoms or Hydrogen atoms. You can choose to inlet those gases from variable leak valve(s) or mass flow controller(s). And then if you want to blow ozone gas to substrate from its neighborhood, you should also order Z stage with admittance nozzle.



Lens holder with alignment stage and rod included in Optical component for laser beam introduction

## ● Optical component for laser beam introduction

In this component, following items are included;

- UV248, Fused Silica, Plano-Convex Lens : 1ea.
- Excimer Laser Mirror (Reflection angle = 45 degree) : 1ea.
- Excimer Laser Mirror (Reflection angle = 22.5degree) : 1ea.
- Lens holder with alignment stage and rod : 1set

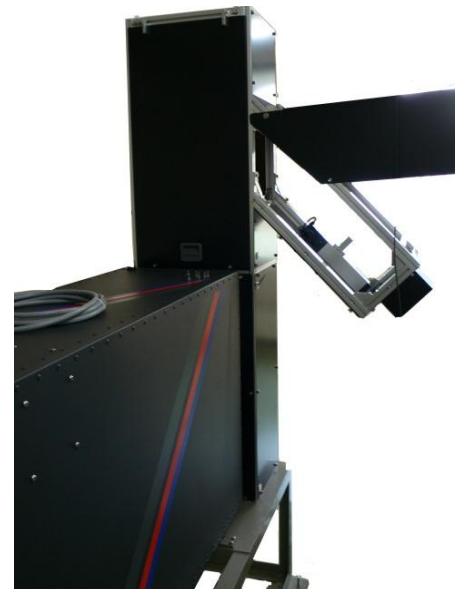
## ● Excimer laser stand and laser optics with protection hood

In this basic component, following items are included;

- Fused Silica Plano-Convex Lens for KrF Excimer Laser : 1 ea.
- KrF Excimer Laser Mirror (Reflection angle = 45 degree) : 1 ea.
- KrF Excimer Laser Mirror (Reflection angle = 22.5degree) : 1 ea.
- Stand for CompexPro 102 Excimer Laser : 1 unit
- Lens and mirror holders with alignment stages and protection hood : 1 set

And then you can add or change with following optional items;

- Motorized lens alignment stages with control software
- Manual Attenuator unit
- Motorized Attenuator unit with control software
- Lens and Mirrors for other wavelength laser
- Stand for other laser



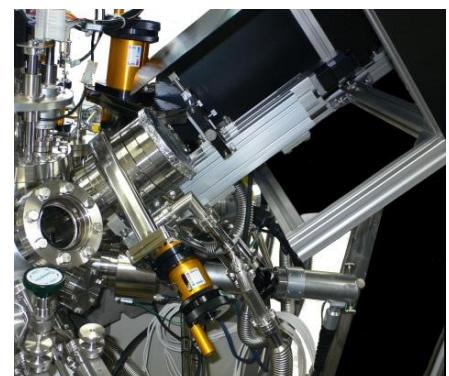
Excimer laser stand and laser optics with protection hood mounting CompexPro 102 Excimer Laser

## ● Pre-annealing heater in Load-Lock chamber

If you want to pre-annealing in Load-Lock chamber, you can order pre-annealing heater. This is mounted on access door of Load-Lock chamber. Substrates will be heated up to 300 deg-C.

## ● Gate valve for laser beam introduction viewing port exchange

Laser beam introduction viewing port will be burned and colored by laser beam. In this case, transmission factor of viewing will become worse, and you should change the point of viewing port illuminated by laser beam or you should exchange viewing port. If you don't want to brake UHV in deposition chamber at this time, you have to require this gate valve with bypass line connected to Load-lock chamber.



