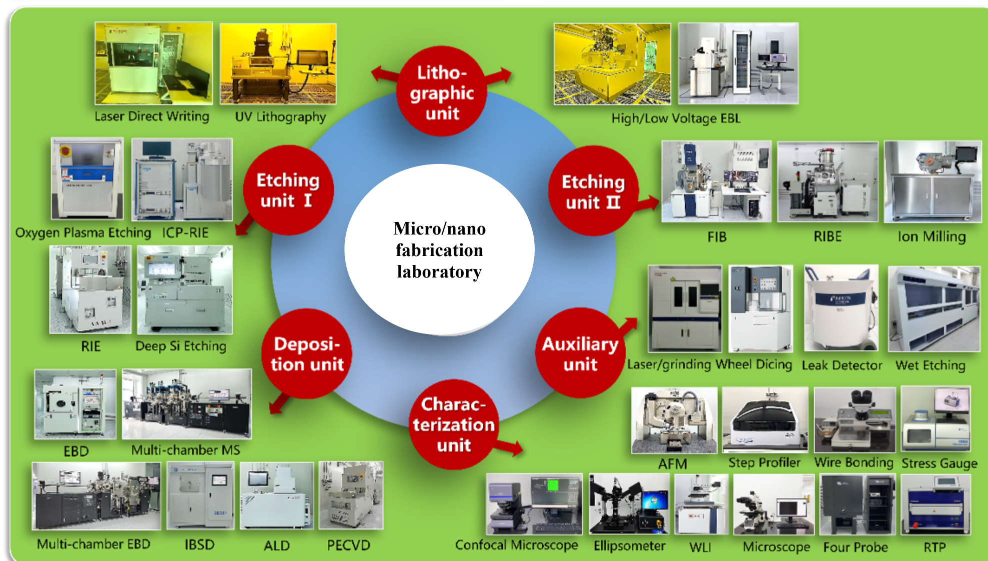
Micro/nano fabrication laboratory

The micro/nano fabrication laboratory mainly meets the necessary requirements of fabricating micro/nano-structures and devices for the users and systems of Synergetic Extreme Condition User Facility. The laboratory contains class 100 clean rooms and class 1000 clean rooms, where the class 100 clean rooms are yellow light areas, which can be used for lithography, developing and resist coating in different ways. And the class 1000 clean rooms are divided into 8 functional areas, which can be used for the lithography, deposition, etching and other fabricating processes of various materials, as well as the characterization of micro/nano- structures and the physical properties testing. The main fabrication process indexes of the micro/nano fabrication laboratory of Synergetic Extreme Condition User Facility are listed as follows: the minimum line width of electron beam lithography of 8 nm, the minimum line width of the UV lithography of 0.5 μm, the resolution of laser direct writing of 600 nm, the minimum line width of Si etching of 30 nm, the highest aspect ratio of Si etching of 30:1, and the slope angle of etching side wall of Si can be adjusted from 85° to 92°.



Main performance indexes of the micro/nano fabrication laboratory

Main Functions	Main Indexes
Electron beam lithography	Minimum line width: 8 nm
UV lithography	Minimum line width: 0.5 μm
Laser direct writing	Resolution: 600 nm
Etching of silicon	Minimum line width: 30 nm Highest aspect ratio: 30:1 Slope angle can be adjusted from 85° to 92°

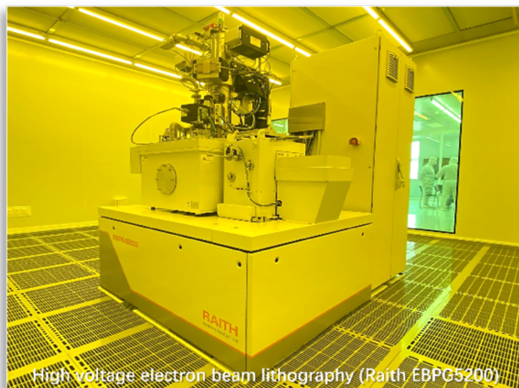
There are 43 sets of instruments and equipment in the micro/nano fabrication laboratory, including 4 lithography equipment, 9 deposition equipment, 9 etching equipment, 10 characterization equipment and 11 auxiliary equipment. The main equipment of the units is introduced as follows:

1. Lithographic unit

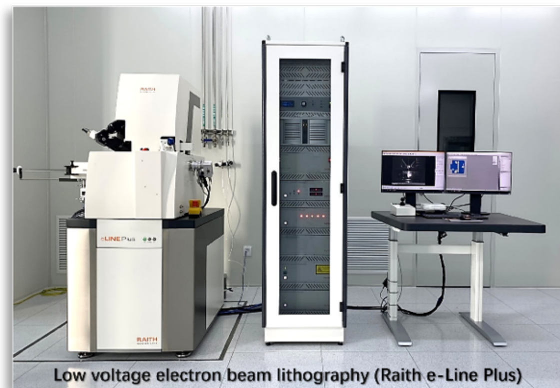
The lithographic unit is equipped with 4 equipment in total: high voltage electron beam lithography (EBL), electron beam scanning/direct writing system, laser direct writing, and contact aligner.

