Swiss Cluster

SC-1 Series

For Smarter and Faster R & D

ACCELERATING MATERIALS **BREAKTHROUGHS**

THE SC-1 SERIES

Our flagship deposition system combines an Atomic Layer Deposition (ALD) chamber at the top and a Physical Vapor Deposition (PVD) chamber at the bottom. The chambers are divided by a gate valve that is closed when performing ALD and opens to run a PVD process without the need to move the substrate or ever breaking vacuum.

This patent-pending innovative vertical chamber arrangement forgoes the need for transfer arms and antechambers, avoiding the pitfalls that make the traditional cluster equipment bulky, slow, expensive, and prone to handling failures.

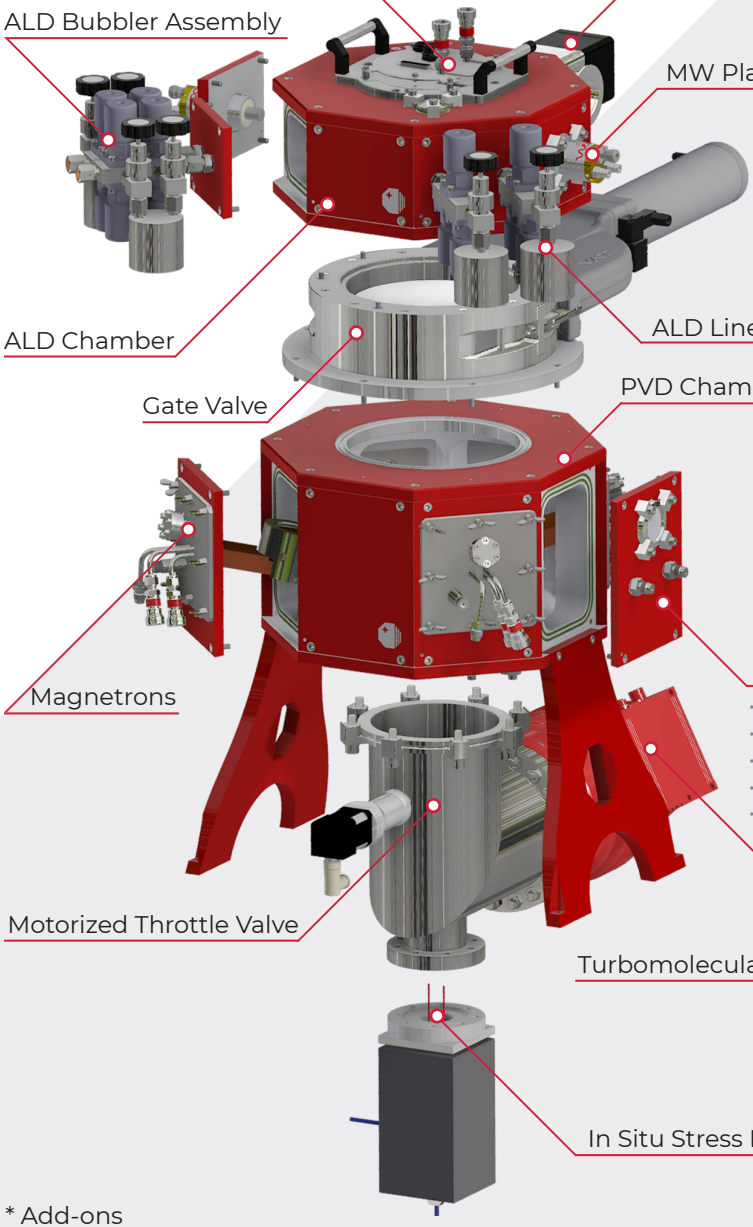
The system is designed to be completely modular and upgradeable. The ALD and PVD chambers can be installed as stand-alone chambers or used together as a cluster deposition system. The ALD can also be used as a load-lock, enabling fast substrate exchange and maintaining base vacuum. The SC-1 can be further modified and customized to fit your requirements.

