TPIS Plasma Source

Atom Source, Ion Source and Atom/Ion Hybrid Source

Magnetron Supply

Beam Neutralizer (Option)

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 2.000 eV. 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 enhanced by the ECR action of a hexagonal magnetic field on which electron cyclotron resonance at the given microwave frequency takes place.

KEY FEATURES AND BENEFITS

- Filamentless Source
- High Performance direct Microwave Coupling (no Need of Tuning)
- User Configurable (easy Exchange of Extraction Optics)
- Compact Design with minimized Air Side Envelope
- Simple Bakeout
- Alumina Plasma Cup with high yield of secondary Electrons
- Suitable for Reactive Gases, incl. Oxygen, Hydrogen, Nitrogen etc.
- grid supply for more versatile, wide range ion energies of 20 eV – 2 keV with same grid set

The extraction optics are designed to be quickly and easily exchanged allowing users to customize 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 optimized.

The design with the bakeable ECR magnets allows simple bakeout 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.

The 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, Tungsten, Molybdenum, BN, alumina and Kapton are the only materials exposed to the vacuum. All joints are welded.

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 is constructed basically as a module 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 retrofit-able by the user and can be added at any time in the future as research needs change.

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 thermalized through multiple collisions on passing through the aperture. These neutrals have proven to be very effective in low damage surface treatments such as Nitration 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. An ion trap (optional) is recommended if ions need to be avoided completely.

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 centimeters 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.

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 ~50 µA 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.

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 ~120 mm of 1 to 2 mA/cm² (focused optics) with ion energies of ~ 1 keV can be obtained while for deposition assistance (Ion Assisted Deposition or Dual Ion Beam Sputtering) the beam energy can be reduced to less than 100 eV with current densities still in the 0.05 mA/cm² range.

Typical Applications

Atom Source Mode

- 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 Mode

- 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

References:

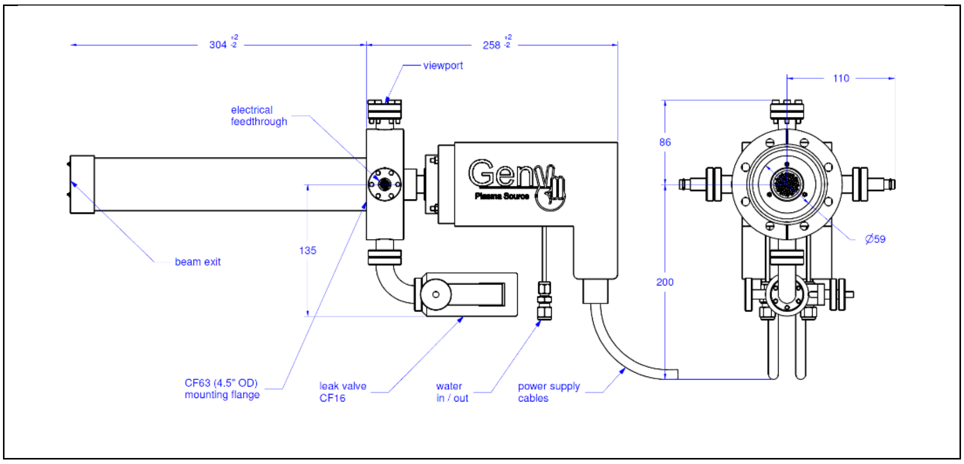
- The role of neutral oxygen radicals in the oxidation of Ag films. A. A. Schmidt, J. Offermann and R. Anton. Thin Solid Films 281-282 (1996) 105-107.

- 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

SPECIFICATION

Dimensions



General Specification

Vacuum Compatibility	Fully UHV compatible, bakeable to 200°C, CF63 (4.5” O. D.)
Microwave Power	~ 180 W
Magnets	Permanent Rare-Earth (air side), no removal for baking
Beam Diameter	~ 25 mm at source (narrower beams also easily produced)
Plasma Cup	Alumina (Standard)
Aperture	Alumina (Standard) or BN
Gas Flow Rate	0.01 to 100 sccm depending on aperture selected
Working Pressure	~ 10^{-7} Torr to 5 x 10^{-3} Torr depending on aperture, pump and
	Application (Differential Pumping Option available)
Working Distance	50 mm to 300 mm (150 mm typical)
Power Supplies	Microwave Supply
	Grid Supply (Ion and Hybrid Source only)
	19” rack mount. 3U height. 230VAC, 50Hz or 115VAC, 60Hz

Atom Source

Atom Flux	>2 x 10^{16} atoms/cm^2/s at 100 mm
Beam Divergence	~ 15° half-angle (typical)
Working Pressure	1x10^{-8} mbar to 1x10^{-2} mbar typical depending on selected
	grids, pump, optional differential pumping and gases
Options	Residual Ion Trap, Differential Pumping, Ion Source Retrofit

Ion Source

Ion Current	0 to 15+ mA (Total Beam Current
Ion Current Density	>2mA/cm2@1.3keV / >0.05mA/cm2<100eV (dist. 120mm)
Ion Energy	25 eV to 2000 eV
Extraction Grids	Molybdenum (Standard)
Options	Beam Neutralization, Differential Pumping, oth. Grid Materials

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