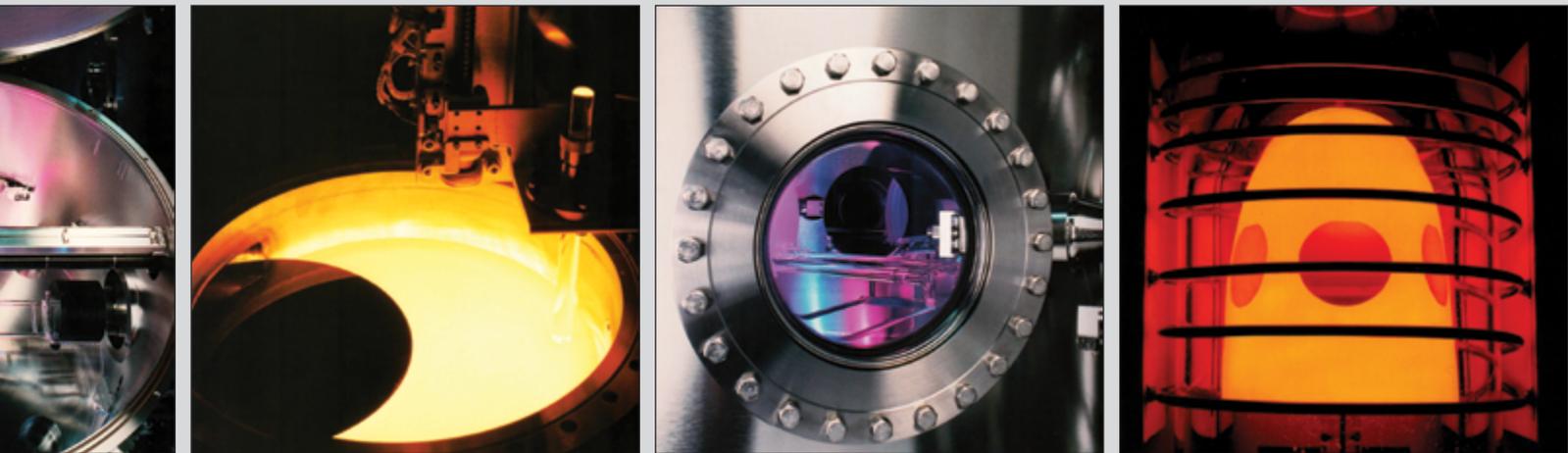


CVD
Equipment
Corporation



CVD Production Systems
for Industrial Coatings
powered by **CVDWinPrC™**

Equipment Design, Engineering, and Manufacturing

Thin film deposition systems for industrial processes

Since its founding in 1982, CVD Equipment Corporation has been an innovation driven company that has delivered close to 1000 systems to our customers. We continue to leverage our core competencies in equipment design and manufacturing to meet and exceed our customers' expectations. We also develop turnkey systems and process solutions for select markets.

Process Solutions

We focus on systems and process solutions by combining our customers' innovations with our own knowledge. We've advanced state-of-the-art technology and made visions turn into commercial realities. Our in-house Applications Laboratory staff are trained to quickly identify all key aspects of your unique processing needs. Whether you are trying to develop a new thin film deposition process solution or are looking to transfer your intellectual property to a pilot line or to full production stage, CVD Equipment Corporation can provide cost-efficient solutions.

Gas Delivery & Exhaust Treatment

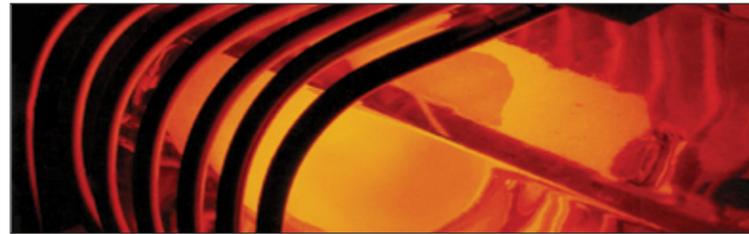
We offer gas/chemical delivery systems and exhaust gas conditioning equipment for use with flammable, corrosive, toxic, or pyrophoric process gases/vapors. Our exhaust conditioning and abatement systems automatically pyrolyze, wet scrub, and neutralize flammable and corrosive effluent. When purchased with our CVD reactor systems, they are integrated into the central control and safety system for turnkey operation.

powered by CVDWinPrC™

Operated through our CVDWinPrC™ process control software, our systems automatically log data and graphically show time-dependent values of user-selected parameters. CVDWinPrC™ also allows users to load preprogrammed recipes, modify, check and create new recipes, and view realtime or saved process data.

