



# Delta Glow™ Applications

April 2000

These application notes describe various ways the Delta Glow product family can be employed to enhance vacuum system performance, deposition of thin films and performance of polymer-based components. Delta Glow products are currently used in manufacturing and process development applications. Manitou Systems engineers can provide assistance with the selection of the proper Delta Glow product for your application.

The Delta Glow™ family of high-energy plasma sources is designed to generate dense gas plasmas for use in thin film deposition, etching and material surface modification applications. Typical applications include vacuum chamber precondition/cleaning, PECVD, polymer material surface treatments, and in-situ enhancements of the thin film deposition process. This “downstream” plasma source accepts raw process gases at one end, creates active gas species in the middle and through the flow created by a vacuum pump emits the plasma (and gas species) at the opposite end.

Vacuum chamber interface is easy and accomplished through industry standard KF-50 vacuum flanges or through custom designed interface plates. Process gas enters the reactor tube via a ¼” VCR type fitting. The standard process tube is manufactured from extruded quartz material. Aggressive fluorine based cleaning processes will require the use of an optional alumina process tube.



The RF power generator provides the necessary radio frequency power and process control for the Delta Glow system. Both C.W. and pulsed power process are available through the use of this RF power system. Manual or fully automatic impedance matching networks complete the RF power delivery system.

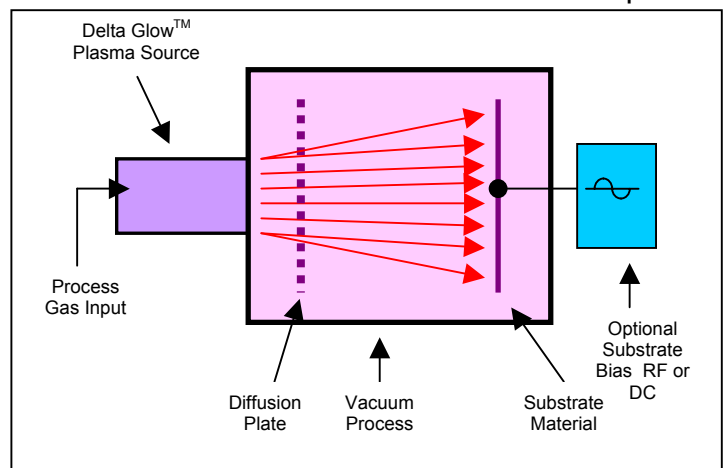


Rugged construction techniques enable use in all industrial-manufacturing environments. All mechanical components are constructed from chemically treated aluminum or stainless steel. RF components are 100% silver-plated for enhanced conductivity. Dielectric parts are manufactured from virgin grade PTFE or ceramic materials. The Delta Glow source comes with a complete owner's manual and necessary tools to install and service the unit. Consumable parts are always available "off the shelf" from the factory.

