Keeping cool with the hottest technology

PVD epitaxial growth on CLUSTERLINE® 300

While MBE offers excellent results in crystalline film quality, its low deposition rates limit its suitability for high-volume applications, but now it looks like we have a solution. Evatec Project Manager, **Markus Mueller**, tells us the story of what's been achieved so far and what's to come.

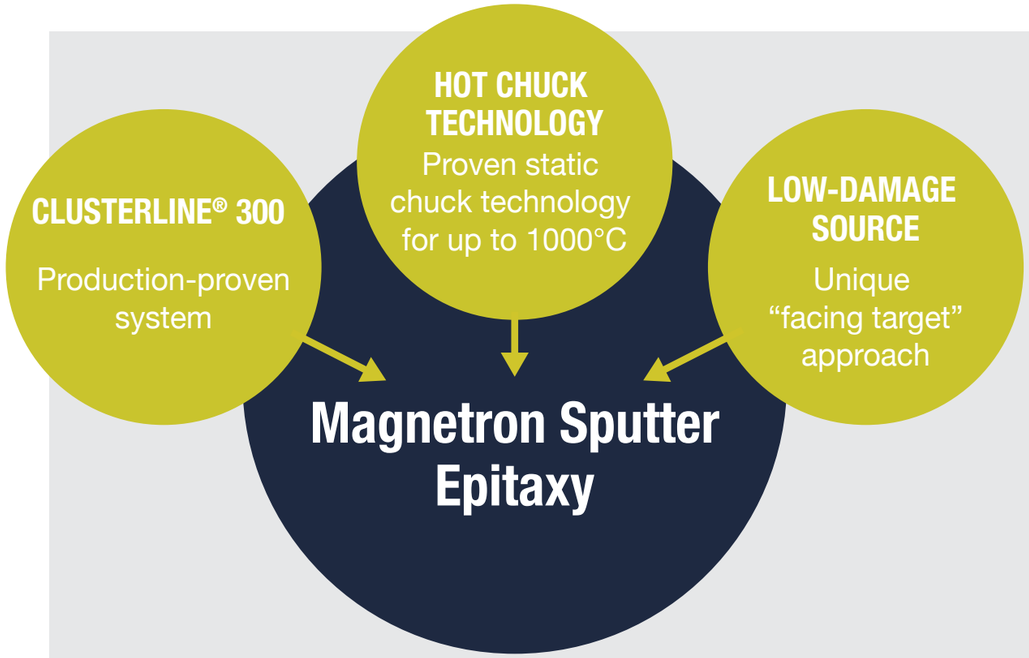
Understanding the challenge

New Evatec developments in "hot chuck" and "cathode" technology look set to enable epitaxial and quasi-epitaxial growth using PVD-based processes, delivering practical production solutions for a wide range of advanced functional materials, including BTO (Barium Titanate), GaN (Gallium Nitride), ITO (Indium Tin Oxide), and LNO (Lithium Niobate).

The first thing we had to do was sit down with customers and set clear goals. Depositing crystalline films with high uniformity was a prerequisite, but we also needed to understand more about the typical materials and film thicknesses they would need in future, the acceptable levels of contamination, the throughput requirements, and other possible limitations we needed to overcome to make a PVD based solution an attractive one for the future. Figure 1 illustrates some typical process requirements. Beyond film uniformity, the system had to be designed to fulfill additional frontend fab specifications.

- **Substrate Temperature:** Up to 750°C
- **Rocking Curve:** < 0.6° (FWHM)
- **Film thickness uniformity:** < 3% (1 sigma)
- **Deposition rates:** > 40nm/h

Figure 1: Four process challenges



CLUSTERLINE® 300 as the basis

The production-proven fab compatible CLUSTERLINE® 300 platform was our starting point. Our approach was to develop a modular PVD solution achieving crystalline growth by combining elevated substrate temperatures with low-damage deposition techniques. A key philosophy was to build on existing know-how wherever possible, further developing and optimizing existing production-proven component parts to shorten development times and minimize risk.

