



MBE Systems

MBE meets Nanoanalytics

- **State-of-the art MBE growth and surface analysis in a single, integrated system**
- **Modular design for flexibility and future enhancement**
- **Advanced research-oriented software control of all MBE growth processes**
- **Compatible with third-party components and sources**
- **Sample size ranging from small to 4" wafers**



MBE and Analysis

The Multiprobe MBE series of systems fulfill the most stringent requirements of modern nanotechnology research by combining high quality MBE with proven multi-technique surface analysis.

Future advanced compound semiconductor devices rely on the most advanced material research. Observing and analyzing nanometer-scale features between epitaxial growth steps, and then returning for continued high-quality epitaxy is now possible with this innovative line of integrated UHV systems. Whilst Omicron has a long and successful track record for adding its advanced analysis equipment to existing MBE systems, experience has shown that the design

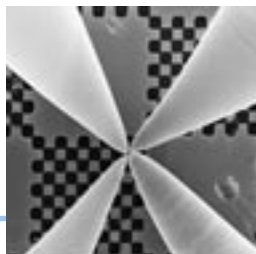
in a **SINGLE** System

of standard MBE systems results in major compromises for the analysis performance. The MULTIPROBE MBE systems reach a higher level of MBE analysis performance. The innovative design concept provides state-of-the-art material quality for the research environment without compromising the ultimate performance from scanning probe microscopy (SPM) and electron spectroscopy (ESCA, SAM, PEEM.) Multiprobe MBE is realised with the demands for ultimate performance analysis systems in mind. It enables the customer to either receive the complete MBE/analysis combination from the beginning or choose to start with one part and then upgrade

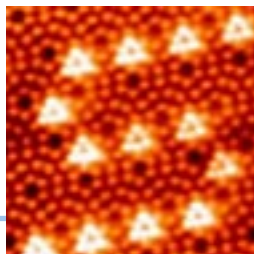
the remaining part later. As the system concept comes out of one hand, all questions or complications arising during usual later additions of analysis equipment have been addressed and solved already. System modularity provides for the exploration of advanced applications in MBE growth processes (such as new material systems), surface analysis (with NanoSAM and UHV SPM) and new techniques (such as in-situ lithography) These techniques, combined in the novel design of the Multiprobe MBE, provide for nanometer analysis in three-dimensions for samples up to 4" wafers.

Omicron Analysis at a Glance:

- UHV-STM and AFM down to atomic resolution for structural analysis
- Scanning Probe Spectroscopy
- In situ and simultaneous combination of SPM, SEM and SAM
- Manipulation of samples down to the atomic scale
- XPS or monochromated XPS for optimum chemical analysis
- Scanning Auger for chemical analysis of structures smaller 10 nm
- 3nm SEM in UHV with the Omicron UHV Gemini column



UHV-Nanoprobe with UHV Gemini Column: Navigation of 4 STM tips on a chessboard pattern



VT-STM: Indium nanocluster array; Data Courtesy: Qi-Kun Xue et. al., Beijing / China

Omicron MBE at a Glance:

- Highest quality advanced material growth
- Compatible configurations for small samples up to 4" wafers.
- Options include RHEED, RGA, and beam flux monitoring.
- Provision for in-situ monitoring techniques such as pyrometry, ellipsometry, and reflectance spectroscopy
- E-beam evaporators for high purity and high temperature materials.
- II/VI and III/V compound semiconductors
- Effusion cells, cracking cells and decomposition sources available
- Software/hardware control system for the growth process
- Large LN2 cryoshield and water cooled cells ensure process stability

System Integration

When the desired structures are in the nanometer range, every combination of MBE with Nanoanalytics requires deep consideration of the level of vibrations throughout the system. For a company with more than 15 years experience of building UHV-systems as well as the incorporated Scanning Probe Microscopes with atomic resolution, such consideration is natural and straightforward. Consequently the MULTIPROBE MBE is build with a rigidity and stability uncommon to standard MBE systems.

