MATS

RF Atom Sources

Nitride MBE Growth

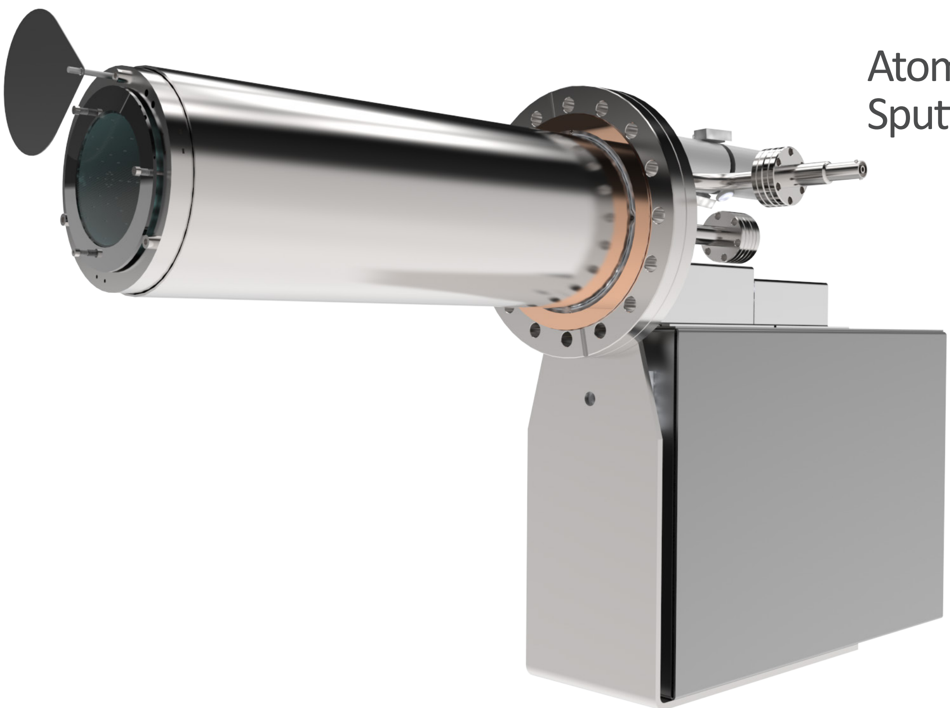
Oxide MBE Growth

Atomic Hydrogen Treatment

Reactive Gas Generation

III-V Dilute Nitride MBE Growth

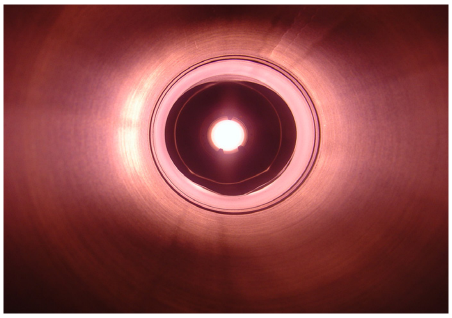
Atomic Gas Specimen Delivery in Sputtering or PLD Applications



MANTIS

Partnered with SIGMA Surface Science

The MATS Series



RF plasma generated by MATS source

Neutral atomic gas species are highly beneficial in the growth of high-quality compound materials such as GaN, GaInNAs, InGaN, InN, ultra-thin Al_2O_3 and high-K dielectrics.

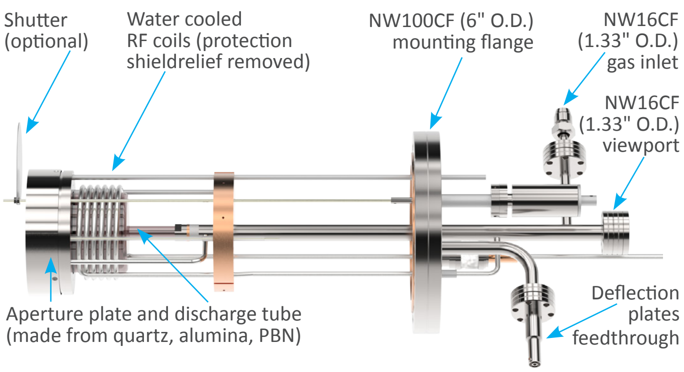
These species are generated by a dissociative process when a process gas is introduced into a cavity (called the discharge zone) where a plasma is then induced by applying inductively coupled RF excitation. The plasma dissociates the process gas into ions and neutral reactive atoms. The neutral atoms travel through the source aperture into the process chamber. Charged particles are retained within the confined plasma.