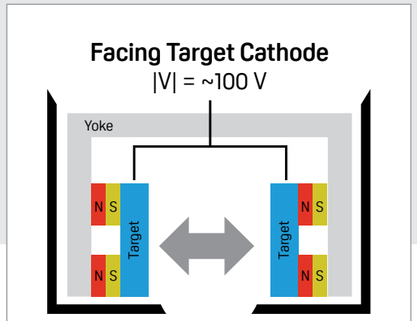


Figure 2: FTC working principle

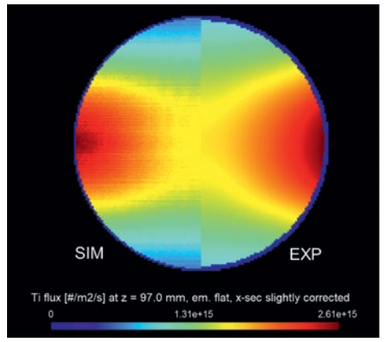
Very Hot Chuck Technology

The central element was the very hot rotating chuck where Evatec built up lots of know-how over the last few years. The newly designed chuck heats 12" wafers up to 750°C with a temperature uniformity of ±2% to support crystalline growth processes. Working in combination with Evatec's Facing Target Cathode (FTC) source (see Figure 2), it also rotates during deposition to ensure the dynamic averaging required to meet strict film performance targets for layer properties across the substrate. Meeting these combined requirements takes precise coordination of thermal control, mechanical design, plasma optimization, and particle control, all integral parts of the overall system concept.

Handling high process temperatures in a vacuum chamber presents several challenges. Many peripheral components, such as feedthroughs, sensors, or the sources are limited to maximum temperatures. To stay within these boundaries, the development team combined:

- Thermal shielding and clever layout
- Active and passive cooling concepts
- The use of temperature-resistant materials

Since radiation is the dominant heat transfer mechanism in ultra-high vacuum, material selection for emissivity and thermal stability is a key part of the design.



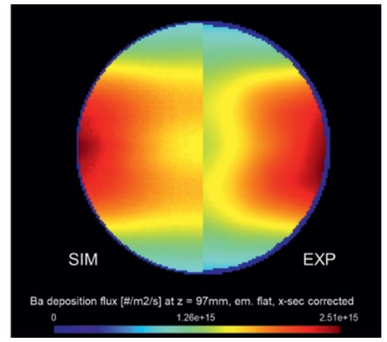


Figure 3: Feasibility studies and samplings validated simulation results.

Facing Target Cathode (FTC) Technology

The deposition source is based on Evatec's established Facing Target Cathode (FTC) technology. The latest design integrates independently controlled FTC sources, arranged and tuned using extensive plasma simulations. This setup allows optimization of both thickness uniformity and deposition rate. Additionally, new RF and DC generators, combined with customized matching units and gas control, are being used to fine-tune process conditions.

Working at high temperatures up to 1,200°C at certain surfaces requires all components to be selected for minimal outgassing and diffusion. This necessitates the use of rare or difficult-to-machine materials with high thermal stability, while still meeting the temperature uniformity requirements. To further reduce particle generation, sources and shielding have also been refined to minimize particle load and improve serviceability while the design needs to allow for simple target exchange in production.

Bringing it all together

Extensive performance simulations and actual component testing on 200 and then 300mm have been at the heart of the development work (Figures 3, 4 & 5).

Solutions on 300mm are coming soon. The 300mm hardware will be ready for customer samplings within our Evatec Competence Laboratory (ECL) in Q2 2026.

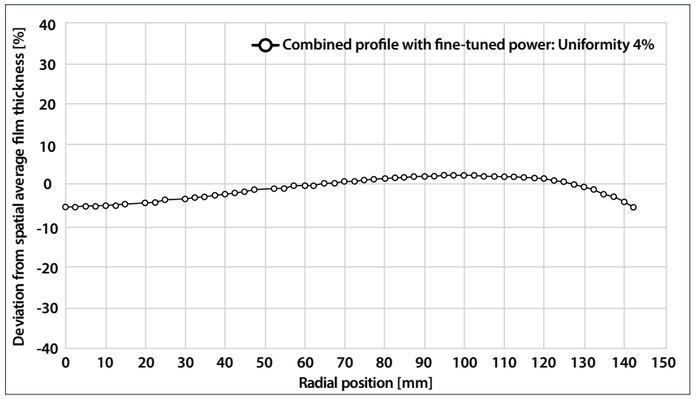


Figure 4: The arrangement of the FTCs combined is only one of the tuning nobs - but a major one.

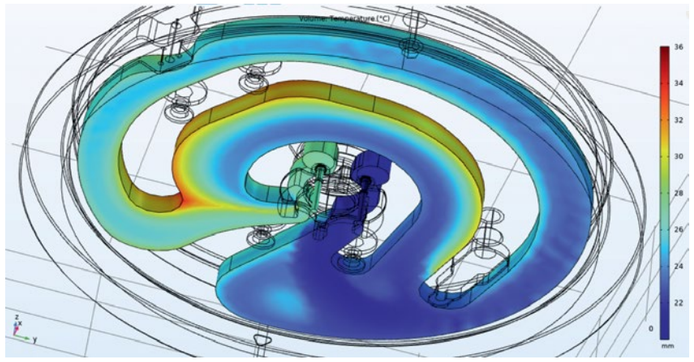


Figure 5: An advanced cooling concept was necessary to deliver a reliable solution.