MBE Design

The MULTIPROBE MBE employs state-of-the-art components for the MBE growth: sophisticated substrate manipulators for continuous rotation at high temperature, standard MBE sources, sources dedicated for low or high temperatures, for low or high growth rates and extremely pure doping conditions. All this is available for the growth of wafer samples up to 4" diameter.

Software Process Control

The system software is designed to support state-of-the-art R&D process and vacuum system control. It is fully user configurable, has "unlimited" hardware and software expansion possibilities, for process, vacuum & mechanical system controlling and monitoring.

Sources are addressed in terms of composition, growth rates, doping levels and thickness. The recipe editor produces any structural feature simply and accurately using a layer/event based structure.

The data of all processes, system and measurement data are logged in a graphical environment. Other third-party software MBE control software can be provided upon request.



Side view on the wafer storage module for up to six 4" wafers.

The MULTIPROBE MBE System Family

MULTIPROBE MBE is realised typically as a single bench version, for some circumstances also as a dual bench version. Whereas the single bench version includes all MBE and analysis equipment on a single frame, the dual bench version combines two independent frames with a transfer station. The examples on these two pages show a variety of single frame versions.

Common features of the three main MBE part configurations include an oil-free pumping system, a liquid nitrogen cooling shroud, a fast sample introduction load lock, various extra ports (for quadrupole mass analyser, quartz microbalance, RHEED, sputtering, viewing, etc.) and two ports for the sample transfer to the analysis UHV system part.

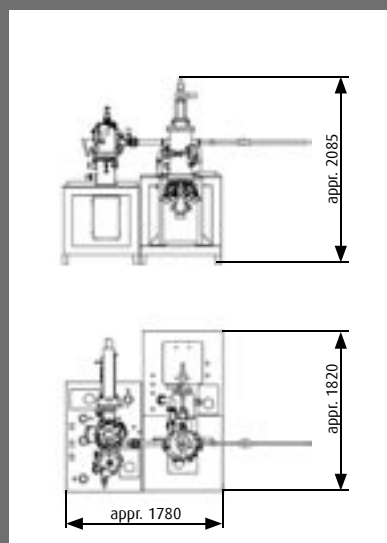
Beyond the analysis chambers, systems can be equipped with additional sample preparation chambers. Typical analytical configurations include SPM, XPS, UPS, AES, SAM and UHV SEM. And it is possible to have a fast sample introduction load lock each for the MBE part and for the analysis part so that both systems can be used fully independently in a multiuser environment.

Small Samples



Standard analysis module for techniques such as SPM, XPS, UPS, AES, LEED, depth profiling, etc. attached to a deposition chamber with a 12" base cluster flange (six 2.75" O.D. ports for effusion cells).

Footprint (all dimensions in mm)

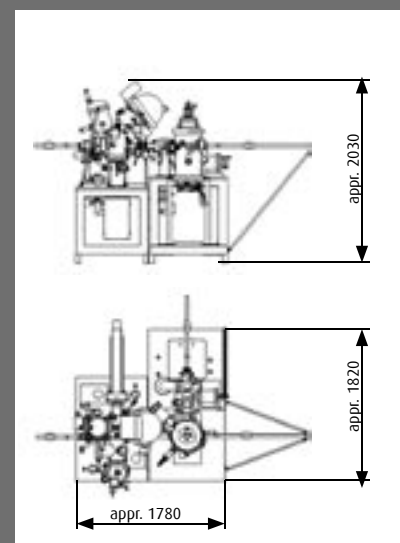


2" Wafer



Standard analysis module attached to a deposition chamber with a 14" base cluster flange for up to three 4.5" O.D. and four 2.75" O.D. ports for effusion cells. Substrate temperatures on the manipulator with continuous rotation up to 1250°C (higher temperatures on request).

