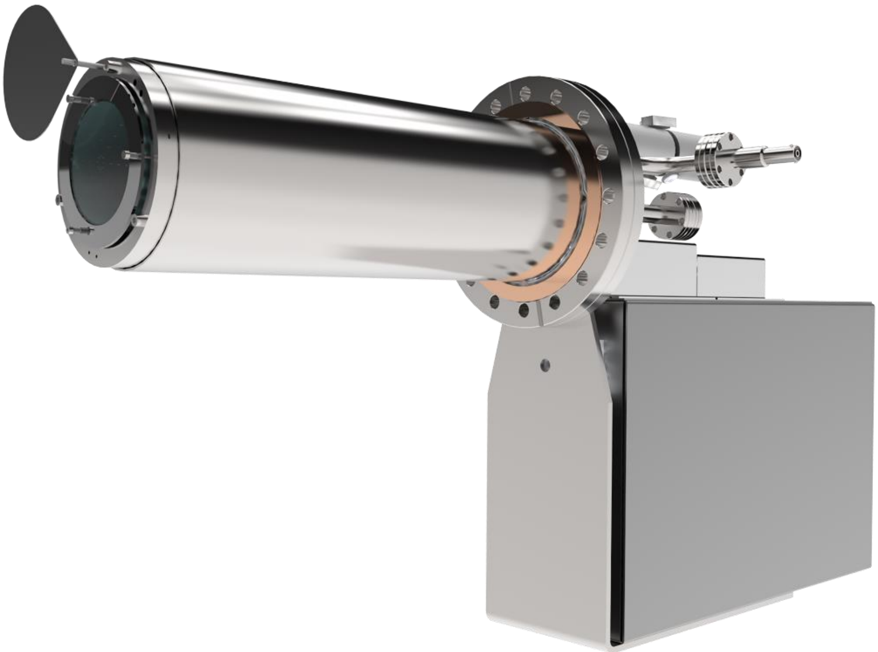
# NL-ATS
# RF Atom Source



**Ion Free Atom Source**

**Nitride MBE Growth**

**Oxide MBE Growth**

**Atomic Hydrogen Treatment**

**III-V semiconductor doping**

**Substrate Cleaning and surface passivation**

The RF Atom source produces a beam of neutral atoms of hydrogen, oxygen, nitrogen or Argon. Neutral atomic gas species are more reactive than molecular species and are ideally suited to MBE, PLD and sputtered growth of electronic materials. Atomic Nitrogen is utilized in the growth of III-V nitrides materials such as GaN, GaInNAs, InGaN, for optoelectronics while atomic oxygen may be utilised in the growth of oxide materials for high band gap semiconductor, High TC superconductors, optical coatings and dielectrics. Oxygen and nitrogen atomic species are also used for doping of III-V and II-VI materials for thin film photovoltaics. Atomic Oxygen is also commonly used for substrate cleaning of residual carbon deposits.

### Atom Source Operation

The atomic 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.

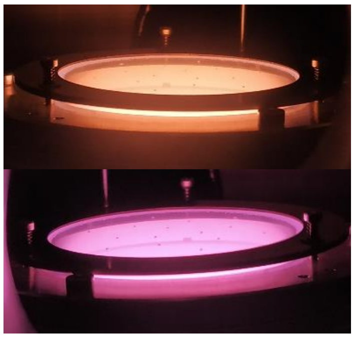


*Figure 1 Operation of* NL-ATS60 with $N_2$ RF plasma (top) and $H_2$ RF plasma (bottom)

### UHV construction

The Nikalyte Atom 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. The compact NL-ATS30 variant is supplied on a CF63 flange and fits on most commercial MBE, ALD and sputter systems. The high power 30mm atomic beam is ideally suited for R&D use. The larger NL-ATS60 variant provides a larger atomic beam diameter of 60mm for production and pilot line systems and is supplied on a CF100 flange.

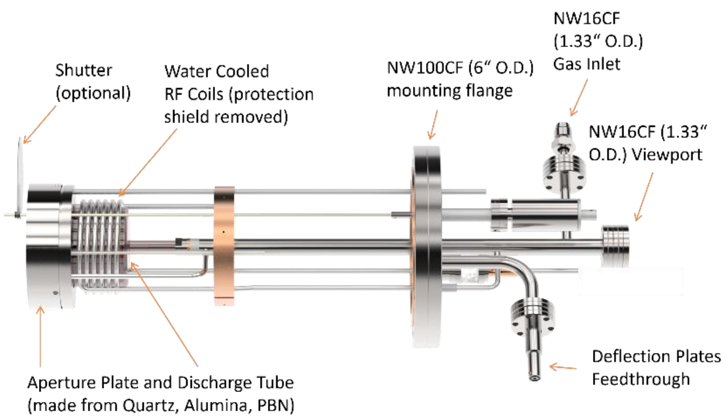



*Figure 2 NL-ATS60* Atom source internal schematic

## RF Power Control

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 figures below.

