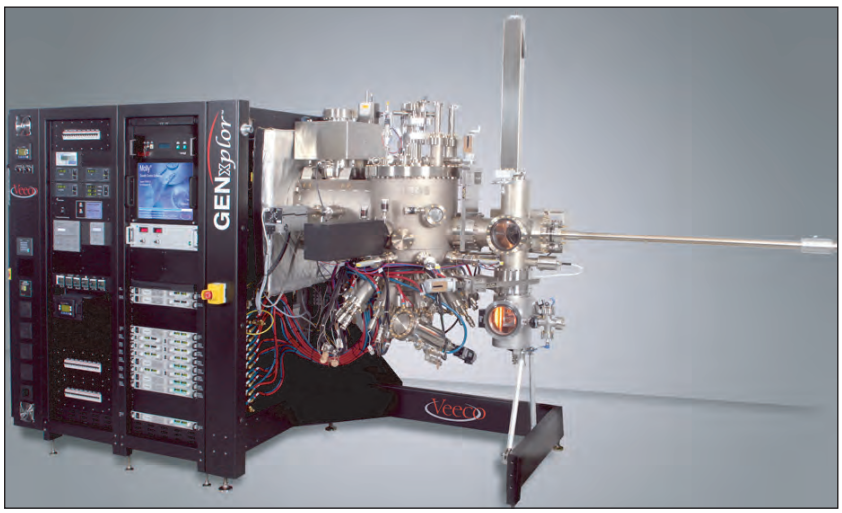
Veeco develops fully integrated MBE system for R&D applications

Gerry Blumenstock of Veeco's MBE business unit discusses how the firm's latest molecular beam epitaxy deposition system has been developed, while professor Michael Santos explains its tailoring for research in his III-V MBE Group at University of Oklahoma.

Epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA has had much success in molecular beam epitaxy (MBE) over the years with systems designed for production. However, the last introduction of a Veeco MBE system for R&D was the launch of the GEN10™ in late 2008, which accommodates a single wafer with a diameter of up to 3".

But recently, at the China MBE Conference in Shanghai in August, Veeco launched a new MBE deposition system, the GENxplor™, which is said to be the industry's first fully integrated MBE system for the compound semiconductor R&D market.



Veeco's new GENxplor R&D MBE system.

The GENxplor uses Veeco's proven GEN10 growth chamber design to deposit epitaxial layers on substrates up to 3" in diameter. However, a new single-frame architecture combines all vacuum hardware with on-board electronics, enabling the system to be up to 40% smaller in footprint than other MBE systems, saving on lab space. Because the manual system is integrated on a single frame, installation time is reduced, Veeco adds. The open-architecture created by the cantilevered growth chamber design also improves ease-of-use by providing convenient access to effusion cells (with user accessibility to all 10 source ports and the configurable base flange) and allowing easier serviceability compared to other MBE systems, says the firm. Also, the integrated Molly software allows easy set-up, integrating easy recipe writing, automated growth control, and always-on data recording.

Coupled with Veeco's recently introduced retractable sources, the GENxplor system incorporates process flexibility, facilitating research on a wide variety of materials including not only gallium arsenide, nitrides and II-VI materials but also oxides, for emerging technologies such as ultraviolet (UV) LEDs, high-efficiency solar cells, and high-temperature superconductors.

"The compound semiconductor R&D community asked for a more affordable, flexible, and easy-to-use MBE system," comments Gerry Blumenstock, senior director of marketing for Veeco's MBE business unit in St. Paul, MN, USA. "We have repackaged Veeco's industry-leading MBE technology into a novel 'all-in-one' design that combines the reactor and electronics on a single frame," he adds.

"The trend in leading-edge MBE R&D is to operate a tool that has open architecture and multi-system integration to allow researchers to grow materials in novel ways," notes Blumenstock.

Also, there is direct scalability to the Veeco GEN20™, GEN200® and GEN2000® MBE production systems, which have the same growth architecture but with volume throughputs. "In designing the GENxplor we took a page out of MOCVD's book," says Blumenstock. "People came from New York and New Jersey [home to Veeco's metal-organic chemical vapour deposition (MOCVD) unit] and we have shared resources," he adds. Consequently, development of the GENxplor system took just 14 months from concept to launch, rather than the 24 months that is usual for a new system.

Development in collaboration with universities

Veeco has developed the GENxplor in concert with customers, the first of which include University of Oklahoma and the UK's University of Nottingham. Most tools that are sold have custom components, tailored to the specific needs of the user.

