Picosun ALD – Enabling The Future

ALD is the manufacturing method of choice for future-oriented industries.

Atomic Layer Deposition (ALD) is the most advanced thin film coating and surface processing technology of today. ALD creates ultra-thin films of various materials - oxides, nitrides, sulphides, carbides, fluorides, metals, even polymers - on practically all kinds of surfaces with digitally precise and repeatable control over film thickness, uniformity, composition, and conformality. ALD films are pinhole-, crack-, and defect-free by nature. The ALD process takes place in vacuum at relatively low temperatures, allowing its application also to sensitive surfaces.

ALD has a central, well-established role in modern semiconductor industries. Functional material layers manufactured with ALD enable constantly miniaturizing integrated circuit (IC) components for faster and more reliable computing, mobile communications, and data transfer and storage.

ALD is present in the most advanced products of today.

“Smart” homes and industries, safer cars and other transportation, quicker and easier medical diagnostics, and wearable health monitoring devices are realized with microscale sensors. ALD is a key technology in cost-efficient manufacturing of these devices. Energy-saving LED lighting is made brighter and longer-lasting by ALD, and precision optical layers for various special applications are created with ALD. In medical technology, patient safety and lifetime of surgical implants are improved by biocompatible ALD coatings. Novel, targeted drug delivery methods are also being developed utilizing powder materials functionalized with ALD.

ALD enables sustainable future.

For sustainable future, ALD films enhance the performance of solar panels and fuel cells. Novel, high energy density batteries and energy harvesting devices utilize ultra-thin ALD layers. Powder carriers activated with ALD coatings show potential for low-cost and environmentally friendly catalysts. Value items such as noble metal jewelry and collector coins can be protected against aging effects, darkening and discoloration by ALD. In watchmaking and jewelry industries, shiny and colorful ALD films with vibrant, metallic hues enable totally new visual look - in non-toxic, non-allergenic, and material-saving way.

Picosun provides production-proven ALD solutions.

Today, many of the world’s largest microelectronics and IC manufacturers have chosen Picosun’s ALD solutions to realize their most advanced products. Outside of the IC realm, our industrial ALD technology has been selected for production use by various, global minting, watchmaking, medical implant, energy, and solid state lighting industries.

We provide our customers turn-key ALD production solutions with the most extensive all-around sales support. PICOSUN™ ALD equipment represent the leading design and manufacturing quality. Every component and feature is carefully selected, tested, and optimized for unaltering performance day in, day out. Our ALD process quality and purity are world-leading. Combined with the highest productivity and reliability, easy operation, and low cost-of-ownership, PICOSUN™ ALD systems are the choice of all forward-going industries.

Picosun’s ALD technology creates unparalleled competitive edge to your products - with atomic layer precision!

We at Picosun stand apart from all other equipment manufacturers due to our unique, groundbreaking expertise in the field - reaching back to the invention of the ALD technology itself. Our exclusive dedication to ALD gives us the most comprehensive understanding of the customer’s needs and the ability to create the optimal solutions even to the most complicated process and manufacturing challenges. Our ALD technology makes the most advanced innovations come true, and offers a revolutionary way to improve the performance, quality, and manufacturing of existing products. Picosun’s ALD solutions propel your industry to the future with one gigantic leap - performed with atomic layer precision!
PICOSUN™ ALD Systems for Industrial Manufacturing

High volume batch ALD systems for industrial manufacturing.

Leading variety of batch handling and automation options.

ALD covers all shapes and surfaces down to the tiniest and hardest-to-reach places conformally, uniformly, and 100% pinhole-free. This makes it an ideal technique for protective and functional surface treatment of various industrial products. ALD films adhere seamlessly to practically all surfaces, from metals, glass, and plastics to even fabrics and powders. As a gas-phase, low temperature method ALD is gentle to the coated item and it can be applied even on the most sensitive substrates such as thin polymer foils. ALD’s self-limiting film growth mechanism results in superior film quality, structurally and composition-wise, with only a fraction of film thickness compared to other, more “coarse” coating methods. This leads to material and cost savings, making ALD economically and ecologically worthy alternative in comparison to various other surface treatment techniques.