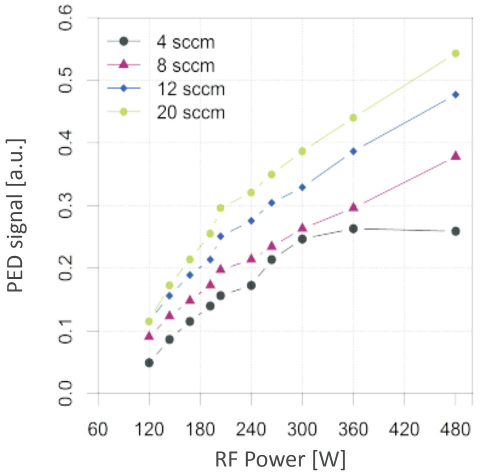
This process produces neutral atoms, which have increased reactivity by many orders of magnitude compared to the reactivity of molecular gases. In addition, the atoms carry negligible kinetic energy and therefore allow rapid film growth without generating defects.

Source Construction

The MANTIS MATS source series is designed to meet rigorous UHV standards for not only MBE-type systems, but also for high quality sputtering or for PLD systems. The instrument has all-metal vacuum seals and is fully bakeable to 250°C. The RF coil and the tip of the source are water-cooled to minimise the thermal impact of the source during its operation. The plasma discharge tube is constructed from high purity ceramic materials which vary, depending on the nature of the gas used for source operation.

MATS60 Plasma Source Internal Layout





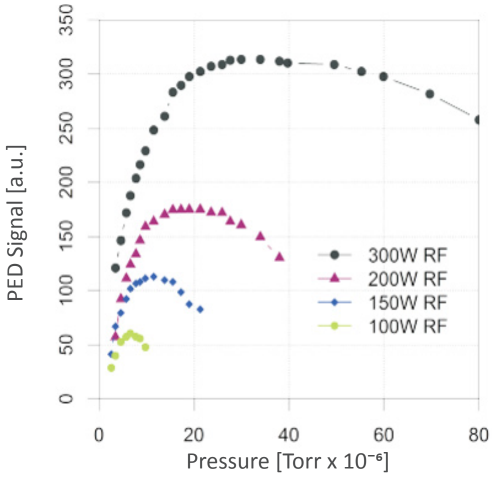
Plasma emission signal as a function of applied RF power at various gas flows. Data supplied by Prof. M. Hopkinson, National Centre for III-V Technologies, University of Sheffield.

RF Power Transfer

The coaxial RF coil is silver plated and optimised for efficient power transfer to the plasma. Full coupling along the entire length of the coil ensures even dissociation and maximum atomic flux. The support components are constructed in such a way to further minimise power losses.

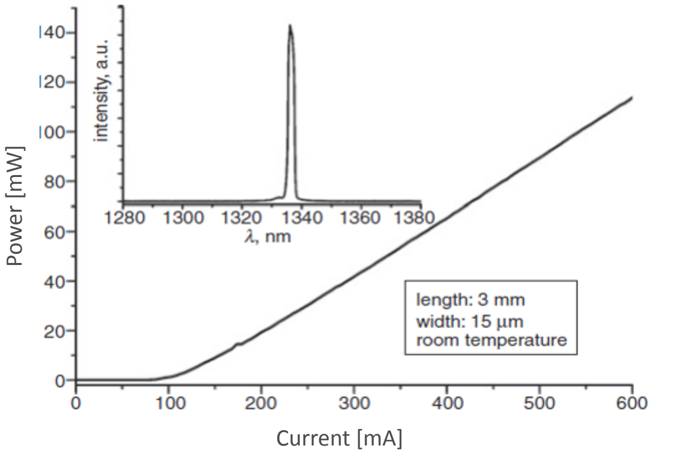
The source is supplied with an automatic matching network unit, which matches the power transfer between the source itself and the RF generator (operated at 13.56MHz). The network detects the changes in impedance produced by the plasma discharge and automatically compensates for them. This makes tuning of the source straightforward and relieves the user of the task of making minor adjustments as plasma conditions change.