Experience **full-automation** and **flexibility**

The SC-1 can fabricate *n* number of multinanolayers of multiple material systems from the PVD and ALD/CVD materials library with our easy-to-use hardware and software. Take control of your components with our *Machine Control* software, and create fully automated processes with our *Recipe Creator* tool. Standard recipes are ready to use for easy operation, and one can easily create new and/or modify recipes at any point.

Add new gas lines, valves, and mass flow controllers; customize flanges and feedthroughs; exchange substrate holders; incorporate microwave plasma sources for PE-ALD and reactive sputtering, or add in situ metrology equipment. The SC-1 series is extremely flexible to incorporate new hardware and be integrated into our software for manual control and recipe creation. Control your process and research with an innovative, flexible, and user-friendly system.

The first off-the-shelf **cluster equipment** combining **ALD** and **PVD** deposition techniques in a **compact**, **modular**, and **fully automated** system


Temperature Gradient Stage
ALD Exhaust Line
ALD Bubbler Assembly
MW Plasma Sources*
ALD Chamber
ALD Line Assembly
Gate Valve
PVD Chamber
Magnetrons
Custom Plates
Feedthroughs
Flanges
Viewports
Gas lines
and more....
Motorized Throttle Valve
Turbomolecular Pump
In Situ Stress Measurements*

* Add-ons

SPECIFICATIONS

Hardware

Substrate Sizes
- 4 in. wafers
- 6 in. wafers
- Different substrate holders available

Substrate Temperature
- Up to 400 °C (homogenous)
- A gradient of 30 °C to 450 °C with the Temperature Gradient Stage (TGS)

ALD Precursor Lines
- Up to 12 precursors with individual inlets
- Standard bottles and bubblers

Magnetrons
- Up to 4 magnetrons with 2 in. targets or 8 magnetrons with 1 in. target
- Custom angles
- HiPIMS compatible

Add-ons
- Microwave plasma sources (PE-ALD)
- In situ wafer stress measurements
- Customized ports and flanges

ALD-PVD Materials
- Al_2O_3, TiO_2, TiN, ZnO, Y_2O_3, ZrO_2, HfO_2, Cu, Al, Ti, Mg, Nb, and more...

Software

Mass Flow Controllers
- 4 Analog MFC
- Up to 60 Digital MFC

Pneumatic Valves (ALD)
- 24 valves

Gate Valves
- 3 gate valves with feedback

Vacuum Gauges
- 4 Analog Sensors 24V

Flow Meters
- 4 Flow meters 24V

Temperature Control Unit
- 16 Channel PID regulation with K-Type sensors

Motor Control Unit
- 6 motors 24V - 1.5A

Additional Connections
- 2 Ethernet
- 4 RS485

Manual Control & Recipe Creator
- Integration and control of all devices

FEATURES

Materials Factory with the benefits of ALD and PVD

Multinanolayered Materials: Hundreds of nanolayers from various material systems from the PVD and ALD materials library can be synthesized. The combination of ALD and PVD layers creates a unique microstructure with tailored properties to fit in your desired application.

Combinatorial Approach: The ALD-PVD microstructure can be further tailored with different film thicknesses along the cross–section with different deposition temperatures across the substrate using our Temperature Gradient Stage (TGS).

Modularity to customize and upgrade

Expandable: The ALD and PVD chambers can be acquired and operated individually and then be upgraded to a cluster system. New devices or in situ metrology equipment can be added and incorporated to the hardware and software.

Compact: By reducing the need of antechambers and mechanical arms, we reduce the complexity and footprint required in the lab.

Fast to accelerate R & D

Automated: The system is fully automated; all the devices and components are connected to our easy to use software. Hundreds of ALD and PVD multinanolayers can be fabricated with the push of a button.

Smart R & D: The TGS allows to screen a temperature window to scan precursors, growth rates, crystal structure, chemical composition, mechanical behavior and more in a single deposition.

