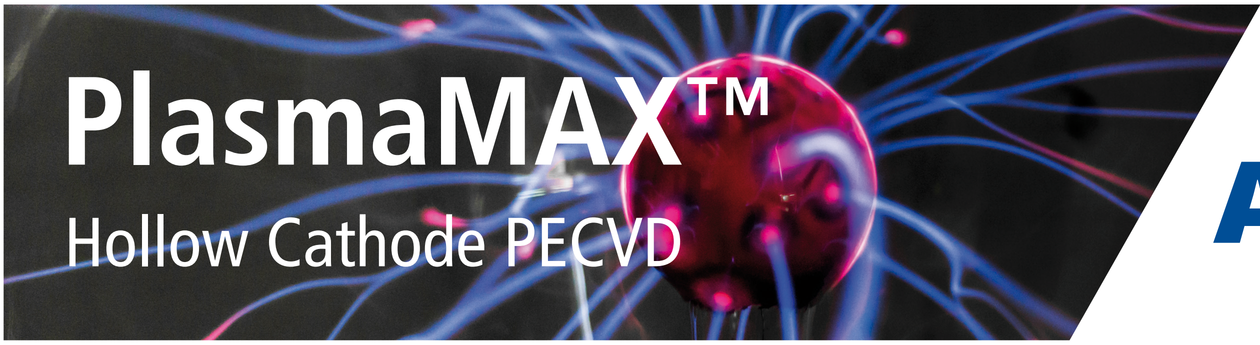


PlasmaMAX™

Hollow Cathode PECVD

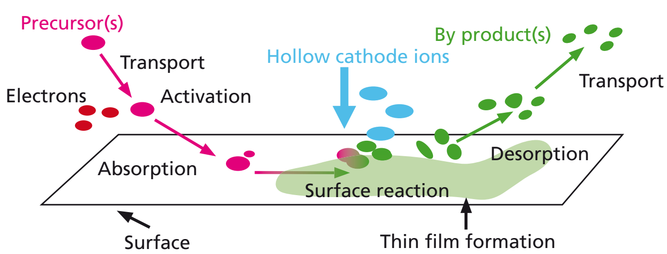
AGC

ADVANCED HIGH-RATE PECVD TECHNOLOGY FOR LARGE AREA COATINGS

AGC Plasma Technology Solutions has revolutionized the paradigm for mass production of large area coatings with PlasmaMAX™ hollow cathode PECVD coating technology. AGC's innovative plasma technology is powered by a state-of-the-art plasma generation system based on multiple linear hollow cathodes and designed by AGC scientists. PlasmaMAX™ enables an industry-first PECVD solution for mass production of large area coatings with an unprecedented four meter substrate width, while ensuring superior quality, low film stress, and unparalleled uniformity control.

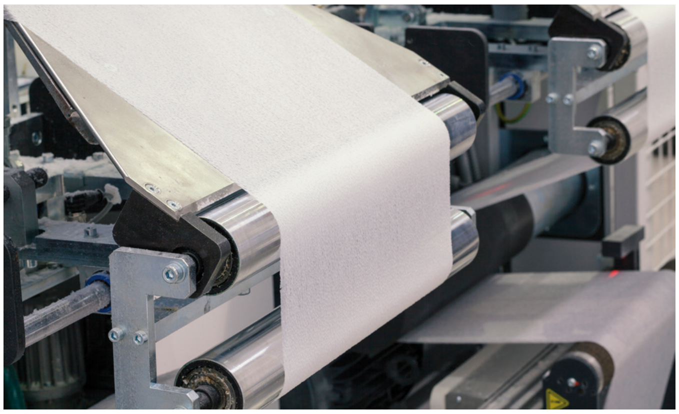
PlasmaMAX™ hollow cathode PECVD is designed to maximize process efficiency and streamline mass production by enabling maximum deposition rates and substrate widths while ensuring maximum quality. This technology optimizes production of barrier coatings, optical multilayer stacks, functionalized textiles, display technologies, and a range of related and custom applications.

Plasma-enhanced chemical vapor deposition (PECVD) is a low-temperature chemical process by which functional thin-films are grown on a substrate surface from a gaseous precursor. The process has underpinned the semiconductor industry since the 1970s as an industrial solution for production of thin-film materials like silicon dioxide (SiO_2) and silicon nitride (Si_3N_4).

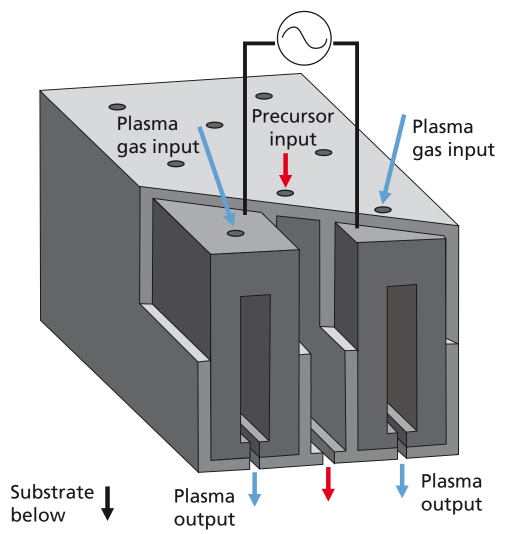


PECVD provides significant advantages to traditional physical vapor deposition (PVD) processes like magnetron sputtering, such as dramatically higher (>10x) deposition rate, low process temperature, high conformality on complex 3-D geometries, low consumables costs, and flexibility to deposit a wider range of materials. However, the difficulty to scale the technology for substrate widths beyond several hundred millimeters has limited its industrial use for the deposition of large area coatings.