The relationship between the applied RF power and optical emission collected from the plasma is linear at high gas flow, as shown in the figure on the right.

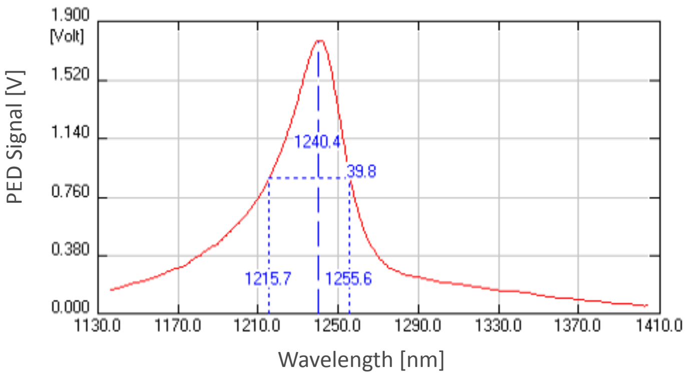


Plasma emission signal from MATS source as a function of gas flow at different RF powers.

MATS Sources are Used in the Most Demanding MBE Applications



Light output power versus drive current of a 1.34µm SQW GaInNAs quantum well laser with low room temperature threshold current density. Data supplied by Prof. M. Hopkinson, National Centre for III-V Technologies, University of Sheffield. (M.Hopkins et al., Electronics Letters Vol 42 No 16 2006 (1))



PL intensity of a new MATS30 source for samples (2% N in In.35/ Ga65As) and only after 5 optimisation runs. Data supplied by Prof. M. Hopkinson, National Centre for III-V Technologies, University of Sheffield.

Gas Flow Dynamics

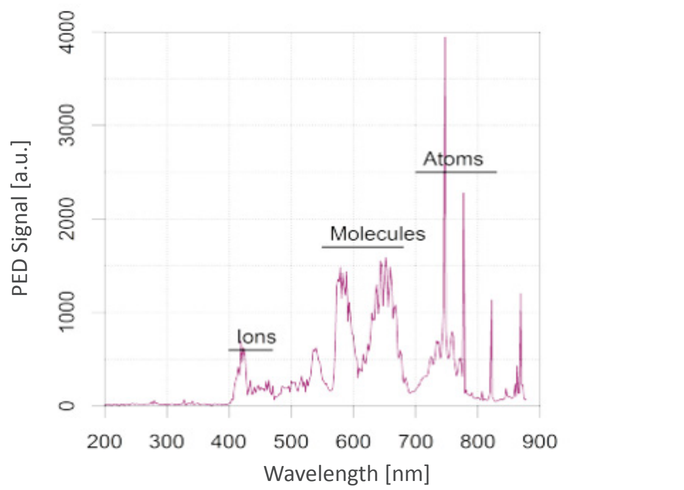
The gas flow in the MATS source can to some extent be tailored to suit a particular application by varying the number and size of holes in the aperture plate. Gas flow determines the pressure within the discharge zone for a given aperture plate and this pressure determines plasma conditions which have a strong influence on the beam constituency. It is advisable to run the source at or slightly above the pressure at which the dissociation reaches a maximum (e.g. this optimum can be found using the **optional** plasma emission detector).

MATS sources can be operated with oxygen, nitrogen, hydrogen and many other gases. The table below shows gas compatibility with various discharge tube materials.

Aperture Material	Gas Compatibility
Quartz (MATS60 only)	O_2, N_2, Ar
Alumina	O_2, H_2
PBN	N_2, H_2,

Optical Plasma Emission Monitoring

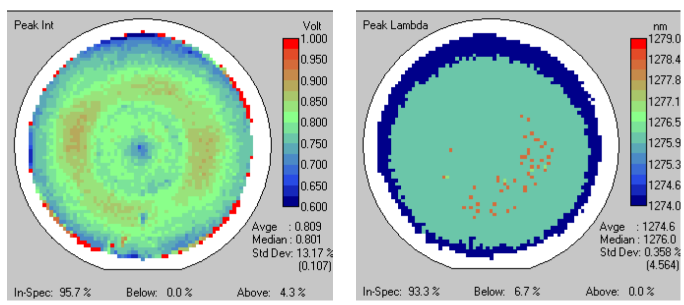
Optical plasma emission monitoring can give an insight into which molecular and atomic species are being generated in the plasma. Optical emission monitoring can be achieved by attaching a spectrometer to the plasma source and monitoring plasma emission lines using the software package provided together with the OES system. By monitoring the plasma emission lines it is possible to adjust the process parameters (such as gas flow or applied RF power) to acquire a plasma that produces predominantly either molecular or atomic species (see below).