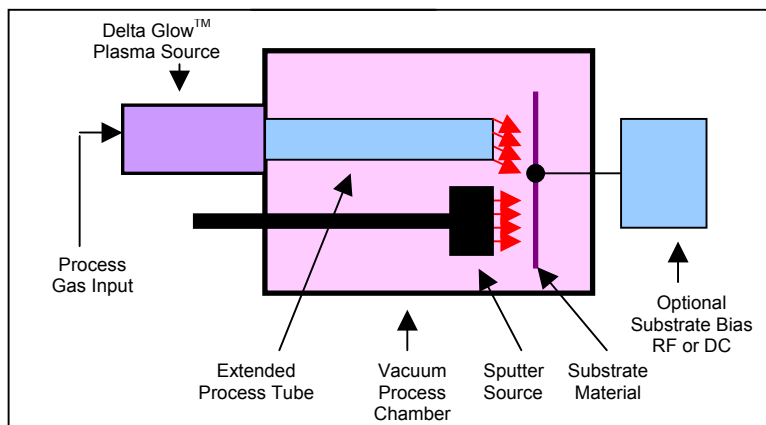
## SEMICONDUCTOR & FLAT PANEL DISPLAY MANUFACTURING APPLICATIONS

**Thin Film Chemical Vapor Deposition** - Delta Glow can be used as the main plasma

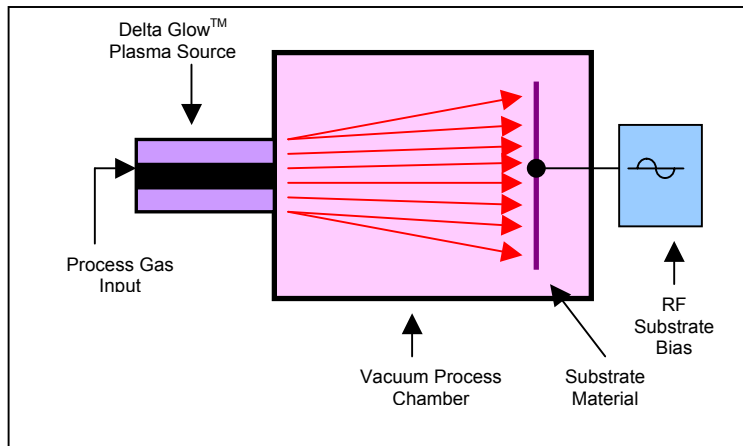
source reacting the process gas in many semiconductor and industrial low temperature CVD processes. The operating frequency of the process has a pronounced effect on the thin film deposition rate and therefore should be selected based on the desired film properties. The Delta Glow source can be configured to operate in non-standard frequency bands. The typical deposition system will include a DG source mounted on the chamber lid with a diffuser plate mounted directly underneath. The resultant plasma radical stream can then be optimized for substrate uniformity by varying the amount and size of the through holes.



**Reactive Sputter Deposition** –PVD processes can be enhanced by the use of the Delta Glow to provide a source of energetic reactive process gas molecules. The reactive gas species is directed towards the substrate surface combining with the material being sputtered to form denser and fully reacted films. Typically, oxygen ( $O_2$ ) is used as the reactive gas component in a metallic oxide film.



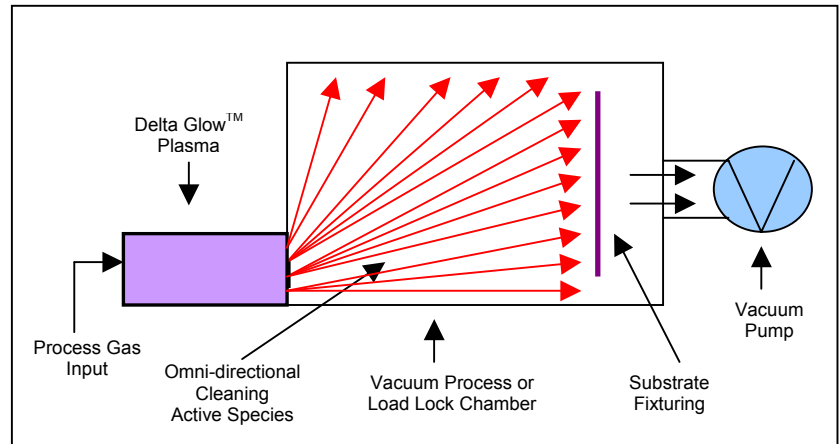
The reactive process window is effectively widened based on the additional energy from the down stream plasma source. The DC sputtering potential may also be lowered when using the secondary plasma, which will reduce the possibility of process arcing. This occurs because the sputtering cathode impedance is reduced.



**Plasma Etching** - Delta Glow is employed to react a gas mixture for the purpose of etching a thin film structure on a semiconducting substrate. The process gas mixture is injected into the up stream end of the Delta Glow and the resultant plasma discharge provides the necessary chemical and physical properties to etch the surface of the substrate. Directionality of the etch is typically controlled with the applied RF substrate bias.

**Plasma Process Chamber Cleaning** – Using highly reactive gas chemistries, the Delta Glow is typically used to clean vacuum process chambers in between process cycles and during equipment commissioning.

Semiconductor and flat panel display CVD process chambers are cleaned using gas chemistries such as  $\text{NF}_3$  &  $\text{O}_2$ . Another new application is the cleaning of high power industrial laser cavities. Built up contaminants are etched from the internal cavity surfaces and removed away with a high vacuum pumping system.