The firm first talked with University of Oklahoma about the concept of the GENxplor in 2012. Subsequently, at the end of October 2013, Oklahoma became the first university to receive commercial shipment of a GENxplor system, which was installed and ready for use by the end of November. Of the total cost of the system, 70% has been funded by grants from the US National Science Foundation (NSF) and the remaining 30% funded by a matching grant from the university. "The University of Oklahoma is at the forefront of compound semiconductor materials research, so it is quite fitting that they are receiving the first GENxplor," comments Blumenstock. "It has been designed specifically for the R&D community, combining an easy-to-use platform with our world-class MBE performance," he adds.

"We have two other Veeco MBE chambers in our lab [a GENII for III-V materials and a GENII for II-VI materials] that have performed very well," comments Dr Michael Santos, professor in Engineering Physics and head of the University of Oklahoma's III-V MBE Group. The GENII system includes four chambers: (1) a growth chamber for III-V materials; (2) a growth chamber for IV-VI and fluoride materials; (3) a surface analysis chamber equipped for Auger electron spectroscopy (AES) and x-ray photoelectron spectroscopy (XPS); and (4) a chamber for scanning probe microscopy (SPM). The group had considered acquiring a Veeco GEN930™ MBE system, due to its compactness allowing it to fit into the lab, yet the GENxplor is even smaller.

"The proven growth chamber and enhanced features of the GENxplor, including robust process flexibility and convenient access to effusion cells, are ideal for the materials research we are conducting for technologies such as lasers, photodetectors, and solar cells," Santos says.

The group's research projects (which involve collaboration with Denmark's University of Copenhagen, Japan's Tohoku University, and the USA's University of Arkansas and Amethyst Research Inc) include:

- spin effects in indium antimonide (InSb) quantum wells;
- topological insulators in narrow-bandgap materials;
- interband cascade lasers, detectors, and thermophotovoltaic devices;
- antimonide materials for solar cell applications.

Recent projects have been funded by the National Science Foundation, the Air Force Office of Scientific Research (AFOSR), the Department of Energy (DOE), NASA, Intel Corp, Microsoft Corp, the Japan Science and Technology Agency, and the Oklahoma Center for the Advancement of Science and Technology.

Although the solar work has only recently started, Santos says that all the projects will be transitioned from GENII to GENxplor.

Oklahoma's GENxplor is configured with nine sources at the moment, says Santos, but can accommodate at least 10. In addition, due to having different inserts, the same uni-block molybdenum substrate holder can accommodate both 3-inch GaAs wafers and 2-inch gallium antimonide (GaSb) or indium arsenide (InAs) wafers. Hence, as well as growing antimonides and arsenides in the new system, the plan is also to investigate different materials, including bismides.

In addition, in the new system all effusion cells have been improved. In the case of antimony, a valved cracker (only available on Veeco systems) allows more precise control, enabling quick switching between antimony and arsenic sources. This useful in, for example, arsenide/antimonide superlattices in interband cascade lasers (which are targeted for energy-efficient longer-wavelength emission) as well as 'third-generation' interband cascade photovoltaic cells, for which the arsenide/antimonide energy-band line-up enables high efficiency.

One objective at Oklahoma is to connect the two systems (GENII and GENxplor), which have different analysis and materials capabilities. Currently, it is common for wafers to be transferred between two separate GENII systems. Also, according to Veeco, it will be possible to transfer wafers between GENxplor systems. However, in GENII systems wafers are situated vertically, whereas in GENxplor systems the wafers are face down, so sample transfer is different. Therefore, "in the near future" Veeco and Oklahoma aim to collaborate on developing a GENxplor-to-GENII transfer station, operating under high vacuum, says Santos.

This should be aided by Veeco's Process Integration Center in St Paul, which is fully equipped to conduct process demonstrations, arrange rapid-start programs, provide early access to evaluate system upgrades and support joint technology developments, especially since the facility which features both a GEN10 system and a GENxplor system.

- At the 30th North America Molecular Beam Epitaxy Conference (NAMBE 2013) in Banff, Canada (5–11 October), Santos' group presented its latest MBE-based research, including 'Heterostructural Integration of II-VI and III-V Materials on Si-based Substrates' and 'High Electron Mobilities of InSb Epilayers and Quantum Wells on Ge-On-insulator Substrates with Post-growth Hydrogenation'. ■

www.veeco.com/genxplor
http://mbsantos.weebly.com