Safety Protocols

The systems have application configured safety protocols embedded into relay logic, PLC, and CVDWinPrC™ software.



Experienced Engineering

Our experienced design, process development, and manufacturing teams will quickly comprehend your unique process requirements and propose the most cost effective technical solution. Our electrical, mechanical, CFD modeling, and software design engineers work closely with our vertically integrated in-house manufacturing operation. This collaborative team can control all phases of your project and provide you with superior value for your proposed requirements. We will deliver a solution incorporating an efficient transfer of your operating parameters.

Process Performance

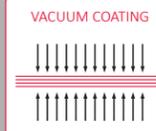
We offer services which can validate the process performance of your system to your specifications prior to shipment, saving your company valuable startup and system characterization time at your facility. Our modular product designs and remote computer monitoring capabilities make diagnosing and servicing your equipment a quick and cost-effective process. Many of our parts are made in-house, which enables rapid prototyping and efficient spare parts support.

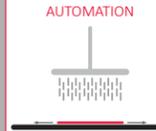


Markets Served

- **AEROSPACE** - Advanced materials enable the next generation of fuel efficient aircraft engines. Many steps in the production process involve chemical vapor deposition or chemical vapor infiltration techniques.
- **MEDICAL** - Implants often require functional coatings for performance and biocompatibility. Since these devices typically have complex geometries and/or porosity, a uniform coatings technology is required to coat all surfaces evenly.
- **SEMICONDUCTOR** - CVD is a widely adopted industrial technique for depositing thin films and complex layered micro- and nano-structures for use in semiconductor devices.
- **SOLAR PHOTOVOLTAICS** - We provide key process equipment used in the fabrication of solar cells. Our equipment is used for processing steps including diffusion, deposition of antireflective layers, oxidation, silicon epitaxial deposition, and selenization and sulfurization.
- **GLASS COATINGS** - CVD is the low cost, high throughput method to make glass coatings. We provide offline and online CVD process equipment for glass coating applications.
- **MILITARY** - Applications are wide-ranging, with many requirements for new materials and technologies to ensure our forces are equipped with the very best equipment.
- **OPTOELECTRONICS** - Semiconductor materials deposited by CVD are widely used in optoelectronics devices such as light emitting diodes and infrared detectors.
- **FUNCTIONAL COATINGS** - Surface coatings and treatment are used in many commercial applications for reinforcement, friction, thermal insulation, corrosion resistance, electrical shielding, optical reflection, wettability, bonding interlayer, etc.
- **TCO COATINGS** - Transparent Conductive Oxides can be coated on soda lime glass sheets and on a wide variety of metal foils and plastics. They can be optimized for rough coating with high haze for solar applications and with low haze for Low-E and other smart glass applications.

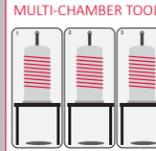
Core Engineering Expertise

VACUUM COATING

Our vacuum system solutions are designed to be low maintenance, robust, and reliable. Vacuum systems are selected based on the types of chemistries involved and process pressure requirements.

AUTOMATION

Our systems are designed to deposit thin films on many different types of materials for a wide range of applications. We have an extensive range of material handling capabilities, including reel-to-reel (roll-to-roll), batch, and cluster configurations.

CLUSTER TOOLS

Our cluster tool systems allow for automatic transfer of substrates between process chambers to deposit different layers using different processes. The systems can also be used for parallel processing of multiple substrates to increase throughput.

MULTI-CHAMBER TOOLS

Our multi-chamber systems are designed for preventive maintenance to be performed on one chamber while the other chamber continues to process, maximizing up-time and system utilization.

REEL-TO-REEL

Our reel-to-reel (roll-to-roll) CVD process tools deposit materials on continuous rolls of metal foils, plastic sheets, fibers, and other materials.

ULTRA HIGH SPEED DELUGE

Ultra-High-Speed Portable Deluge System provides the user with a portable, automatic fire and explosion suppression system where standard fire extinguishing systems cannot provide the desired level of protection or safety.

EXHAUST ABATEMENT

Our industrial exhaust conditioning and abatement systems automatically pyrolyze, wet scrub, and neutralize corrosive gases and vapors. When purchased with our CVD reactor systems, they are integrated into the central control and safety system.

Atmospheric Pressure CVD (APCVD)

APCVD is a thin film deposition process with typically high deposition rates. CVD Equipment Corporation offers solutions to scale up your APCVD processes from research to production volumes. We have demonstrated our competency in the solar industry, where we offer online and offline APCVD CVDgCoat™ systems to meet the high volume, low cost demands of solar module production.

