Plasma Source

Atom Source, Ion Source and Atom/Ion Hybrid Source

The tectra Plasma Source* is a multi-purpose source which can easily be user configured to produce either atoms or ions and finds uses in a wide range of HV and UHV applications. By easy exchange of the beam optics the source can be configured to operate in several distinct modes. The main modes are Atom Source, Ion Source and Atom/Ion Hybrid Source. Besides delivering different species (atoms, ions, radicals) the Plasma Source covers the complete energy range from neutral thermal atoms to above 1.500eV. The shape of the beam and current densities can be altered by using different beam optics.

A plasma is created in a coaxial waveguide by evanescent wave coupling of microwave energy at 2.45GHz. The plasma is further enhanced by the ECR action of a quadrupole magnetic field producing an extensive surface in the plasma on which electron cyclotron resonance at the given microwave frequency takes place.

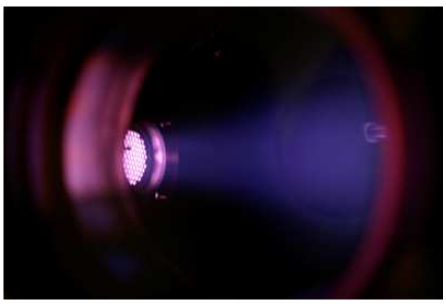
new GenII Version Plasma Source

Since 1997 tectra has produced more than 50 Plasma Sources as Atom Source, Ion Source and Atom/Ion Hybrid Source. Based on this experience we now present the second generation Plasma Sources, the Gen2.

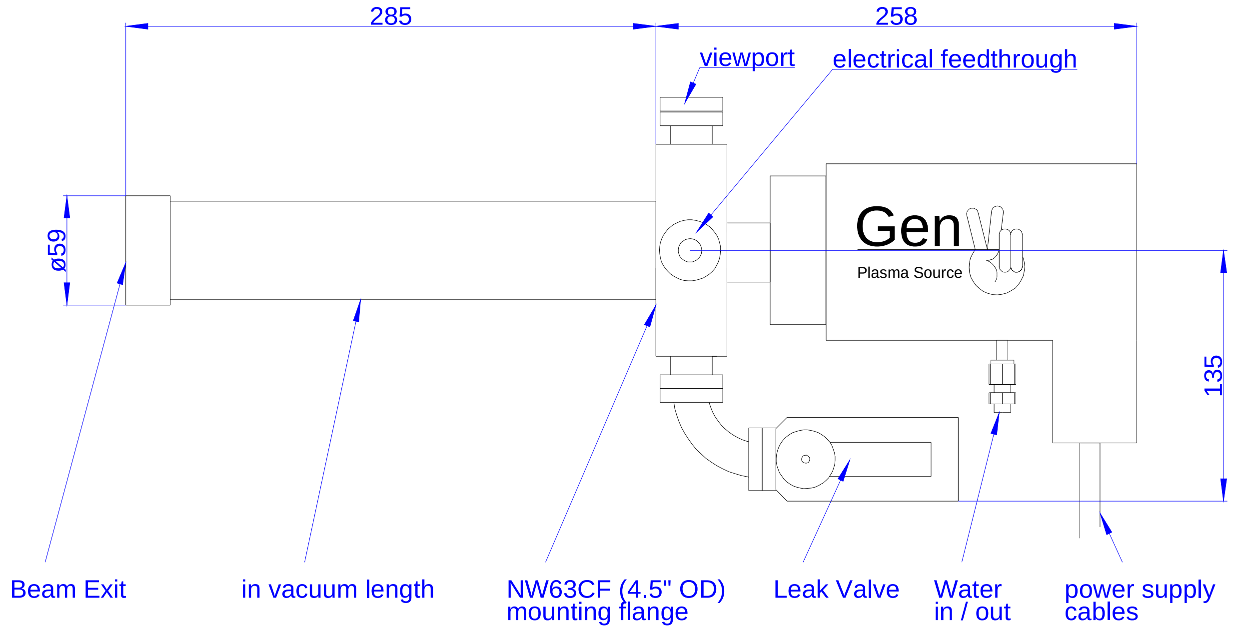
Gen Plasma Source

New Features of Gen2 Plasma Source:

- high performance direct microwave coupling (without need of tuning)
- improved microwave guide with minimised attenuation
- higher plasma density resulting in higher ion current
- bakeable magnets, still on air side, with closed cooling loop
- more compact, space saving air side setup
- Al_2O_3 plasma cup now standard with higher yield of secondary electrons and better resistance against aggressive gases
- additional display of extraction current to optimise the beam shape
- improved stability of microwave generation
- new grid supply for more versatile, wide range ion energies of 20eV - 2keV with same grid set LED to show if plasma is on or off



Key Features:	
Filamentless	Suitable for use with most gases including reactive gases such as oxygen, chlorine, hydrogen, nitrogen etc.
No microwave tuning	Factory set. Simply turn the plasma on and off.
User configurable	The extraction optics are designed to be quickly and easily exchanged allowing users to customise their source to suit a particular combination of sample size, working pressure and current density. Easily exchanged apertures enable beam diameter, gas load and atom flux to be optimised.
simple bakeout preparation	new bakeable ECR magnets allow simple bekeout preparation by just undoing 4 screws. The magnets are still on the air side on a closed cooling loop. Hence no sintered material is in-vacuum.
Al_2O_3 plasma region	Alumina plasma cup as standard with higher yield of secondary electrons and better resistance against aggressive gases such as Oxygen
compact	the air side envilope sizes are brought to a minimum of just 258mm from flange (knife edge side) to case end (see schematic below)



Integration of the robust microwave generator and the ion source, mean that no tuning of the source is required and there is no waveguide to construct or install.

Due to the evanescent wave coupling, no electrodes are present in the plasma i.e. no filaments or other metal. The plasma is entirely surrounded by alumina or other dielectric materials e.g. BN. Therefore the source is also suitable for use with reactive gases such as oxygen and hydrogen. A selection of apertures and conductances allows the optimum balance between gas flow, working pressure and beam current to be achieved.

The source is designed as a true UHV source making it suitable for use in UHV applications such as MBE as well as sputtering and other HV processes. Stainless steel, OFHC copper, BN, alumina and Kapton are the only materials exposed to the vacuum. All joints are welded. The magnets and all microwave parts are easily removed for bakeout at temperatures in excess of 200℃.

Modes of operation:

Four distinct modes of operation are possible with this source depending principally on the beam optics which are fitted. The beam optics are constructed as one piece and may easily be exchanged by the user to allow the source to be used in another mode. The parts necessary to convert the source from one mode to another are all retrofittable by the user and can be added at any time in the future as research needs change.

(1) Atom source

The specially designed aperture plate inhibits ions from escaping from the plasma, yet allows reactive neutrals to escape and form the dominant beam fraction. The emitted particles are largely thermalised through multiple collisions on passing through the aperture. These neutrals have proven to be very effective in low damage surface treatments such as nitridation and oxidation(1,2). The further addition of an ion-trap option can completely remove the residual ion content from the beam where this may be of concern.

(2) Downstream plasma source

With this aperture plate a larger proportion of the charged particles in the plasma are allowed to escape. There is no active extraction or acceleration of the charged particles but a considerably higher ion current reaches the sample in this mode as compared with the atom source above. Samples mounted a few centimetres from the source are said to be "downstream" of the ion source and away from the most energetic species. Ion energies are defined by the intrinsic plasma potential and are around 25eV.

(3) Hybrid source

The beam optics in this mode combine the atom source aperture plate with electrodes providing active extraction of ions from the plasma. With no voltage applied to the electrodes the source functions like the atom source at (1) above. With voltage applied to the electrodes, ions with controllable energy can be added to the atom beam. Total beam current is in the ~50µA range. Using this mode the advantages of both a low kinetic energy, chemically reactive, atom beam and a much higher kinetic energy, highly anisotropic ion beam may be explored.

(4) Broad Beam Ion Source

Dual or triple high conductance grid electrodes are used to produce the broad beam ion source mode. For sputtering applications, current densities at ~120mm of $2mA/cm^2$ (focused optics) with ion energies of 1.3keV can be obtained while for deposition assistance (Ion Assisted Deposition or Dual Ion Beam Sputtering) the beam energy can be reduced to less than 100eV with current densities still in the $0.05mA/cm^2$ range.