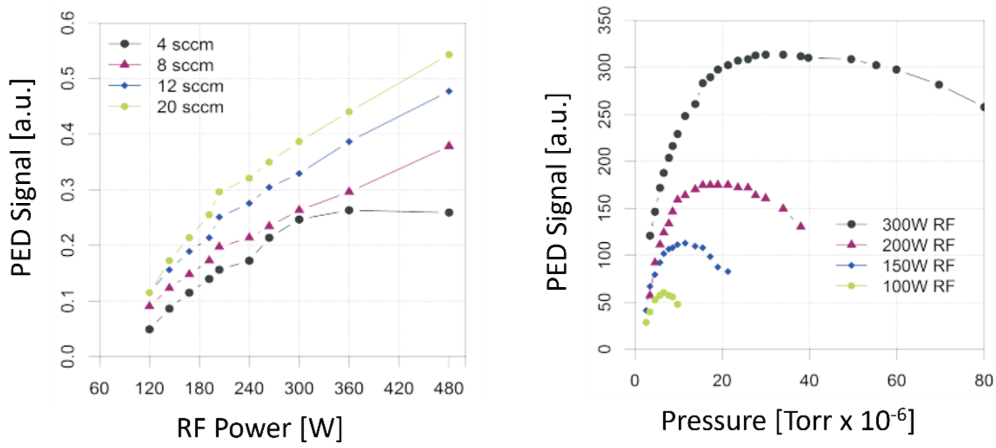



*Figure 3 Plasma emission signal as a function of applied RF power (left) and gas flow (right)*

## Gas Flow Control

The gas flow in the Atom source can tailored to suit a particular application by varying the number and size of holes in the aperture plate. The 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).

The Nikalyte Atom sources can be operated with oxygen, nitrogen, hydrogen and many other gases. The source can be equipped with a choice of quartz, Alumina or PBN discharge tube to suit the atomic gas species.

## 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.

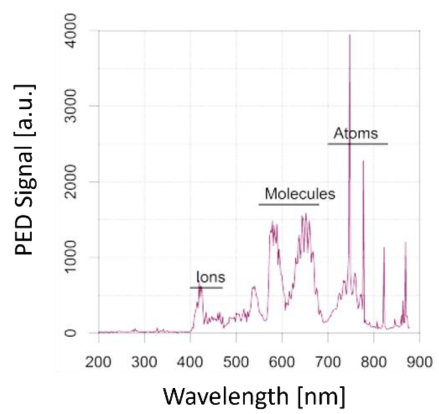



*Figure 4 Optical Emission Spectrum for $N_2$ in the NL-ATS30*

### Beam Neutralisation

The plasma confinement design 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. Such low current can be detrimental to film properties if sufficient point defects are created. The atom sources can be equipped with optional ion deflection plates to remove the last fraction of ions.

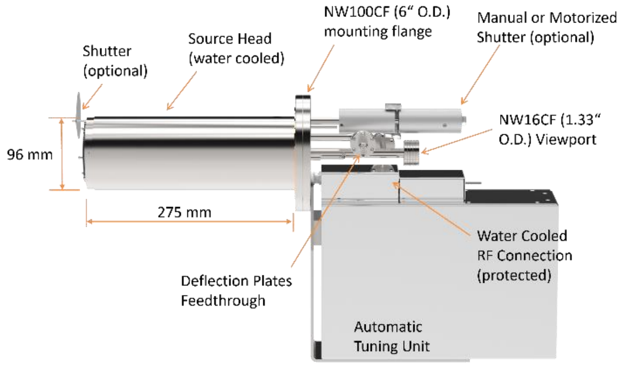



*Figure 5 NL-ATS60 Schematic*

## Specifications

| | NL-ATS30 | NL-ATS60 |
|---|---|---|
| **Mounting flange** | NW63CF (4.5" O.D) | NW100CF (6" O.D.) |
| **UHV compatible** | Yes, Bakeable up to 250°C | |
| **In-vacuum length** | 275mm | |
| **In-vacuum diameter** | 60mm | 96mm |
| **Beam diameter** | 30mm | 60mm |
| **Gas Compatibility and discharge tube/aperture plate material** | $O_2$ Quartz, Alumina | |
| | $N_2$ PBN, Quartz | |
| | $H_2$ Quartz, PBN, Alumina | |
| | Ar Quartz | |
| **Aperture plate design** | 0.5mm diameter holes as standard<br>37 holes as standard<br>(other diameters and number of holes on request) | |
| **Gas Flow** | 0.1-10Sccm for $O_2$ and $N_2$ dependent on aperture plate design | |
| **RF Power** | 50-300W | 50-600W |
| **RF Tuning** | Automatic | |
| **Shutter** | Manual or Automated | |
| **Cooling** | Min Water flow 1.0l/min | |
| **Optical plasma monitoring** | Optional | |
| **Ion beam deflection plates** | Optional | |

### Power Supply Specification (Optional)

| | |
|---|---|
| **RF Power Supply** | 13.56MHz, 600W (35Amps @ 4.5KV peak)<br>Automatic matching network including controller<br>Forward power metering: +/-1% full scale, +/-1% reading<br>Output power stability: +/0.5% long term, +/-1% Watt<br>Single phase, 100-240VAC, 50/60Hz |
| **DC Power supply (deflection plates)** | Up to 500V, up to 1mA<br>Single phase, 100-240VAC, 50/60Hz |