Our APCVD systems are used to deposit a layer of material typically several micrometers thick onto wafers or other types of substrates. They are used to grow epitaxial films of Si, compound semiconductors, SiO₂, anti-reflection (AR) coatings, and transparent conductive oxide (TCO) coatings. APCVD is also used as a surface finishing process for items such as tools and turbine blades to improve lifetime and performance.



Fluidized Bed CVD (FBCVD)

Fluidized bed chemical vapor deposition (FBCVD) is a process technology used to coat powders or particles. The fluidized bed reactor (FBR) is designed to allow for injecting a fluidizing gas with the appropriate vapor or gas CVD precursor. As the powder is fluidized, the vapors/gasses will permeate through the powder and react to form thin films or nanomaterials on all surfaces of the powder. The FBRs are typically designed for continuous or batch processing of particles and powders.



Crystal Growth

Our Vertical Bridgman Crystal Growth system is an advanced process tool for the growth of bulk single crystal ingots. The system is optimized for controlled process development and user safety.

The Vertical Bridgman Crystal Growth system includes two independently controlled furnace subsystems; the melting and growth furnaces. A linear drive mechanism provides automated precision movement of the furnace assembly through the process zones between a start position and stop position at a programmable velocity profile with minimal vibration.

A high slew-rate mode permits quick setup and removal of the crystal growth crucible or ampoule. A rotary drive subsystem rotates the crucible or ampoule during the process to improve thermal uniformity.

Hydride Vapor Phase Epitaxy (HVPE)

HVPE is a high rate deposition process for growing high quality crystals. A common application is the production of gallium nitride (GaN) templates and bulk crystals. Gallium chloride is generated in-situ via a chlorination reaction. The chloride is then mixed with ammonia in the presence of the substrate at high temperature to form the GaN crystal. Doping is readily achieved with fine control.

Other III/V semiconductor crystals can be produced via HVPE, including indium phosphide (InP) and gallium arsenide (GaAs). Growth rates of up to ~ 300 μm/hr are readily achievable with HVPE.

Our HVPE systems can be configured for the particular requirements of the end user.



Chemical Vapor Infiltration (CVI)

Chemical vapor infiltration (CVI) is a chemical vapor deposition (CVD) process that is performed at low pressures to allow for coating of the internal surfaces of a porous material. Using heat and low pressure, precursor vapors penetrate the pores / fibers of the material and react to form a conformal coating on the internal surfaces.

Our CVI platform can be used to coat the internal surfaces of porous materials having complex shapes and geometries. Multiple systems are in production for coating biocompatible porous material for use in medical implants and aerospace components.



Low Pressure CVD (LPCVD)

Our LPCVD systems can uniformly deposit many thin film materials, including wide bandgap semiconductors, silicon carbide (SiC), nitrides, oxides, poly and epi silicon, transparent conductive oxides (TCOs), graphene, Si/SiGe epitaxial films, metallic and ceramic films, etc. The LPCVD systems are also used for nanomaterials synthesis including carbon nanotubes, graphene, semiconducting nanowires, and 2D crystals including boron nitride and molybdenum disulfide. LPCVD coatings typically exhibit excellent uniformity, high purity, and good step coverage.

We apply different vacuum system technologies depending on the requirements of the process. Vacuum systems are selected based on the types of chemistries involved and process pressure requirements. Our vacuum system solutions are designed to be low maintenance, robust, and reliable. Vacuum systems are integrated into a central control and safety system.

Liquid Phase Epitaxy (LPE)

Our LPE Reactor system provides the user with a process controlled furnace for automated, user-specified segment driven process recipes that provide optimum control over wafer processing and repetitive results from run to run. The overall system is designed to give the user reliable and repeatable growth of LPE layers.

The LPE system is capable of processing a wafer over a uniform flat temperature zone. All system components are located on the side, top, or front of the furnace, with either a left or right side glovebox.

An automatic, cantilevered, non-contact wafer loading system is incorporated within the system for loading and unloading of the graphite process boat. The loading system consists of a quartz boat holder that is cantilevered from the automatic end cap assembly.



Selenization and Sulfurization (SAS)

Our SAS process systems use thermal treatment (either infrared or resistance) with precursors such as diethylselenide and hydrogen sulfide. The SAS process is used commercially in the solar industry for CIGS, CIS, and CIGSeS thin film solar module production. Surfaces are controllably converted into either a selenide or sulfide compound.