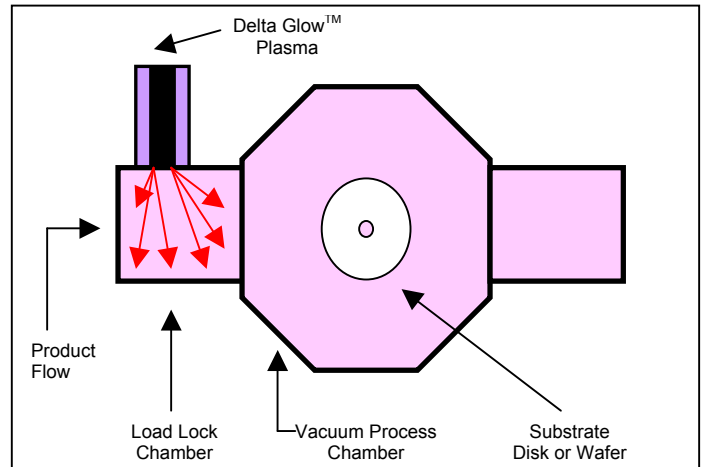
**Exhaust Gas Abatement** – Exhaust gas from many semiconductor plasma processes can be post processed through the Delta Glow plasma source. The DG-300 is placed in-between the high vacuum pump and the process chamber. The rich plasma discharge is used as a secondary reaction to neutralize and abate the main process effluents.

# VACUUM SYSTEM APPLICATIONS

**Vacuum Chamber Cleaning & Conditioning During The Manufacturing Process** - Delta Glow provides the means to generate an energetic plasma discharge for the purpose of bombarding the internal surfaces of a vacuum chamber with ions and electrons. The plasma discharge stimulates and mobilizes water vapor while the vacuum pumping system provides the method for removal. Ultra Violet wavelength light emitted from the plasma also helps with the water vapor desorption process. The Delta Glow plasma source can be used as a production tool to reduce initial pump-down times. Typical process gasses for these applications include argon and oxygen.

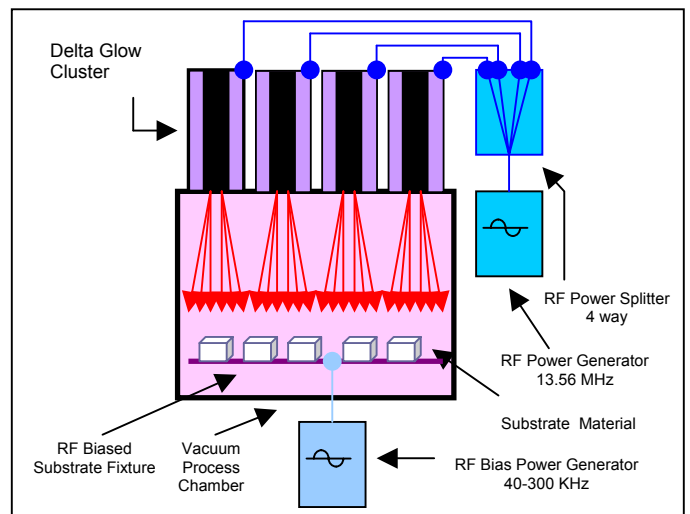
The plasma source is simply bolted onto the chamber undergoing test and operated continuously through the overnight base pressure pump-down cycle. The use of this product combined with other industry de-gas accepted techniques including high temperature bake out and cryogenic cooled probes will decrease the manufacturing and test time.

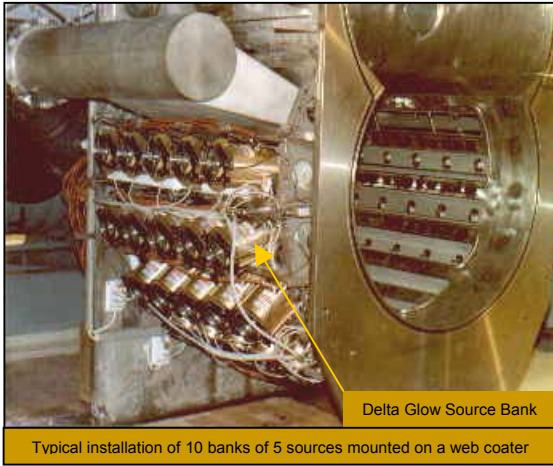
**Load Lock Vacuum Chamber Conditioning** – The substrate dwell time in the vacuum load lock chamber is a typical throughput-limiting factor in today's high-speed process equipment. Delta Glow can be utilized to reduce the pump down during each cycle. In addition to removing the water vapor in the load lock, its soft plasma discharge will also provide a source of plasma that will clean and de-gas the substrate and its carrier. The Delta Glow can be installed as an OEM component or added to the vacuum chamber at a later date.