User-friendly to beginner and advanced users

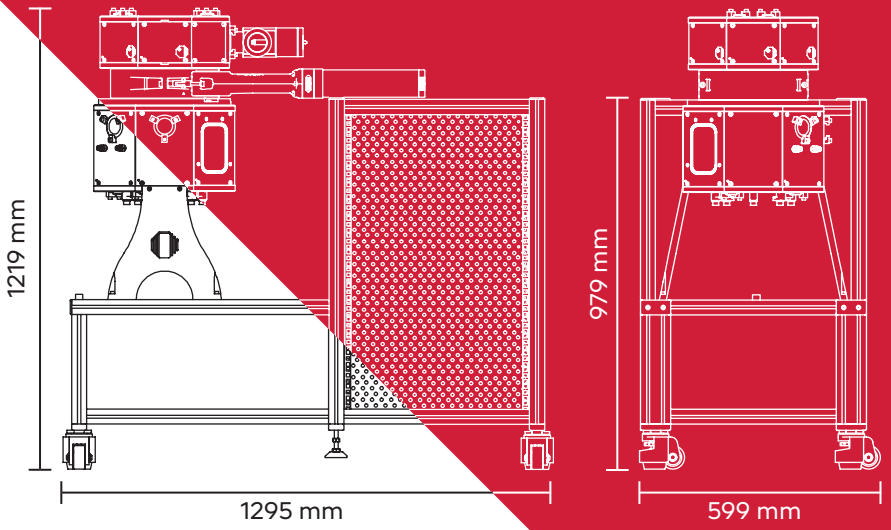
Recipe Creator: With our easy to use *Recipe Creator*, complex recipes can be made easy with different parameters in both ALD and PVD process during the deposition. Incorporate your devices or homemade systems and control it with our software.

Low Maintenance: The easy attachable/detachable panels makes this equipment extremely easy to replace, clean and service the parts.

TECHNICAL DATA

Dimensions (L x W x H)	1295 mm x 599 mm x 1219 mm
Weight	150 kg approx.
Base pressure PVD*	$5x10^{-7}$ mbar
Base pressure ALD**	$5x10^{-3}$ mbar
Max. power required***	3.8 kW @ 230V
Water flow required***	0 - 8 l/min
CDA	5 - 6 bar

* recommended turbo pump: 700 l/s
** recommended dry pump: 80 l/s or higher
*** depends on temperature requirements, vacuum pumps, and components

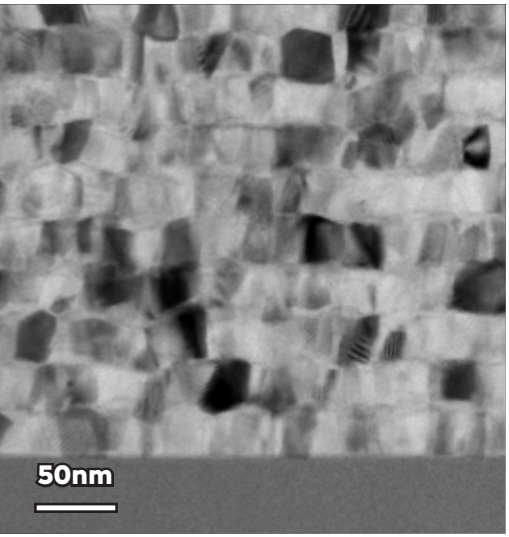


The dimensions do not suit your **exact requirements**?

We can modify and customize the chambers and system to fit your needs. Let us do the engineering work while you focus on the materials science.

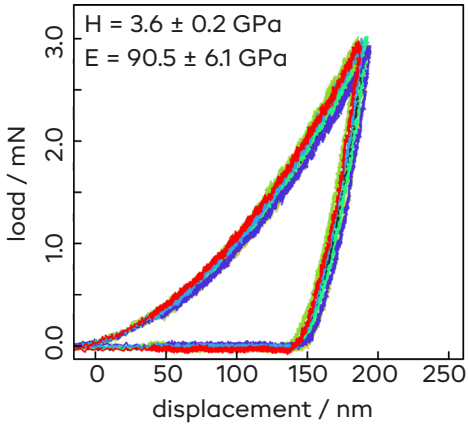
APPLICATIONS

Nanostructured materials can be engineered with a unique microstructure, tailored to different applications.