PlasmaMAX™ PECVD's customizable form factor allows easy integration into any horizontal or vertical in-line vacuum coater, as well as any roll-to-roll web coating process. Its versatile design platform and high process stability across a wide pressure range enable compatibility and interoperability with most pre-existing CVD and PVD equipment, providing optimized performance at the lowest total cost of ownership.



PlasmaMAX™ creates functional thin-film layers of metal oxides, nitrides, oxy-nitrides, and polymers on almost any substrate. The substrate form can be a rigid panel or a flexible web, while the substrate material can be glass, polymer, or metal. PlasmaMAX™ can even coat conductive and magnetic substrates (e.g., steel) because it does not require the use of costly magnets or high frequency power supplies which are typically required in other coating systems.



Plasma generation is achieved inside pairs of monolithic hollow cathodes which are alternately driven by commercially available Mid-Frequency AC or pulsed DC power supplies. Advanced modeling of gas and plasma dynamics is used to optimize cathode geometry for highest performance and extended maintainability. PlasmaMAX™ hollow cathodes rely on an advanced protective coating which enables the extended use of a range of process gases like hydrogen, helium, nitrogen, argon, and even pure oxygen with no inert gas blend. High-density plasma jets are sprayed into the process area from optimally designed nozzles located along the length of each cathode. Reactive precursor gas is uniformly introduced to the process area to allow for an even coating. A novel coating source design protects the plasma generating surfaces from precursor contamination which thereby substantially extends the service life of the system.

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Advantages of PlasmaMAX™

- Dynamic deposition rate (DDR) up to 10x higher than traditional PVD processes.
- Creates thin-films with superior quality and mechanical durability.
- Largest substrate widths possible in industry for PECVD coatings with proven scalability to four (4) meters.
- Highest uniformity control for large area PECVD coating applications.
- Wide process stability range and customizable form factor enables in-line interoperability with most pre-existing CVD and PVD equipment platforms.
- Environmentally sustainable dry alternative to traditional resource-intensive wet processes.
- Lowest total cost of ownership due to inexpensive consumables (10x less costly than PVD) and minimal required maintenance.
- Easy manipulation of pressure, precursor mixture, gas input ratio, and plasma power to precisely control properties like refractive index, optical clarity, film stress, adhesion, flexibility, hardness, and density.
- Coatings on wide range of substrate materials and forms.
- Long coating campaign lengths possible without the need to regularly vent system.
- Addition of magnets possible for optimization of plasma geometry.
- Plasma pre-treatment (without precursor) for promotion of subsequent coating adhesion.

Industry	Typical Applications	Coating Materials
Optical coatings	Low-E glass, solar control glass, anti-reflective surfaces, multi-layer stacks	SiO_2 ,TiO_2, ZnO, Al_2O_3
Surface functionalization	Hydrophobicity, hydrophilicity, oleophobicity, anti-microbial surfaces	SiO_2, fluorine-based polymers, carbon-based (fluorine-free) polymers
Display	OLEDs, anti-scratch, anti-fingerprint	TCOs, DLC, Si_3N_4, SiO_2 ,TiO_2
Protective coatings	Mechanical durability, chemical durability	DLC, Si_3N_4, SiO_2
Barrier coatings	Moisture barriers, oxygen barriers for flexible packaging	SiO_2

Technical Specifications	
Dynamic deposition rate (DDR)	up to 500 nm-m/min
Uniformity	< +/- 1% across 1,000 mm substrate width < +/- 5% across 3,200 mm substrate width
Substrate width	200 – 4,000 mm
Operating pressure	1 mTorr– 1,000 mTorr
Power density	20 – 80 kW/m plasma @ 20 – 100 kHz
Process gas flow	500 – 4,000 sccm/m plasma
Process gas compatibility	H_2, He, N_2, O_2, Ar (non-exhaustive)
Coating materials	SiO_2, Al_2O_3, TiO_2, Si_3N_4, ZnO, DLC, TCOs, and polymers

AGC Plasma Technology Solutions is the industrial coatings unit of the world's largest glass producer AGC Inc. (Asahi Glass Company) and a one-stop provider for plasma-based vacuum coating equipment. The group leverages decades of thin-film coating experience on large area glass products to innovate and develop new industrial solutions from proof-of-concept to mass production. AGC Plasma Technology Solutions operates R&D and production facilities across the United States and EU.

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