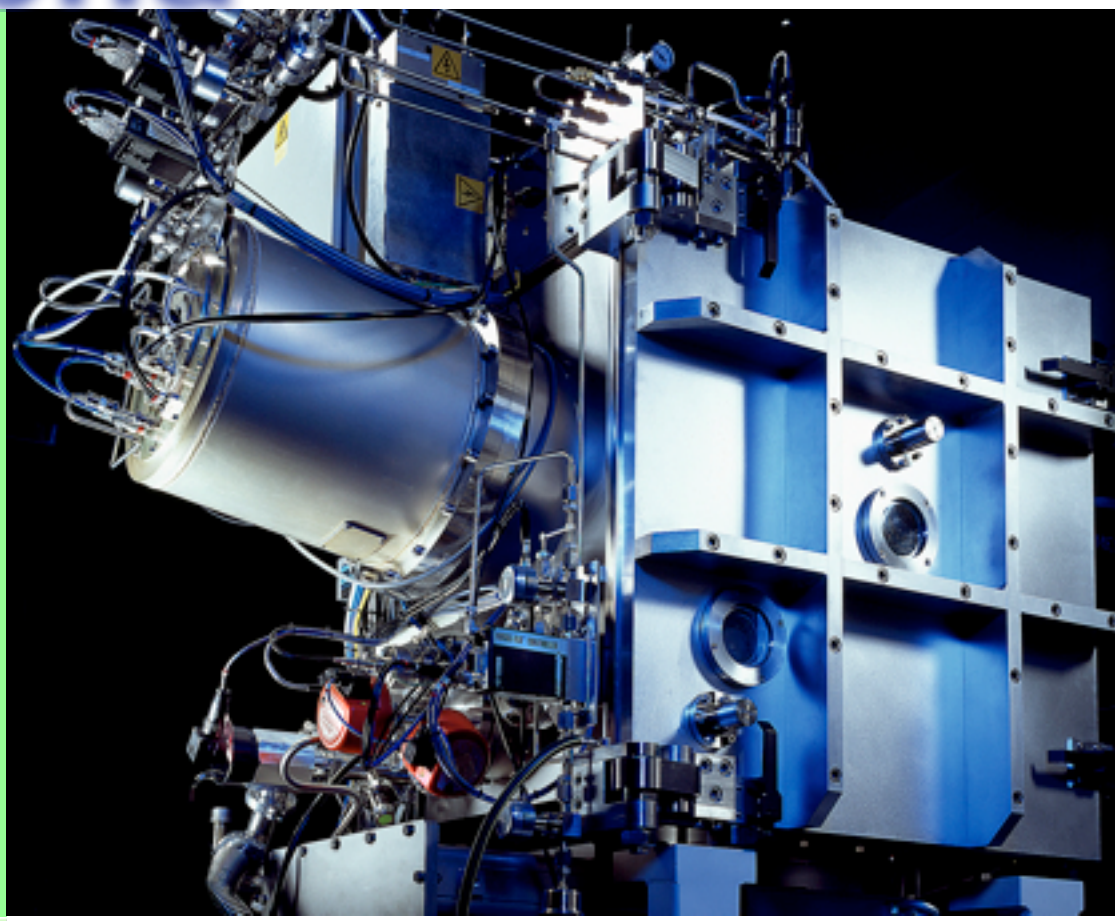
Alpha^{120}

Broad Ion Beams



Nordiko

Broad Ion Beam Mill
short form specification

The Alpha^{120} is a small scale but technically advanced Broad Ion Beam Mill. The system may be offered with or without a vacuum load lock. In base form it is manually operated but is also available with full automation.

The technology utilised within the system is borrowed from the larger Nordiko 7000 and 7500 production systems.

The process chamber may be fitted with a 15 cm, a 20 cm or a 25 cm ion source, making it suitable for processing wafers up to 3” (75 mm) , 4” (100 mm) and 6” (150 mm) respectively.

The process module is supported on an extruded aluminium frame. This frame is extended in one dimension to house the power distribution, services and power supplies etc. The optional single wafer, single occupancy vacuum load lock is fitted above this frame extension.

The system may be used for noble gas milling using; Ar, Kr or Xe. It is also suitable for operation with Oxygen. The system can be configured for operation with other reactive gases including halogens where chemically resistant process pumps are selected.

For reactive operation there are two options. The reactive gas may be introduced directly in to the ion source. This configuration is referred to as Reactive Ion Beam Etching, RIBE. Alternatively the ion source may be operated using a noble gas and the reactive gas or gasses may be introduced locally to the substrate. This configuration is referred to as Chemically Assisted Reactive Ion Beam Etching, CARIBE.