▲ *TEM image of a ~2.6 µm thick film of a multinanolayer composed of 100 layers of 25 nm of PVD aluminium alternating with 1 nm of ALD Al_2O_3*

Image Courtesy of
Dr. Thomas Edwards, Empa



Get your grain growth **under control**

200 Nanolayers of Alternating Al-Al_2O_3

Microstructural stabilization of metallic coatings is one strategy to increase significantly the mechanical properties of the material. This is achieved by effectively interrupting the grain growth with 100 ultrathin interlayers of 1 nm thick ALD Al_2O_3 in between 100 layers of 25 nm thick PVD aluminium across the thickness of the coating. The ALD film stabilizes the grain size and acts as a pinning plane for grain boundary motion by segregation. This can greatly reduce the boundary energy and lead to a stable nanoscale grain size even at higher temperatures.

This unique thin film engineering can increase by 6 times the hardness of pure aluminium to 3.6 GPa and the elastic modulus to 90 GPa, outperforming the strongest aluminium alloys.

◀ *Nanomechanical mapping of the PVD/ALD Al-Al_2O_3 nanostructured multinanolayer film to determine the enhancing effect of thin ALD films.*

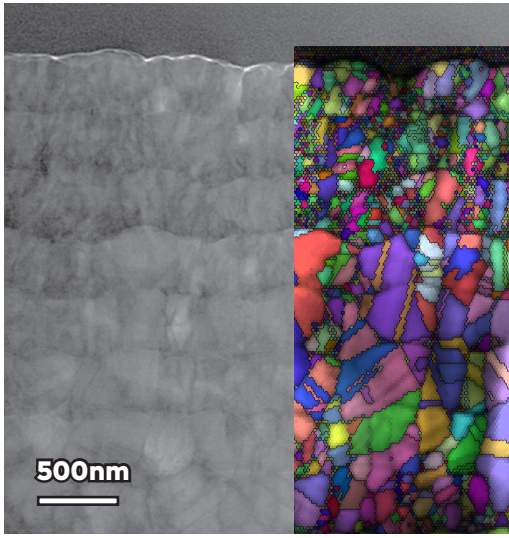
Image courtesy of
Dr. Alex Groetsch, Empa

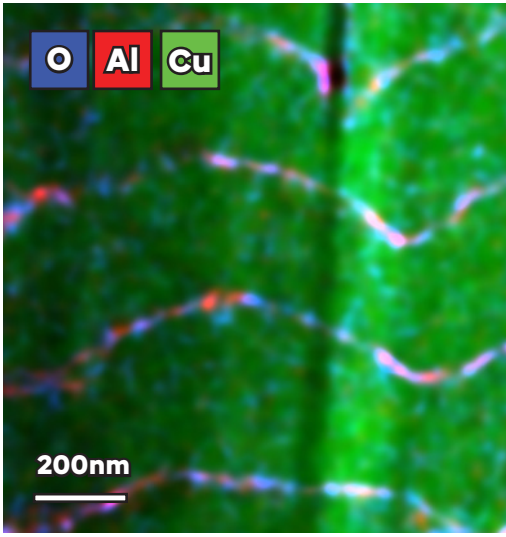
Reducing grain sizes in metallic materials can significantly increase their strength. However, smaller grain sizes are prone to grow and lose this property, especially at high temperatures. Introducing stable interfaces during the growth of metallic layers can interrupt the grain growth during deposition, block the dislocation motion and minimize the grain growth at high temperatures. Additionally, the combination of different grain sizes with stable interfaces can increase both strength and plasticity.

Nanograded Cu-Al_2O_3 Multilayers

Multinanolayers with functionally graded nanograins of PVD-Cu with interlayers of ALD-Al_2O_3 fabricated with the SC-1 using the TGS: from 400 °C to RT in the *x* and *z* directions. Every Cu layer is deposited with decreasing temperature to fabricate grains with decreasing sizes from bottom up. The ultrathin Al_2O_3 layers effectively break the grain growth in the growth direction and hinders it in the lateral direction.

