

User Manual

RF Atom Source

DCAX-60 /DCAX-30



These are the original English instructions



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All pertinent state, regional, and local safety regulations must be observed when installing and using this Component. For reasons of safety and to help ensure compliance with documented system data, only the manufacturer shall perform repairs to components.

When devices are used for applications with technical safety requirements, the relevant instructions must be followed.

Failure to observe this information can result in injury or equipment damage.

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1 PREFACE

1.1 Purpose of These Instructions

Thank you for purchasing this RF Atom Source. The purpose of this document is to make you familiar with the features and functions of the RF Atom Source, so that you can safely operate it as an end-user.

This documentation should therefore be regarded as an integral part of the RF Atom Source. These instructions are intended for the following product models:

- DCAX-60
- DCAX-30

1.2 Using this manual

To make best use of this manual:

- **Read the entire manual first.** Do not attempt to operate or perform maintenance of any kind on the product before you have thoroughly reviewed this manual.
- **Use this manual as a tool for putting your own knowledge into practice.** This manual does not cover the theory, principles, or best practices for any particular UHV application.
- **Remember that many DCA products are configurable.** It is not possible to address all aspects of all configurations in a single manual. If you are not finding the information you need, please contact us using the *Technical Support* information.
- **Refer to all graphics in context.** The graphics in this manual may not exactly match your product. Graphics are intended to illustrate only the features relevant to the topic at hand. Any optional, configurable, or missing features are identified, if contextually relevant.

1.3 Explanation of Safety Warnings

⚠ DANGER

Danger indicates a hazard with a high level of risk which, if not avoided, would result in a large negative effect, irreversible in several aspects, whether or not acute.

⚠ WARNING

Warning indicates a hazard with a medium level of risk which, if not avoided, would result in significant negative effect only in the longer term, requires significant effort to reverse by specialist intervention, irreversible without this intervention and effort.

⚠ CAUTION

Caution indicates a hazard with a low level of risk which, if not avoided, would result in a negative effect, usually completely reversible within the short term without specialist intervention.

NOTICE

Indicates information considered important, but not hazard-related.

1.4 Intended User

This manual is intended for trained UHV-process professionals, technicians, and persons under the direct guidance of such individuals. If you are not among these groups, please do not attempt to use the information in this manual to operate the equipment.

Read and understand this manual and its safety instructions before using this product. Failure to do so can result in serious injury or damage to the component/system.

The manufacturer is not liable for cases of material damage or personal injury caused by incorrect handling or non-compliance with the safety instructions. In such cases, the warranty will be voided.

1.5 Obtaining Documentation and Information

1.5.1 Additional Resources

In addition to these user instructions, the following related documentation should be consulted:

- RF Matching Unit User Manual – Seren/Comet
- RF Generator User Manual - Seren/Comet
- DCA System User Manual (if applicable)
- DCA Control Software Manual (if applicable)
- TDK Power Supply User Manual
- Eurotherm 3500 Series (if applicable)
- MKS/Brooks Mass flow controller (if applicable)

1.5.2 List of Component Manuals Ordering Documentation

Documentation, user instructions and technical information can be requested by contacting DCA Instruments Oy at info@dca.fi.

1.5.3 Other languages

This is the English user manual. Manuals in other languages are available upon request.

1.5.4 Documentation Feedback

If you are reading DCA Instruments Oy product documentation on the internet, any comments can be submitted on the support website. Comments can also be sent to info@dca.fi.

We appreciate your comments.

1.5.5 Technical Support and Service

For other service-related questions, information, technical assistance, or ordering user instructions, please contact the manufacturer: support@dca.fi

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2 CRITICAL INFORMATION

This chapter provides important safety information, product cautions and a summary of important notes about your DCA component.

2.1 Safety Precautions

Carefully study this user guide and any related documentation listed in 1.5.1. Only properly trained personnel should operate or maintain the product.