Gate valve for laser beam introduction viewing port exchange and motorized lens alignment stages

## Specification of PAC-LMBE

Deposition chamber	Shape, dimension and material	Phi 300mm x H 500mm, Cylindrical horizontal layout chamber (SUS304, EP finish)	
	Ultimate vacuum pressure	< 5.0E-9 Torr (6.7E-7 Pa)	
	Vacuum pumping line	800L/s TMP, 237L/min RP, pneumatic valves and bypass line etc.	
	Vacuum pressure monitor	UHV range : Nude ion gauge (standard) / Full-range gauge (option) Process range : Capacitance manometer (Max range: 1 Torr) Fore-line monitor : T/C gauge	
	Process gas inlet	Variable leak valve and cut valve (standard) / Mass flow controller (option)	
	Laser beam introduction port	CF4.5" (ICF114) synthesized quartz viewing port with quartz shield plate 45 degree from horizontal direction Gate valve for laser beam introduction viewing port exchange (option)	
	Laser power monitor port	CF4.5" (ICF114) Blank (standard) / Synthesized quartz viewing port with shutter (option)	
Multi-target manipulator unit	Target size and loading number	1 inch (phi 25.4mm) x 3mmt 6ea.	
	Clear position	1 position for laser power monitor	
	Target moving mechanism	Z-motion : +/-20mm manual (standard) / stepping motor drive (option)	
	Target rotation mechanism	AC speed control motor drive	
	Target revolution mechanism	High resolution stepping motor drive for twist motion	
	Mounting flange	CF8" (ICF203), with CF2.75"(ICF70) viewing port for mask & substrate observation	
Substrate heating unit	Type of substrate heating	Halogen lamp type substrate heating (chiller not included, cooling water required)	Laser diode type substrate heating 808nm, 120W (chiller included)
	Substrate size	Up to 1.5 inch (phi 50mm) / up to 2 inch (optional holder)	10mm square
	Maximum temperature	More than 800 deg C	More than 1,000 deg C
	Temperature gradient	Impossible	Impossible
	Moving mechanism	Z1-motion : +/- 20mm, Z2-motion : +/- 20mm	Z1-motion : +/- 20mm
	Substrate rotation mechanism	Stepping motor drive with sensor	
Load-Lock (L/L) chamber with transfer mechanism	Shape, dimension and material	Phi 160mm x H 240mm, Cylindrical horizontal layout chamber (SUS304)	
	Ultimate vacuum pressure	5E-7 Torr (6.7E-5 Pa)	
	Vacuum pumping line	77L/s TMP, 160L/min RP, pneumatic valves and bypass line etc.	
	Vacuum pressure monitor	UHV range : nude ion gauge (standard) / Full-range gauge (option) Fore-line monitor : T/C gauge	
	Holder stocker	Substrate holder : 2 ea., Target holder : 4 ea.	
	Pre-annealing heater	None (standard) / up to 200 deg C (option)	
Common System	Frame	Chamber frame : 1 set	
	Rack	Power supply and control rack (JIS conformity) : 1 or 2 set(s)	
	Computer / Controller	Windows®PC installed LMBE control software in and/or electronic manual controller	
Utility	Power Supply	AC200-240V 3-phase 100A	AC200-240 3-phase 100A AC200-240 1-phase 10A (for chiller)
	Cooling water	water pressure : > 2kgf/cm <sup>3</sup> , water flow : > 20L/min	Not necessary
	Gas inlet	Purge and Vent gas line : 1 x 1/4"SWG, Process gas line : 1 x 1/4"SWG	
	Compressed gas	0.5 MPa (5 kg/cm <sup>2</sup> ) of Nitrogen or air with pressure regulator	
Option units	RHEED units	RHEED with single-stage differential pumping unit : Conventional 30 kV RHEED	
		RHEED with double-stage differential pumping unit : High pressure RHEED	
		Parallel scanning RHEED : in-plane substrate scanning RHEED	
		RHEED pattern processing system : High resolution CCD camera unit, shade, pattern processing software	
	Combinatorial mask positioning unit	Long mask : 0 to 160mm stepping motor drive	
	Ozonizer	Several percent ozon gas generator	
	Radical beam source	Oxygen atom, nitrogen atom or hydrogen atom generator	
	Optical components	Optical component for laser beam introduction : simple laser beam optical unit	
Excimer laser stand and laser optics with protection hood : complete laser beam optical unit			

\* Specifications and appearances may be subject to change for improvement without notice.

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