Today, Picosun’s ALD technology is in daily production use to manufacture anti-tarnish, anti-corrosion, and decorative coatings on collector coins, watch parts, and jewelry, and biocompatible and bioactive coatings on medical implants.

Dense, inert, hermetic, flexible, and transparent ALD films challenge the traditional methods also in PCB (printed circuit board) protection against corrosion and tin whiskering. In wear protection, ALD layer improves the quality, reliability, and lifetime of the anti-wear coatings manufactured with other methods such as PVD (physical vapor deposition) by forming a nanoscale sealant over the pinholes and cracks in the PVD layer.

Examples of the use of ALD in various industrial products.

<table>
<thead>
<tr>
<th>Product</th>
<th>ALD film function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical implants (dental, joint), surgical fixators</td>
<td>Bioactive layer to enhance osseointegration, biocompatible encapsulant</td>
</tr>
<tr>
<td>Implantable medical devices (e.g. pacemakers, Cochlear implants)</td>
<td>Biocompatible encapsulant</td>
</tr>
<tr>
<td>Collector coins</td>
<td>Anti-tarnish coating</td>
</tr>
<tr>
<td>Watch parts</td>
<td>Anti-tarnish and/or decorative coating</td>
</tr>
<tr>
<td>Jewelry</td>
<td>Anti-tarnish and/or decorative coating</td>
</tr>
<tr>
<td>PCBs</td>
<td>Protection against tin whiskering and corrosion</td>
</tr>
</tbody>
</table>

Customer data showing examples of film thickness uniformities achieved in PICOSUN™ ALD tools on 150 mm and 200 mm (6” and 8”) Si wafers.

<table>
<thead>
<tr>
<th>Material</th>
<th>Non-uniformity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al2O3 (batch)</td>
<td>0.13</td>
</tr>
<tr>
<td>SiO2 (batch)</td>
<td>0.77</td>
</tr>
<tr>
<td>TiO2</td>
<td>0.28</td>
</tr>
<tr>
<td>HfO2</td>
<td>0.47</td>
</tr>
<tr>
<td>ZnO</td>
<td>0.94</td>
</tr>
<tr>
<td>Ta2O5</td>
<td>1.0</td>
</tr>
<tr>
<td>TiN</td>
<td>1.10</td>
</tr>
<tr>
<td>CeO2</td>
<td>1.52</td>
</tr>
<tr>
<td>Pt</td>
<td>3.41</td>
</tr>
</tbody>
</table>

Picosun’s batch ALD technology allows cost-efficient processing of e.g. surgical implants, coins, printed circuit boards, jewelry items, and watch parts.
# Technical features

| Substrate size and type | 156 mm x 156 mm solar Si wafers in batches of 50/100 pcs (both sides/back-to-back)  
Up to 300 mm x 300 mm glass sheets in batches of 10-20 pcs  
Large batches of 3D objects (e.g. watch parts, jewelry, coins, medical implants, machined parts)  
Powder and particle substrates  
Roll-to-roll, max. 300 mm width substrate  
Porous, through-porous, and HAR samples |
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Process temperature</td>
<td>50 - 500 °C</td>
</tr>
</tbody>
</table>
| Substrate loading options | Manual loading with a pneumatic lift  
Semi-automatic loading with a linear inline loader  
Fully automatic loading with an industrial robot |
| Precursors | Liquid, solid, gas, ozone  
Level sensors, cleaning and refill service  
Up to 6 sources with 4 separate inlets |
| Weight | 400 + 300 kg |
| Dimensions (W x H x D) | 149 cm x 191 cm x 111 cm |
| Options | PICOFLOW™ diffusion enhancer, N₂ generator, gas scrubber, customized designs, factory host software connectivity |
| Acceptance tests | Standard tool acceptance criteria with Al₂O₃ process |
# PICOSUN™ P-1000 Pro ALD System