System Configuration
common components

Vacuum Chamber

The process chamber is a stainless steel, 304, fabrication with a full aperture aluminium access door and an aluminium back plate.

The door carries a shuttered viewport for viewing substrate loading and beam operation. The inner walls of the chamber and the door are protected from heavy deposition by removable aluminium alloy liners.

The chamber sits upon an extruded channel aluminium support frame. The base of the frame is fitted with castors and screw-down feet.

Ion Source

The Nordiko ion source is rf excited and employs a bucket style multi-cusp magnetic confinement field. The source body is an aluminium cylinder with a dielectric window at one end. Opposite the window, at the other end of the cylinder an ion extraction assembly is fitted.

The source is excited at 13.56 MHz. The power is efficiently coupled from the rf generator to the source antenna via an automatic impedance matching unit.

Ions are extracted from the ion source, focussed and propagated into the chamber by the extraction assembly. This is formed by a triode multi-aperture electrode structure. The first electrode is positively biased, the second is negatively biased and the third is earthed. Solid state, low stored energy power supplies are controlled by the system automation and supervisory system.

Neutralisation

Illumination of insulating, or isolated surfaces by an energetic positive ion beam will rapidly cause the surface to charge. To address this the system is fitted with a plasma bridge neutraliser. This is a dc excited filamentless electron source that provides the necessary electron flux to realise charge neutralisation at surfaces impacted by the ion beam.

The neutraliser has two solid state power supplies; one to excite the glow discharge and one to extract the ion from the discharge.

Substrate Table

The substrate table provides two axes of rotation: continuous on-axis rotation of the substrate to be processed; and a second axis that allows the substrate to be presented to the incident ion beam at an angle, from normal to glancing incidence.

Mounted on the table assembly, so that its orientation to the impinging beam changes with the inclination of the table is a pneumatically actuated shutter.

The worktable, to which the substrate is clamped, is water cooled. Both axes of rotation are via magnetic fluid seals.

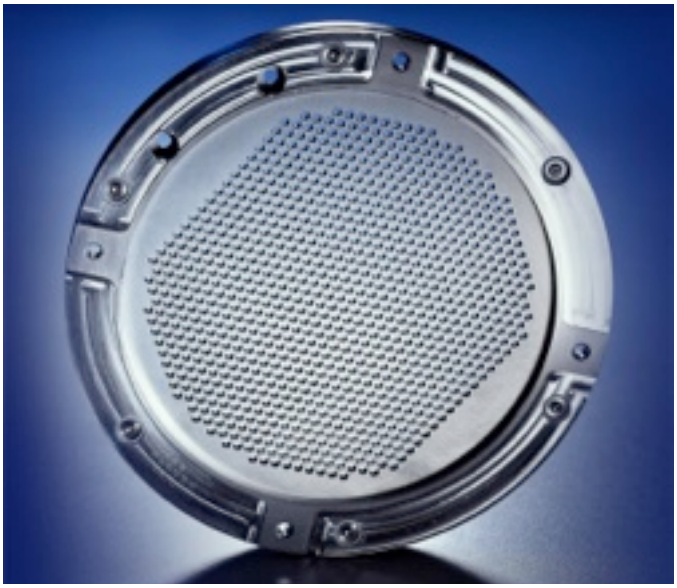
Wafers to be processed are held in contact with the table by a spring energised full ring clamp. For loading and unloading this is opened by pneumatic actuation. The linear motion for actuation is sealed by an edge welded bellows.

Vacuum Group

The process module is evacuated by a directly coupled magnetically levitated 1400 $l.s^{-1}$ turbomolecular pump with an onboard controller, when a 15 cm ion source is used. This is substituted with a 2000 $l.s^{-1}$ turbomolecular pump with an onboard controller, when a 20 cm ion source is used and a 3200 $l.s^{-1}$ turbomolecular pump with an onboard controller, when a 25 cm ion source is used. This is backed by a dry pump. The standard pump provides 30 $m^3.hr^{-1}$ displacement. Larger backing pumps are available on request.

Pressure is measured using a combination gauge. This provides a measurement range from $1x10^{-8}$ to 1500 Torr and combines cold cathode inverted magnetron, MicroPirani and Piezo differential sensor technologies. It also provides a display of the pressure directly on the gauge head.

An interlock vacuum switch is fitted. To guard against over pressurisation on venting, an over pressure relief valve is fitted.