1) Electron beam lithography

EBL is used to directly write photoresist patterns on the substrates, has the advantages of ultra-high resolution, nanometer precision and complex graphics processing. The following figures show the equipment images of high voltage and low voltage EBL systems, respectively.



High voltage electron beam lithography (Raith EBPG5200)



Low voltage electron beam lithography (Raith e-Line Plus)

Minimum line width：≤8nm；Write field stitching precision：≤ ±15nm；Alignment precision：≤ ±15nm；Maximum write field：1mm
Highest voltage：100KV； Largest sample：8 英寸；Beam current stability：≤ ± 0.5%/h；Beam position stability: ≤ 50nm/h

2) Laser direct writing and UV lithography systems

Laser direct writing and UV lithography systems are used to fabricate microscale and sub-micrometer scale resist patterns by direct writing and mask plate, respectively, which can be used for the fabrication of microscale and sub-micrometer scale structures and devices of various functional materials. The following figures show the equipment images of laser direct writing and UV lithography, respectively.

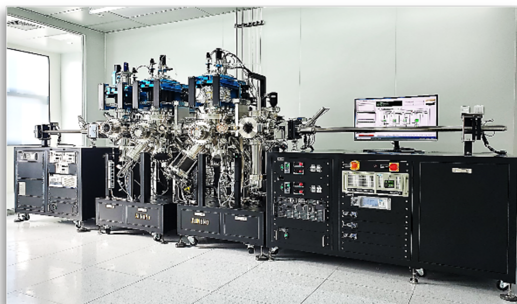
Laser direct writing (Heidelberg-DWL66+)

Highest resolution:	0.6 μm
Largest direct writing speed:	600 mm^2/min
Largest sample size:	8 inch
Laser controllable power level:	255 levels
Alignment precision:	≤100 nm

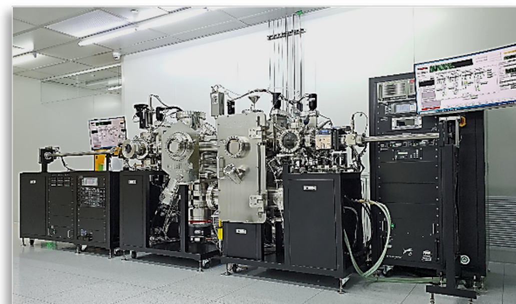
UV lithography (SÜSS-MA/BA6)

Highest resolution :	0.5 μm
Light intensity uniformity:	≥97.5%
Largest sample size:	6 inch
Front alignment precision:	≤ 0.5μm
Back alignment precision:	≤ 1μm

2. Deposition unit



Multi-chamber ultra-high vacuum magnetron sputtering:
Equipped with 3 high vacuum chambers, can be used for the deposition of metal films including Nb, Ta, Fe, Au and nitride, oxide films like TiN, ITO, as well as the deposition of Al film under low temperature.
○ **Technical indexes:** Ultimate vacuum: ≤ 2×10^{-10} Torr; Largest sample size: 4 inch; Film uniformity: ≤ 3%; Maximum heating temperature: ≥ 850℃; Sputtering target size: 3 inch; RF Power: ≥ 500W



multi-chamber ultra-high vacuum electron beam deposition:
Equipped with an ion milling chamber and 2 high vacuum chambers, can be used for the plasma cleaning, electron beam deposition and dynamic/static oxidation treatment of superconductive Al film.
○ **Technical indexes:** Ultimate vacuum : ≤ 5×10^{-10} Torr; Largest sample size: 4 inch; Film uniformity: ≤ 2 %; Maximum heating temperature: ≥ 1000℃; Maximum flow rate of oxidation chamber: 200sccm, Static and dynamic oxidation can be selected

There are 9 sets of equipment of deposition unit in total: plasma enhanced chemical vapor deposition (PECVD), multi-chamber and ultra-high vacuum magnetron sputtering (MS) system, multi-chamber and ultra-high vacuum electron beam

deposition (EBD) system, thermal evaporation, atomic layer deposition (ALD), ion beam sputtering deposition (IBSD), rich-oxygen EBD, ion sputtering, lithography pretreatment system of wafer. The following figures are technical indexes of multi-chamber ultra-high vacuum MS and EBD systems.

3. Etching Unit

The etching unit equipped with 9 equipment in total: focused ion beam (FIB) etching, reactive ion beam etching (RIBE) system, reactive ion etching (RIE) (2 sets), inductively coupled plasma (ICP) RIE (2 sets), Ar ion beam etching, microwave plasma etching, wet etching systems (2 sets), the images and technical indexes of the main etching system are as follows.

1) Focused ion beam and reactive ion beam etching systems

Focused ion beam (Hitachi - NX5000)

○ Equipped with focused electron, Ga^+, and Ar^+ beam, can directly write all kinds of micro/nano-devices and nanostructures, meanwhile, has the abilities of high-resolution imaging and materials' deposition.