Footprint (all dimensions in mm)



4" Wafer System

4" Wafer / SiGe System

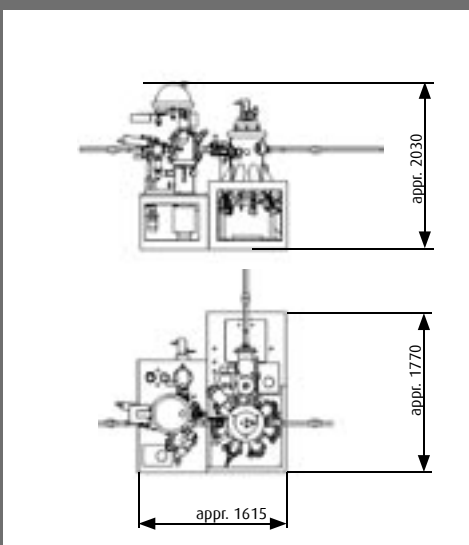


The deposition chamber provides six radially distributed 6" O.D. ports for effusion cells plus a spare 16" base flange for further effusion cells or an electron beam evaporator.

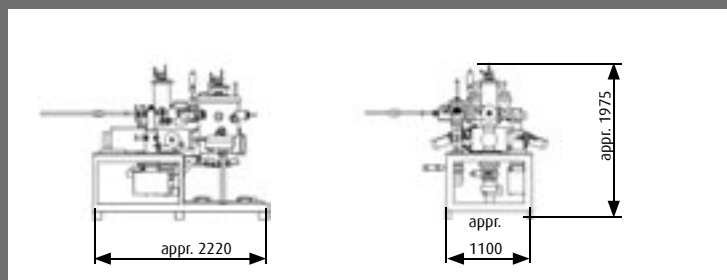


A deposition chamber with a large 20" O.D. vessel provides up to six 6" O.D. ports for effusion cells and two additional 10" ports for electron beam evaporators, two 4.5" O.D. ports for flux measurement using a quadrupole mass spectrometer, and four additional 2.75" O.D. ports for doping sources. The system is supplied with a substrate manipulator for temperatures up to 1250°C with continuous rotation, an electrically insulated wafer holder (optional), LN2 cooling shroud to suit VBC connectors, a buffer chamber with storage option for up to six 4" wafers, wafer degassing up to 1250°C and two ports for hydrogen cracker sources. Standard Omicron small sample plates can be transferred directly to an analysis system using a piggy-back 4" wafer holder.

Footprint (all dimensions in mm)



MBE-Footprint (all dimensions in mm)



Example of a Realised System



Analysis System

The analysis system consists of two chambers housed on an extremely rigid bench. The analysis chamber offers ports for high end surface analysis such as:

- high resolution in situ and simultaneous STM and SEM,
- position readout and repeated analysis of the same sample area after MBE treatment
- scanning electron gun source (UHV-Gemini column),
- scanning auger microscopy.