System Configuration
common components

Gas Metering

Gas is metered to the ion source and to the neutraliser by electronic mass flow controllers. Two channels are provided for the ion source, and one for the neutraliser. Each is fitted with a high integrity downstream isolation valve.

SIMS Probe (option)

A Hiden IMP 301/3F PIC type B, type 423041 is installed on the process module in a position to sample material etched from the wafer. For differential pumping of the probe a 200 $l.s^{-1}$ turbomolecular pump and a shared dry mechanical pump are provided. An auxiliary ion gauge is also fitted to shut down and protect the ion probe in the event of a pressure excursion.

Vacuum Load Lock

The load lock allows the transfer of a single wafer to or from the process module under vacuum. This significantly mitigates the time penalty of needing to vent and open the chamber for substrate loading, and the associated extended re-evacuation time.

The assembly is configured to house and transfer a single wafer at time. It is configured in a linear fashion. The transfer arm has two motion axes; the first is the linear movement used to translate the wafer from the load lock to the process module, or visa versa: the second is a vertical motion used to achieve hand off to or from the substrate table. These two motions are sealed using Viton o-rings.

Between the load lock and the process module is a pneumatically actuated rectangular gate valve.

The load lock is evacuated by a dry pump shared with the main process chamber. A dedicated pump is available on request. Pressure is measured in the load

Automation & Services
summary & options

lock by a combination gauge that provides measurement from 1,000 to 10^{-5} Torr. It is also fitted with an onboard display.

For ion milling applications a rough vacuum level is generally considered sufficient prior to wafer transfer. A small turbomoelcular pump may be fitted as an option.

Automation

The system is automated and supervised by the Nordiko automation system. The control system comprises an integrated suite of modular hardware and software components specifically configured for each individual machine or tool.
Control of the tool is centralised in the embedded industrial computer, running Windows. It is a modular computer system comprising a power unit, CPU, and variable numbers of digital, analogue, and serial (RS232) input and output units. The modules are assembled and supported on a standard DIN rail and mounted in the electrical rack of the tool. The HMI (Human Machine Interface) application is provided by Nordiko running within a Windows™ environment on a PC.

Environment & Services

The system is compatible with clean room installation. The system is suitable for operation within a temperature range from 18° to 30° C and a relative humidity range from 20 to 60%. The services required include; electrical line power, cooling water, clean dry air, dry vent gas, process gas and internet access.

Electrical: 400 V, 3 phase, with neutral and earth, minimum system current 32 A (208 V 3 phase configuration is available upon request).
Cooling water: 5 $l.min^{-1}$ (1 us $gal.min^{-1}$). The water resistivity must also be controlled.
Conductivity: Max 200 $\mu S.cm^{-1}$
Temperature: nominal 20°C (must be less than 30° C and 2° C above the ambient dew point).
Clean dry air (compressed): min 5 Kg $f.cm^{-2}$ (71 lb $f.in^{-2}$).
max 7 Kg $f.cm^{-2}$ (100 lb $f.in^{-2}$).
Vent gas, dry air or N_2: filtered to 5 µm.
flow rate max 25 $l.min^{-1}$ intermittent.
max pressure; 1 Kg $f.cm^{-2}$ (14 lb $f.in^{-2}$).
Process gas (Ar): Purity, N4 (99.99%).
0.02 µm filtered by the customer.
Dual stage, metal diaphragm, pressure regulator with gauge. pressure control from 0 to 3 Kg $f.cm^{-2}$ (0 to 42 lb $f.in^{-2}$). customer supplied.
Flow rate, as per mfc (typically 50 sccm max).
Remote Support: Internet access required.

Summary Configuration

Process module chamber, stainless steel 304 fabrication, ISO vacuum ports.
Aluminium alloy full access door and aluminium alloy rear plate.
Aluminium support frame, with castors and jacking feet.
1400 $l.s^{-1}$, 2000 $l.s^{-1}$, 3200 $l.s^{-1}$ turbomolecular pump depending upon the ion source size.
30 $m^3.hr^{-1}$ inverter driven dry mechanical pump.
15, 20 or 25 cm rf ion source.
300/600 W 13.56 MHz generator.
Automatic impedance matching transformer.
+ve dc bias supply 600 V, 1300 mA.
-ve dc bias supply 2000 V, 250 mA.
Single neutraliser.
2 x psu 600 V, 1.3 A.
Dual axis substrate table, tooled for 3”,4” or 6” wafers.
Continuous rotation up to 30 rpm.
Pan inclination 180° of arc.
Three channels of electronic mass flow control.
Single wafer, single occupancy vacuum load lock, shared mechanical pump.
System automation.