# SURFACE MODIFICATION APPLICATIONS

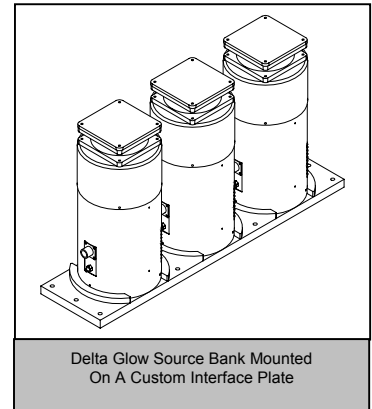
**Polymer Materials Surface Enhancements & Modifications** – High-energy plasma chemistries generated by the Delta Glow source may be used to treat or modify the surface characteristics of many types of polymer (plastic) materials. The automotive industry currently treats plastic parts such as bumper surrounds and other paintable parts for the purpose of increased adhesion. The medical industry uses plasma to treat the inside and outside diameter of catheter tubes to increase the lubricity or promote cell growth. These devices are used in pacemakers and implants.





The substrate material is typically processed in a large batch vacuum chamber or actually passed beneath the Delta Glow's process tube exhaust port. The illustrated process system configuration includes a dual frequency (13.56 MHz & 40-300 kHz) plasma process. The Delta Glow sources are operated at 13.56 MHz and powered by a single RF generator with a 4 way isolated power splitter.

The Delta Glow source bank is considered the main plasma source (to provide energetic gas radicals) in conjunction with a secondary plasma source (to provide the substrate surface reaction and process uniformity across the substrate). The substrate bias is provided by a low frequency RF generator. This hardware configuration is typical of both stationary (batch) and moving web systems.

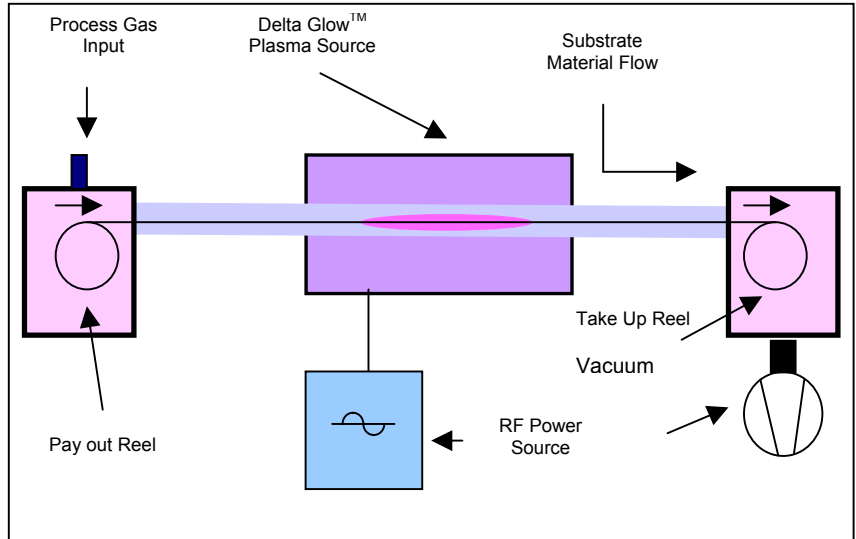


In multiple source cluster operation, the object is to provide the proper RF power ratio to



each of the individual plasma sources for the purpose of process uniformity. The Manitou RF power splitter pictured at the right illustrates a 6-way device that produces 1/6 the input power with isolation between each output port. This enables 6 plasma sources to be powered equally from one RF generator. Please note that this system will require 6 separate matching networks, as the system impedance is nominally 50 ohms. With this configuration, the sources can be operated in or out of phase, and also with fixed attenuation to dissipate (or spill) excess power to achieve separate fixed levels of power as measured in between sources.