○ Ga+ resolution: 4.0nm@30KV; Secondary electron resolution ≤0.7nm @15KV ; Largest sample size: 2cm×2cm; Deposited metal: C、W、Pt

Reactive ion beam etching (Haasrode-Lorem-R)

○ Etching of metal, semiconductor, dielectric films, achieve the fabrication of special-shaped structures such as blazed gratings and tilted gratings, can also realize the etching of normal micro/nano-structures.

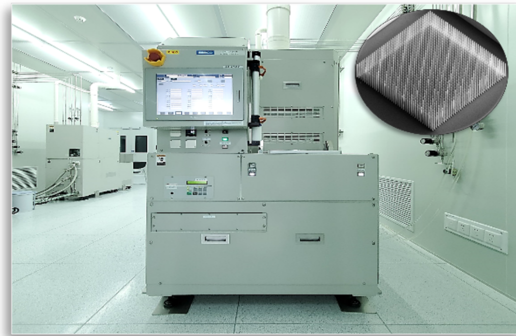
○ Largest sample size: 8 inch, SiO_2 etching rate: ≥20nm/min; Selectivity: Cr/SiO_2 ≥ 3:1; Etching aspect ratio: ≥3:1; Uniformity: ≤ ±5%

2) Inductively coupled plasma reactive ion etching

Inductively coupled plasma reactive ion etching (Sentech – SI 500)

○ Mainly used for the etching of oxide and semiconductor, realize the fabrication of all kinds of micro/nano-structures.

○ Largest sample size: 8inch; Lower electrode temperature: -20℃~250℃; Etching aspect ratio: ≥5:1; Selectivity: PR/GaAs: ≥ 4:1, SiO_2/LnP>10:1; Etching uniformity:<5%; Side wall tilted angle: 90±1°



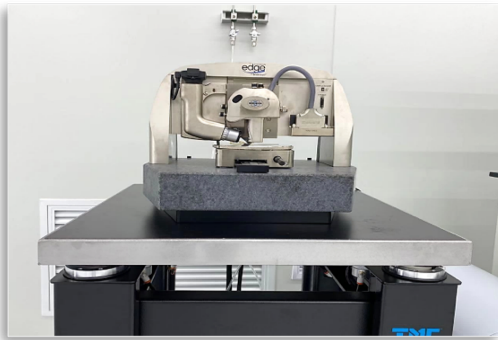
Inductively coupled plasma reactive ion etching (Samco - RIE-400iPB)

○ Applied to the deep Si etching process, realize the fabrication of micro/nano-structures with high aspect ratio.

○ Largest sample size: 4 inch; Etching aspect ratio: ≥30:1; Maximum etching speed: ≥8μm/min; Selectivity: Si/PR ≥ 25, SiO_2/Si ≥ 400; Uniformity:<5%.

4. Characterization Unit

The characterization unit has 10 sets of equipment: atomic force microscope (AFM), step profiler, precision movement stage, metallographic microscope, digital microscope, stereoscopic microscope, film-stress gauge, laser scanning confocal microscope, ellipsometer, white light interferometer (WLI). The following figure shows the photograph and the technical indexes of the AFM. AFM utilizes the interaction between atoms and molecules to characterize the microcosmic morphology of the objects, which is a powerful analytical instrument for studying the surface profile of solid materials including insulators.



Technical Indexes:

Scanning Range: 90 μm×90 μm×10 μm

Z-axis noise level: < 0.05 nm

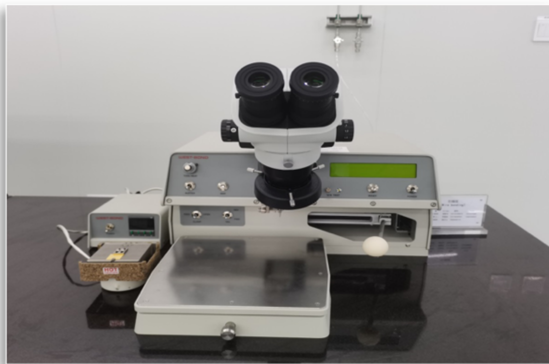
XY -axis noise level : < 0.15 nm

Largest sample size: ≥ 150mm

Stitching mode: Full-automatic

5. Auxiliary Unit

The characterization unit has 11 sets of equipment: wire bonder, laser dicing machine, grinding wheel dicing machine, rapid thermal processing (RTP), program-controlled spin coater (2 sets), program-controlled hot plate (2 sets), dry sample cabinet (2 sets), vacuum oven. The following figure depicts the image and the technical parameters of wire bonder, which is used for metallic wire connection between micro/nano-devices on chip.



Technical indexes:

Bonding pressure: 10-150g

Largest sample size: 2cm×2cm

Maximum super sonic power: 4W

Wire materials: SiAl Wire/Au Wire

Diameter of wire: 25 μm

Contact Information: Dr. Zhang, E-mail: zhangzs@iphy.ac.cn.