Metal Organic CVD (MOCVD)

Our MOCVD systems have the capability of depositing layers of desired composition on a suitable substrate with graded composition (achieved by programming the software to ramp the appropriate flows). Exact process control produces MOCVD layers with abrupt interfaces or individual layers having a graded composition.

Our MOCVD systems are designed to meet your production requirements with flexibility and low operating cost. The systems allow for the deposition of II-VI and III-V materials. Batch processing of single wafers or multiple wafers is available. The systems are designed to process wafer sizes as specified by the end user. A temperature controlled showerhead delivering exact quantities of precursors and gases, coupled with substrate rotation during deposition, provides excellent deposition uniformity.

Ultra-High Vacuum CVD (UHVCVD)

CVD Equipment Corporation's resistance heated, single, dual, or triple chamber, Ultra High Vacuum Chemical Vapor Deposition system is an automatically controlled research or production system for processing of 8" diameter or smaller wafers. The process chamber operates at temperatures up to 1100 °C. The UHVCVD system is capable of pumping a clean thermal process chamber to a level of $<2 \times 10^{-8}$ Torr.

A typical use of this system is in low temperature deposition of silicon and silicon germanium films where abrupt changes in composition and dopant levels is required.



Rapid Thermal Processing / Annealing (RTP/A)

CVD Equipment Corporation offers research and production rapid thermal processing systems and rapid thermal annealing systems for many applications including solar cells, graphene, carbon nanotubes, nanowires, LEDs, MEMS, semiconductors, and industrial coatings. RTP can be configured for oxidation, annealing, silicon dioxide, silicon nitride, contact alloying, tin oxide, GaAs implant activation, PSG and BPSG reflow, silicon dielectrics, and many other processes.



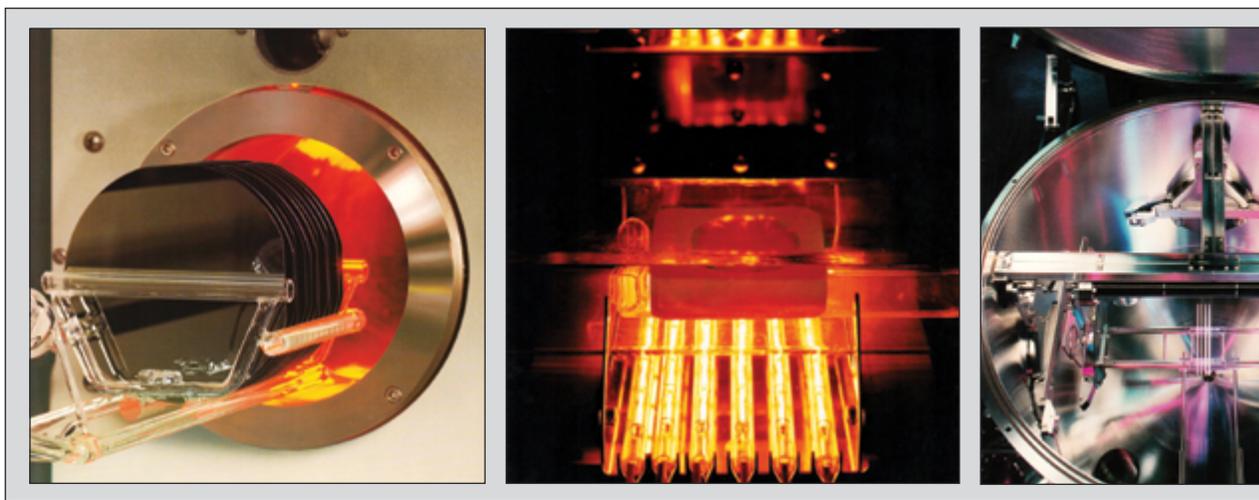
SDC[®] Gas & Chemical Delivery and CVD Exhaust Conditioning Systems

Many processes require the use of hazardous gases which can be flammable, toxic, corrosive, or pyrophoric. Industry standards and government regulations mandate the proper storage, delivery, and treatment of these gases to ensure that hazards to personnel and environment are minimized.

Our manual and fully automated delivery and exhaust treatment solutions are offered as standalone units or as integrated packages with our deposition process equipment.



The systems shown are examples of many CVD systems we design and manufacture in-house for innovators working on next generation process and material development. We have customers worldwide at universities, governmental labs, start-ups, and fortune 500 companies.



COVER IMAGES left to right: ① Wafer boat loading into annealing furnace ② Single wafer rapid thermal processing ③ Low pressure CVD chamber ④ Robotic wafer loading ⑤ Ultra high vacuum chamber ⑥ Multi-wafer MOCVD reactor

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