**Pass Through Plasma Processing** – Plasma treatment of a dielectric strip or roll-to-roll substrate material is achieved by passing it through the center of the Delta Glow process reactor tube. The dense plasma region can be adjusted to provide the proper density for the process without overheating the material. Dual vacuum chambers are located on either side of plasma source and contain the pay out and take up reels, pumping port and process gas inlet. Process gas is typically introduced up-stream from the vacuum pump and plasma source. Magnetic and/or waveguide beyond cutoff assemblies may be used to concentrate the plasma discharge within the Delta Glow body region. An example of this application would be the surface treatment of catheter tubing used in the manufacture of medical devices. Other surface enhancements include better wettability, gas barrier protection and, many properties related to complete cross-linking of the substrate surfaces.

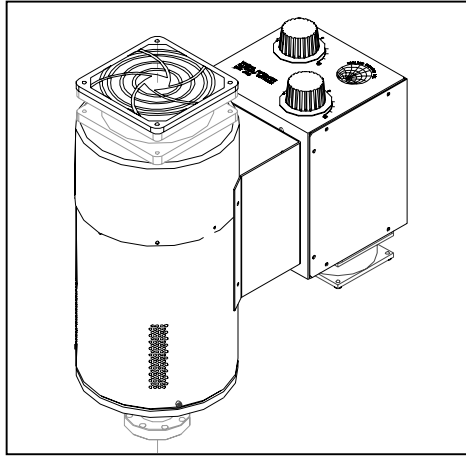


**Powder substrate surface treatments** – The outside surfaces of many types of powdered materials can be treated to provide enhanced properties such as hydrophilic or hydrophobic. The material is treated by passing it through the plasma source's dense plasma region in a vertical fashion. The typical apparatus consists of a long, vertically mounted dielectric tube which is vacuum pumped at the various points along its length to ensure acceptable vacuum process levels. The substrate material is introduced at the top end and is processed by falling through the plasma region. Depending on the required process parameters (plasma region dwell time), the "system" may employ a single or multiple Delta Glow sources. The multiple source configuration is powered by a single RF generator and isolated RF power splitter module. A typical application is to treat a PTFE powder to enable homogeneous mixing with liquids or enable the powder to flow better during subsequent processes.



Model DG-300 With Waveguide Cutoffs

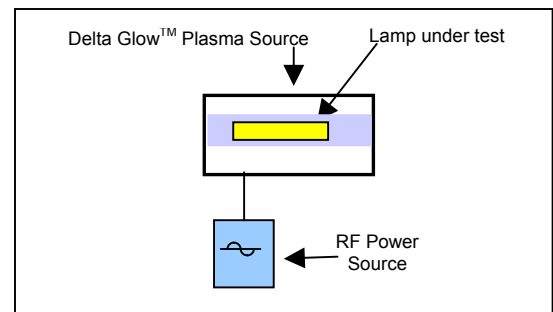
## INDUSTRIAL TESTING APPLICATIONS



**O<sub>2</sub> Radical Generator** – The Delta Glow can be used to produce a stream of rich atomic oxygen and metastables. The atomic oxygen is used in many plasma processes as a reactive process gas component. Typical applications include ashing (or etching) of organic films on wafers in semiconductor manufacturing, modifying the surfaces of polymer materials and in testing of materials and assemblies used in spacecraft and satellites.

### **Production Tool To Ignite & Test Gaseous Lamps**

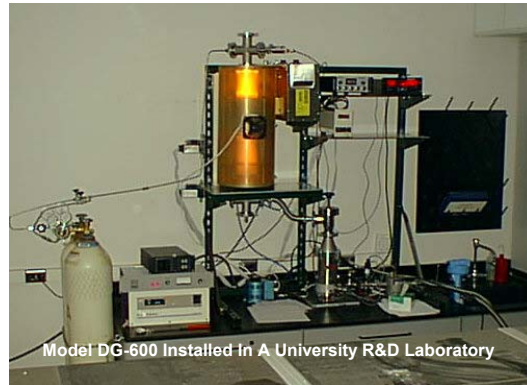
– The inductive RF energy coupling of the Delta Glow source can be used to ignite leaded and *leadless* lamps for the purpose of manufacturing test or development. Typical applications include the testing of consumer lamp types such as low-pressure sodium and mercury vapor. This non-contact test method allows for easy positioning inside the source while the monitoring of the discharge wavelength is accomplished via fiber optics or other optical techniques. A typical lamp is placed concentrically inside the source body. When the RF power is turned on, the RF energy is tuned and will couple to the lossy gas inside the bulb thus providing breakdown and ignition. This hardware will also prove useful as the basis for a special purpose industrial light source. A bulb containing gaseous material (that will glow at the desired wavelength) can be integrated into the Delta Glow source with the appropriate light pipe output. Custom designed packages are available to complement OEM equipment.