▼ *TEM image and TKD mapping of Cu-Al_2O_3 multinanolayers with decreasing grain sizes from a deposition of 400 °C to RT (bottom to top).*





► *EDX analysis showing a clear separation between PVD-Cu and the conformal ALD-Al_2O_3 layers. The Cu layers present no oxidation or contamination from the ALD process.*

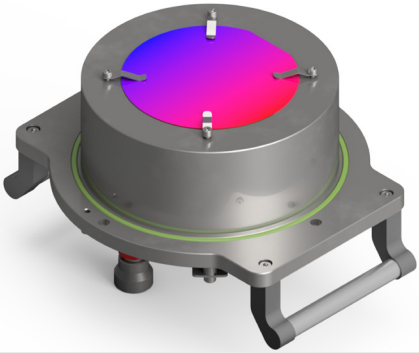
Top and bottom images courtesy of Dr. Amit Sharma, Empa

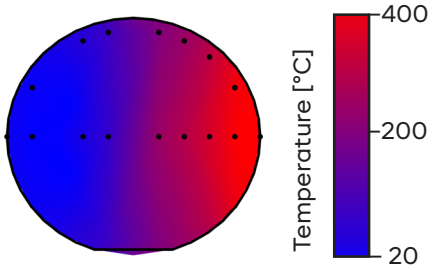
COMPONENTS & ADD-ONS

Temperature Gradient Stage

The Temperature Gradient Stage (TGS) is our own off-the-shelf substrate holder capable of temperature gradients from 450 °C to 30 °C, as well as a homogeneous temperature of up to 400 °C on a 4-inch wafer.

The temperature gradient can be tailored to different temperature windows by actively cooling with different water/air flows. This allows the screening of new materials and processes to be done in a substantially lower number of experiments. This saves a significant amount of time in the synthesis and characterization.





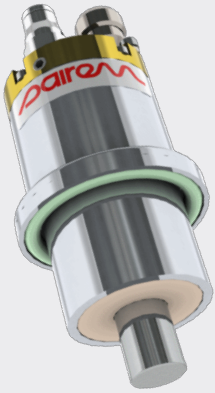
▲ *Temperature test from 400°C to 30°C with thermocouples along the TGS*

Microwave Plasma Sources & Generators

We incorporate microwave plasma sources and generators from **SAIREM** for Plasma-Enhanced ALD and Microwave Plasma Assisted Reactive Sputtering.

The Aura-Wave is an Electronic Cyclotron Resonance (ECR) microwave coaxial and self-matching plasma source working with 2.45 GHz solid state generators which can sustain stable plasmas from 10^{-4} to 10^{-2} mbar.

The source makes it possible to reach plasma densities of 10^{-1} cm^{-3} in a multisource configuration at 10 cm from the source plane with most gases.



Electronics & Software Control Systems

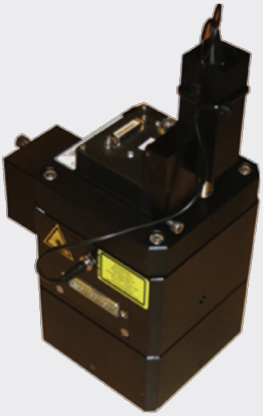
Replace your old and bulky electronics and software control system from your process equipment with our all-in-one electronic control units. Extend the lifetime, features and possibilities of your deposition systems.

- Connect all your existing devices (MFCs, motors, valves, heaters, etc.) and use them with our *Machine Control* and *Recipe Creator* software.
- Incorporate new devices and components and customize your software needs.
- Ask our experts about upgrading your system and have full control and automate your process.

In Situ Mechanical Stress Measurements

This system from **Vajotec** can be incorporated into the SC-1 to measure the mechanical stresses during an ALD and/or PVD process. The system regularly scans the substrate through an optical window.

The change in curvature of your wafer is constantly recorded and provides information about residual tensile or compressive stresses in your films.



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Swiss Cluster started in 2019 as a spin-off by a team of researchers and engineers from the Swiss Federal Laboratories for Materials Science and Technology (Empa) in Thun, Switzerland. The company was officially registered on November 2020.

The expertise of the team covers various thin film deposition techniques (ALD, CVD, and PVD); vacuum and plasma deposition technologies; as well as the whole realm of materials characterization.

The combined knowledge in these fields are harnessed to bring innovative ideas towards optimizing research and production processes to ultimately synthesize novel and better materials.

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