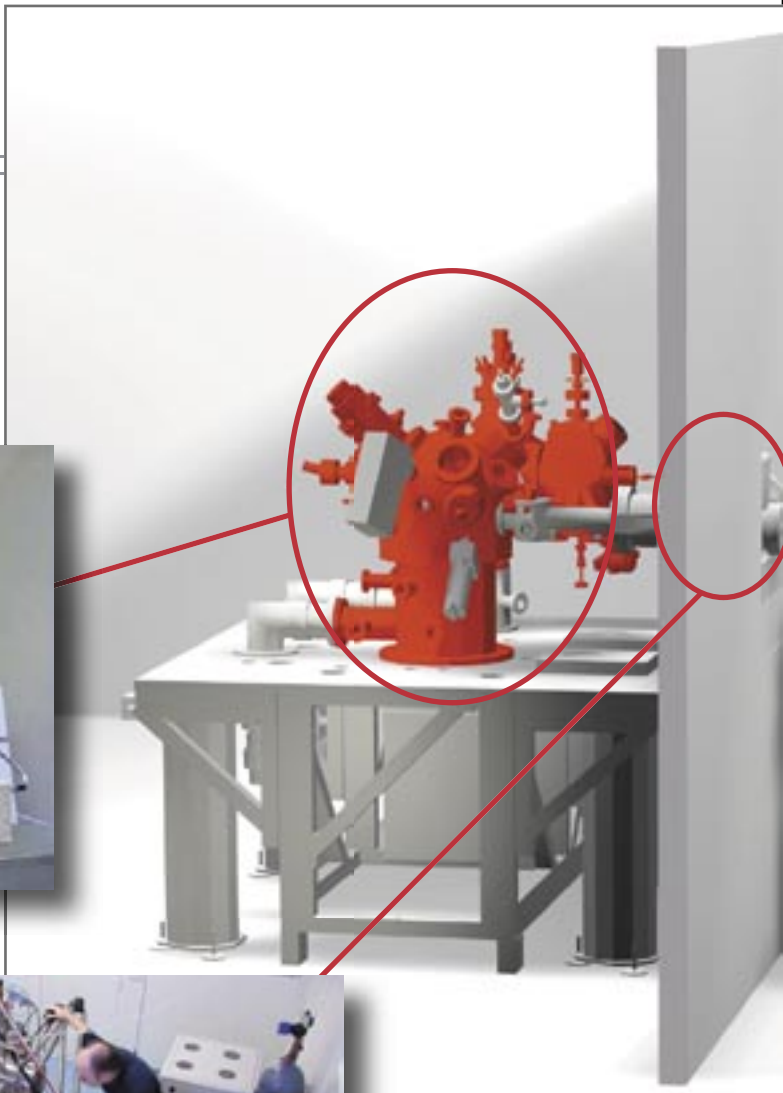
The combined preparation and analysis chamber offers further ports for surface analysis such as STM/AFM with variable sample temperature (25 -1500K), LEED/Auger, for sample preparation (sputtering, thin film evaporation, heating) and a fast entry lock for the introduction of small samples.