Atom Source Mode Applications:	**Ion Beam Mode Applications:**
• Nitriding e.g. GaN, AlN, GaAsN, SiN etc. • Hydrogen cleaning, hydrogen assisted MBE. • Oxidation e.g. ZnO, Superconductors, Optical coatings, Dielectrics. • Doping e.g. ZnSe	• Ion beam assisted deposition (IBAD) for both UHV and HV processes • Sputter deposition and dual ion beam sputtering • Sputter cleaning / surface preparation in surface science, MBE and HV sputter processes. • In-situ etching e.g. Chlorine

Specifications

a) General

Vacuum compatibility:	Fully UHV compatible
Bakeable:	>200℃
Microwave power:	250W max at 2.45GHz
Magnet type:	Permanent rare-earth on air side, yet no need to remove for baking
Mounting:	NW63CF (4.5"OD)
In vacuum length:	300mm (custom lengths possible): In vacuum diameter max = 57mm
Beam diameter:	~25mm at source (narrower beams also easily produced)
Plasma cup:	Al_2O_3 Alumina
Aperture:	Alumina (or Boron Nitride)
Gas flow rate:	0.01-100sccm depending on aperture selected
Working pressure:	~10^{-7} Torr to $5x10^{-3}$ Torr depending on aperture, pump and application - please contact tectra to discuss your application. Differential pumping option available
Working Distance:	50mm-300mm. 150mm typical
Cooling:	Fully water-cooled (including magnetron)
Power supplies:	Microwave Grid supply* * Ion and Hybrid Source only 19” rack mount. 3U height. 230VAC, 50Hz or 115VAC, 60Hz 19” rack mount. 3U height. 230VAC, 50Hz or 115VAC, 60Hz

b) Atom source

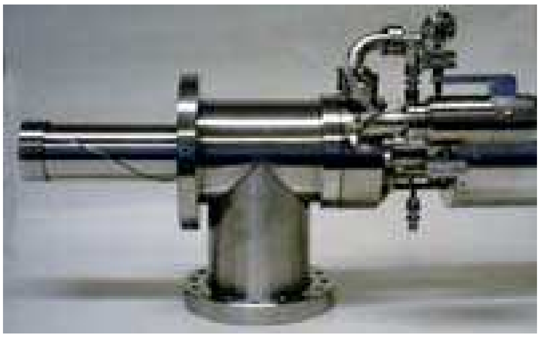
Atom flux	>2x1016 atoms/cm2/s at 10cm
Beam divergence:	~ 15° half-angle typical
Gases	Nitrogen, Oxygen, Hydrogen (any most other non-condensible gases)
Working pressure:	$1x10^{-8}$ mbar to $1x10^{-1}$ mbar typical (using 500l/s pump) and depending on selected grids, pump, optional differential pumping and gases.
Working distance:	<50mm to >300mm (150mm typical)
Options:	(1) Residual Ion Trap (2) Differential pumping (3) Ion source retrofit kit (4) Plasma igniter

c) Ion source

Ion current:	0 - 20mA (max.). Total beam current measured at 15cm dist.
Ion current density:	>2mA/cm^2 at 1.3keV and >0.05mA/cm^2 at <100eV at 120mm distance.
Ion energy:	25eV - 2000eV
Beam diameter:	~25mm at source (narrower beams down to 1mm easily produced)
Extraction grids:	Molybdenum (Graphite optionally) Focused and collimated beam grid sets available
Gas flow rate:	5-10sccm typical (lower and higher flow ratespossible)
Working pressure:	$1x10^{-8}$ mbar to $1x10^{-1}$ mbar typical (using 500l/s pump) and depending on selected grids, pump, optional differential pumping and gases.
Working distance:	<50mm to >300mm (150mm typical)
Options:	(1) Immersed filament beam neutralisation (2) Plane, focused and divergent grid sets made from Mo or pG (3) Differential pumping (4) Shutter (5) Faraday Cup integrated in shutter

Options:

Plasma Source (GenI) with differential pumping
for low pressure operation and with shutter



Plasma Source with differential pumping
for high pressure operation

special Atom aperture for reduced flux/small samples

Atom aperture with quartz collimator tube
special Atom aperture for reduced flux/small samples

Elongated version (GenI) with second gas inlet

References:

- The role of neutral oxygen radicals in the oxidation of Ag films. A. A. Schmidt, J. Offermann and R. Anton. Thin Solid Films 281-282 (1996) 105-107.
- Design and performance of a versatile cost-effective microwave ECR plasma source for surface and thin film processing. R.Anton, T. Wiegner, W. Naumann, M. Liebmann, C. Klein, C. Bradley. Rev.Sci.Instr. Feb 2000

*developed in collaboration with Prof. Dr. Anton, University of Hamburg, Inst. für Angewandte Physik