# RESEARCH & DEVELOPMENT APPLICATIONS



**Gas Discharge Study Applications** - The Delta Glow™ plasma source finds applications in basic R&D and may be configured to act as its own complete process chamber. Support components including vacuum pumps, mass flow controls, pressure gauges and biasable/heated substrate stages or fixturing may be added to complete the system. Highly excited gas chemistries may be analyzed through the use of residual gas analysis or optical monitoring techniques. The Model DG-600 has been specially designed to provide easy access to the large diameter plasma process tube (150 mm) through the use of industry standard vacuum flanges at each end. Delta Glow™ will effectively react process gasses such as  $\text{NF}_3$ ,  $\text{O}_2$ ,  $\text{CF}_4$ ,  $\text{CF}_6$ ,  $\text{N}_2$  and Ar.



## Product Information

### Delta Glow Accessories

Various accessories are available to complement your Delta Glow installation. These include user/equipment safety components, installation hardware/fittings and process control systems. Contact us directly for our installation guide or assistance with selecting the proper system components.

**Input Gas Control** – The Delta Glow may be equipped with a manual or automatic process gas control device. Typically, a needle type leak valve is used for non-critical cleaning applications and an automatic mass flow controller for critical processes. The user will need to inform MSI of the application and process gas type to enable us to propose the proper control device. The control device may be equipped with VCR or Swagelock type fittings.

**Automatic Impedance Matching Network** – The standard Delta Glow plasma source is equipped with a manually adjusted impedance matching network. This standard configuration will meet the requirements of most applications when powered by our Model PB-300 or Cesar RF generators. If tighter or faster process control is required, the user should request the optional Series ATK automatic impedance matching network. An automatic matching network will ensure quick plasma ignition in addition to motorized adjustments resulting in continuous low reflected power and maximum RF power transfer to the plasma discharge. The Model ATK-600 is currently available for plasma sources operating in the 13 to 40 MHz range. Its control interface mates directly with the Cesar RF generator models and may also be used with the Model PB-300 generator when an optional rack mount control panel is supplied. Please contact the factory for additional details.

**UHV Compatibility** – A non-UHV compatible (standard) Delta Glow may be used to perform cleaning processes in a UHV vacuum system as long as it is isolated from the UHV vacuum chamber by a gate valve. The use of this valve will ensure that the integrity of the UHV vacuum system is maintained when the Delta Glow is not in use. MSI can supply this valve on request. The user should advise us of the vacuum system interface flange. UHV compatible Delta Glow models will be offered in the near future.

**Fluorine Process Capability** – The use of fluorine containing process gasses require the reactor tube and associated o-ring seals to be upgraded. MSI supplies a Delta Glow model, which comes, equipped with an alumina reactor tube (99.8% pure) and o-rings which will withstand the corrosive atmosphere.

**Output flanges and adapters** – The typical input and output flange is a type KF50. The process gas input fitting is an adapter - type VCR ¼ to KF50. The user may elect to use an adapter fitting to connect the Delta Glow source body to other types of fittings.

**RF switch and cables** – The Delta Glow can be used with an existing RF generator with this adapter kit. Included is a switch box and RF cables. The user will need to furnish a source of 24VDC to operate the switch box.

**Power splitter** – Multiple source cluster operation is possible through the use of this power splitter module. The power splitter accepts a single RF input from the RF generator and provides multiple isolated outputs. Each output is connected to the individual plasma source/matching network combination.

**RF Generators** – The Delta Glow may be supplied with a multi featured RF generator that is capable of operating the plasma source and also controlling the Model ATK-600 automatic impedance matching network. These units are available in 300 and 600 watt versions. The user may also use our basic model, the PB3-300 that is available in 300 watts only. Request the individual RF generator data sheets or consult the Delta Glow owner's manual for more information.

Specifications subject to change without notice.  
Contact Manitou Systems for the latest specifications.  
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