Optical emission spectrum recorded from nitrogen plasma in MATS30.

Beam Neutralisation

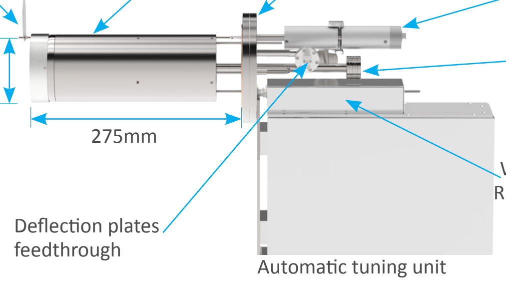
The nature of the plasma confinement and the front aperture plate ensures that almost exclusively neutral particles escape from the discharge zone. However, in all plasma sources, there is a tiny residual ion current. In the case of the MATS series of sources, this residual ion current represents less than 0.001% of the total particle current in the beam. Such low current can be detrimental to film properties if sufficient point defects are created. Consequently, the MATS source can be equipped with optional ion deflection plates which act to remove the last vestige of ion current present in the beam.



Wavelength uniformity ~ 5nm for 1270nm emission (~2% N in In.38/Ga.62As).
Data provided by Prof. M. Hopkinson, National Centre for III-V Technologies, University of Sheffield.

Layout Schematics

MATS60 Plasma Source Layout



The MANTIS MATS30 is the most popular atom source for epitaxial growth processes. The standard DN63CF (4.5" O.D.) flange mount not only allows the source to be integrated into almost all commercially available MBE systems but also into most sputtering and PLD systems. High plasma density allows typical growth rates up to 1 micron per hour deposition rate for epitaxial materials. The MATS30 is fully serviceable by the user.

The MANTIS MATS60 is a large-scale atom source that is ideal for production and pilot production applications and for use with larger wafers. The large aperture delivers uniform coverage across large samples and platens used in the production environment. Mounted on a standard DN100CF (6" O.D.) flange, the MATS60 can be integrated to most larger-scale deposition systems. The MATS60 source is also proven in high-throughput atomic hydrogen processes.

Specifications

	MATS30	MATS60
Mounting flange	NW63CF (4.5" O.D.)	NW100CF (6" O.D.)
UHV compatible	Yes, bakeable up to 250°C	
In-vacuum length	275mm - special length on request	
In-vacuum diameter of source head	60mm	96mm
Beam diameter	30mm	50mm
Gas compatibility	O_2, N_2, H_2, Ar	
Discharge tube/aperture plate material	For oxygen: Quartz, Alumina For nitrogen: PBN, Quartz For hydrogen: Quartz, PBN, Alumina	
Aperture plate design	0.2/0.3/0.5mm diameter holes - other diameters on request 5/9/37 holes as standard - other number of holes on request	
Gas flow	0.1 - 10sccm for oxygen/nitrogen (typical) (gas and aperture dependent)	
Applicable RF power	50 - 400W	50 - 600W
Power supply	600W RF power supply	
RF tuning	Automatic	
Cooling	Minimum water flow of 0.5 l/min	
Shutter	Integral manual or motorised shutter (optional)	
Deflection plates	Optional	
Beam thermalizer	Optional	
Optical plasma monitoring	Optional	
Ion source conversion kit	Optional	

Power Supplies (Optional)

Cable length	5m - special length on request
RF power supply	13.56MHz, 600W (35Amps @ 4.5KV peak) Automatic matching network including controller Forward power metering: +/-1% full scale, +/-1% reading Output power stability: +/0.5% long term, +/-1% Watt Single phase, 100-240VAC, 50/60Hz
DC power supply (deflection plates)	Up to 500V, up to 1mA Single phase, 100-240VAC, 50/60Hz

For further information please contact:
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