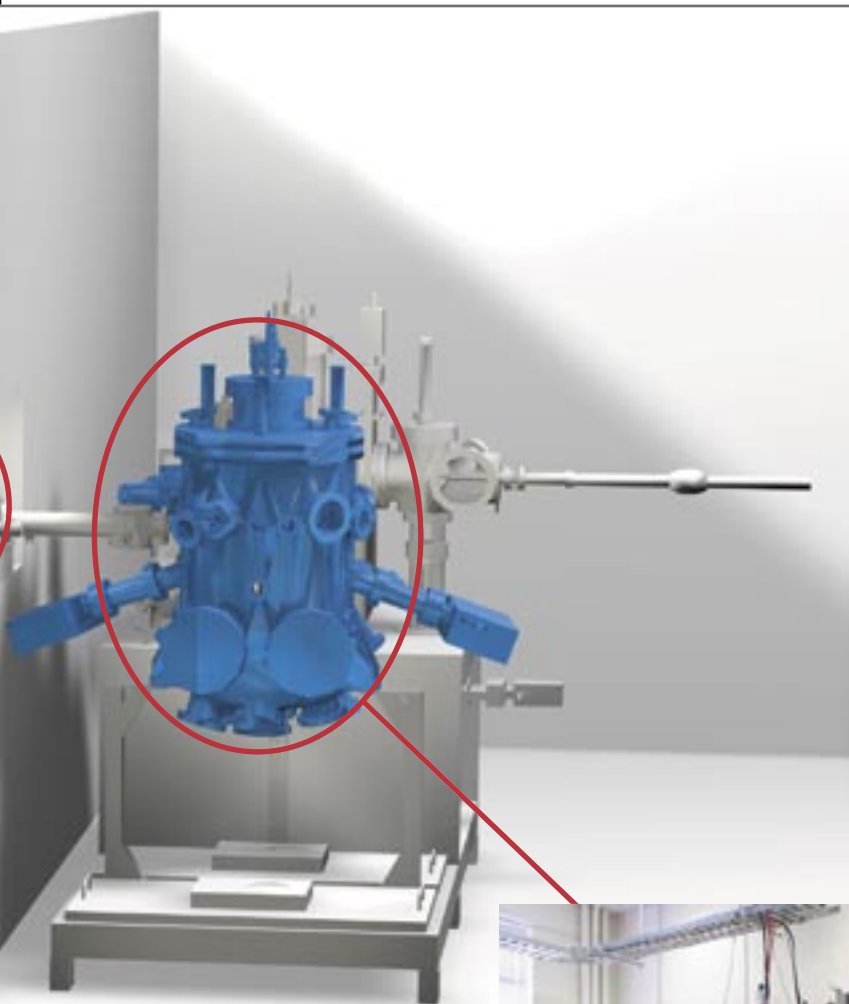


Sample Transfer / In-situ Analysis

Omicron 's sample handling is well-proven for probe microscopy and electron spectroscopy and is used in hundreds of research labs world-wide. It provides safe and rapid sample transfer between the MBE area and the analysis area. Samples can be directly transferred from the MBE chamber to the UHV SPM for monitoring and analysis. This ensures samples remain uncontaminated as they were grown.

The possibility to combine an MBE system with STM and AFM measurements allows both conducting and non-conducting samples, for instance gate oxides, to be examined. Wafer holders with an adaptor for standard OMICRON sample plates enable MBE with the same parameters as wafer samples, as well as permitting subsequent multi-technique surface analysis.





MBE System

The MBE part of the system is dedicated to the production of SiGe compound semiconductors. It allows the use of up to six Knudsen cells combined with two e-beam evaporators.

Each cell is individually controlled by its own power supply and PID controller, and special provisions have been made to achieve especially long times between refills of the e-beam evaporators.

The deposition rate and thickness measurement is realised using various feedback & control hardware including:

- flux control measurement by a quadrupole mass spectrometer
- quartz micro balance
- optical thickness monitoring
- temperature readout of Knudsen cells
- wafer/manipulator PID control using a thermocouple or pyrometer

The system is equipped with a buffer chamber for sample preparation (degassing at temperatures larger than 1000°C) and a wafer storage module for up to six 4" wafers.

Solid Design

In order not to let the MBE system compromise the performance of the Analysis system an extremely rigid and solid design is required.

Therefore Omicron uses its well proven bench and chamber design with a massive chamber wall for the analysis part which includes the STM/SEM combination, a stable bench frame (square tubes) and a thick bench top plate. This allows for atomic resolution in SPM mode with parallel operation of the MBE system.

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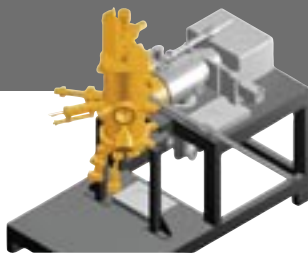
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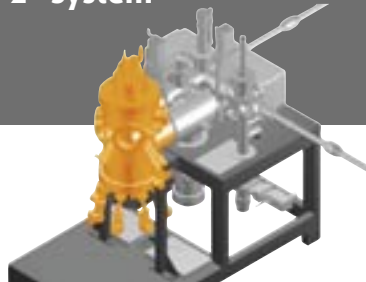
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Omicron MBE-Variability

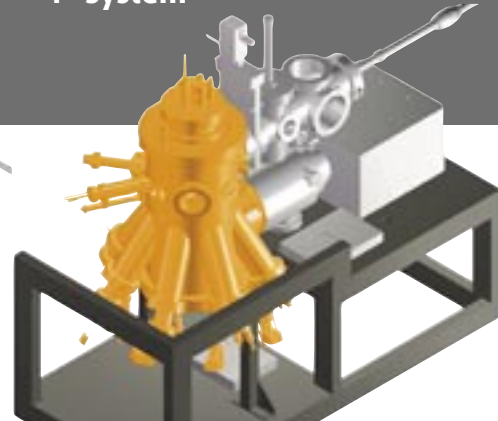
Small Sample



2" System



4" System



The MBE stand-alone parts of the MULTIPROBE MBE combine flexibility and upgradeability. All systems include a fast entry chamber in the basic version. Sample storage in the fast entry chamber can be added (see 4" example). Another possibility is to have an additional buffer chamber for sample preparation and storage (see 2" example).