## Technical features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
</table>
| **Substrate size and type** | 156 mm x 156 mm solar Si wafers in batches of 800/1000 pcs (both sides/back-to-back)  
Up to 400 mm x 600 mm glass sheets in batches of 30/50 pcs (both sides/back-to-back)  
Large batches of 3D objects (e.g. watch parts, jewelry, coins, medical implants, machined parts)  
Porous, through-porous, and HAR samples |
| **Process temperature** | 50 - 500 °C |
| **Substrate loading options** | Manual loading with a pneumatic lift and a forklift cart  
Fully automatic loading with an industrial robot |
| **Precursors** | Liquid, solid, gas, ozone  
Level sensors, cleaning and refill service  
Up to 12 sources with 8 separate inlets |
| **Weight** | 2000 kg |
| **Dimensions (W x H x D)** | 230 cm x 270 cm x 125 cm |
| **Options** | PICOFLOW™ diffusion enhancer, N₂ generator, gas scrubber, customized designs, factory host software connectivity |
| **Acceptance tests** | Standard tool acceptance criteria with Al₂O₃ process |
**Additional Options**

**PICOFLOW™ diffusion enhancer**

The PICOFLOW™ diffusion enhancer enables and improves the coating of deep trenches and other high aspect ratio samples, as well as porous, through-porous, powderous, or otherwise complex nanostructures. The PICOFLOW™ feature is available for all PICOSUN™ ALD tools.

**POCA™ and PICOVIBE™ powder coating systems**

Picosun offers powder coating solutions for both industry and R&D. Our POCA™ 300 flow-through cartridge is ideal for catalysts, phosphors, battery materials, and medical substances, and it can be directly integrated into the PICOSUN™ P-300 production-scale reactor frame. Picosun’s novel, innovative PICOVIBE™ feature improves the powder coating process even further by enhancing the distribution of the precursor vapors inside the powder batch, resulting in uniform film formation on every particle.

**Roll-to-roll feature for continuous ALD**

Continuous ALD is a potential manufacturing method for printed electronics and OLEDs, thin film batteries, smart textiles, organic sensors, and flexible displays. The large scale PICOSUN™ roll-to-roll ALD feature accommodates substrates up to 300 mm of width and it can be directly integrated into the PICOSUN™ P-300 production-scale reactor frame.
At Picosun, we are committed to the highest level of customer service, to ensure always faultless performance of your ALD tool.

Our PICOSUPPORT™ services guarantee all-inclusive support, with customer-specific content, scope, and duration. All of these are separately negotiated during or after a successful PICOSUN™ ALD tool delivery. The flexibility, customizability, and extensiveness of the PICOSUPPORT™ services enable our tool users to always get the most out of their investment, with uninterrupted production, maximum yields, and minimal system downtime. The PICOSUPPORT™ services are available, with selected scope and coverage, for both old and new Picosun customers.

Examples of the contents of your PICOSUPPORT™ package:

- Advanced training with customized scope for complex film and process development. This is a perfect way to extend ALD system operations and maintenance knowledge and capabilities or ramp-up competencies with your new personnel.
- Consultancy services from process troubleshooting and application-specific help to full production ramp-up are available from our most experienced ALD chemistry and process specialists.
- Spare parts available through Picosun with short lead times and competitive price. Optional Critical Spares Management where operations critical spare parts components, based on the tool configuration, risk assessment, and availability, will be stocked at Picosun to be available with next day delivery.
- Periodic maintenance from qualified and certified personnel to ensure smooth and continuous operation. We can offer comprehensive periodic maintenance and inspection services with the highest quality and cost effectiveness.
- HelpDesk service to assist with tool usage and problem solving. It is available with different service level options from non-urgent 8/5 support to 24/7/365 Emergency Service with on-site escalations.

All the services are provided by Picosun’s own, highly experienced specialists or by our regional, highly trained and qualified Picosun service partners. The PICOSUPPORT™ services collect all of our extensive expertise in ALD technology into a simple, effective, and cost-efficient package to ensure the ultimate performance of your PICOSUN™ ALD system.

To learn more about the PICOSUPPORT™ service alternatives, contents, and pricing structure please contact sales@picosun.com.
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Leading industrial thin film solutions