2.1.1 Operation Safety Checklist

1. **Never** operate the source without the RF shields in place.
2. **Never** attach the RF power or HV cables to the source unless the source is in an evacuated, grounded vacuum chamber.
3. **Ensure** that the RF and HV power supplies are properly grounded.
4. **Do not** place any objects near the RF feedthrough or connections when RF power is applied.
5. **Never** touch the RF feedthrough when RF power is applied.
6. **Never** touch the HV feedthrough when voltage is applied.
7. **Never**, under any circumstances, open any power supplies without first removing the mains cables.
8. **Never** run the source without water cooling.
9. **Do not** remove the source from the chamber unless all cables, gas lines and water lines have been removed.
10. Allowing the plasma to extinguish when the source is operating at an RF power in excess of 300W may cause damage to the cavity. Only under the express advice of DCA Instruments Oy should this be performed.

2.1.2 Personal protective Equipment

The RF Atom Source should be handled per general UHV practices. Powder-free protective gloves should be used to avoid contamination.

2.1.3 Installation safety information

Inspect the RF Atom Source for damage before installation. If there is any visible damage, do not install the RF Atom Source and notify DCA within one week of receiving the product. Failure to notify DCA within this time period may affect the users right to claim for repairs or replacement under warranty.

2.1.4 Maintenance safety information

All cleaning and maintenance tasks shall only be carried out by qualified and skilled personnel. To ensure the optimal performance of the RF Atom Source, regular maintenance shall be carried out by qualified personnel in accordance with the manufacturer's instructions.

Maintenance and inspection should be done on a regular basis. If there is any visible damage, excessive overheating, or instability of the component, stop using it and consult the troubleshooting guide in this manual.

⚠ WARNING

Equipment Modifications to the RF Atom Source are not permitted. Any alterations made to the RF Atom Source without written permission from the manufacturer will void the warranty. Unauthorized alterations may lead to hazardous situations.

See the Appendix I for an overview of the spare parts. You can always order spare parts by contacting the manufacturer.

Only clean the component with a lint-free cleanroom compatible cloth and suitable solvent (e.g., ethanol or IPA).

The RF Atom Source may feature safety marks in areas that pose a risk of injury or with other important instructions. Always replace missing or damaged safety marks immediately. If you replace safety marks with new ones, make sure that you place the new safety marks in the same places.

2.1.5 Repair and modification Safety information

⚠ WARNING

DO NOT attempt to repair components without permission and explicit instructions from the manufacturer. Contact DCA Instruments if the system/component requires repair. Do not attempt to modify the system/components before consulting DCA Instruments.

2.1.6 Safe Disposal




Do not dispose of electric equipment, accessories, and packaging together with household waste material (only for EU countries). In observance of European Directive 2012/19/EC on waste of electric and electronic equipment and its implementation in accordance with national law, electric equipment that have reached the end of their life shall be collected separately and returned to an environmentally compatible recycling facility.

2.2 Graphical Symbols

2.2.1 Explanation of safety information on the system

Table 1 below provides safety information relevant to the RF Atom Source. The labels are located as close as possible to the relevant area it is applicable to.

Table 1 Explanation of safety information relating to the system and the location of safety labels.

Symbol	Warning / Caution	Hazard Location
	<p>HIGH VOLTAGE May cause electric shock or burn. Trained personnel only.</p>	<p>Power Supply / Electrical rack</p>
	<p>HYRODGEN - FLAMMABLE Flammable gas No smoking or open flames.</p>	<p>Gas panel (If Applicable)</p>
	<p>RF VOLTAGE HAZARD Contact with Internal RF source can cause burns and/or electrical shock. Disconnect and lock-out power before removing cover.</p>	<p>RF Source</p>

3 INTRODUCTION

3.1 Product Description

The DCAX Series of RF atom sources are designed for use in UHV or HV deposition systems where a source of reactive, low energy atomic species is required. The source generates an internally confined plasma which acts to dissociate molecular gases such as oxygen, nitrogen or hydrogen. A set of holes in the front of the plasma **discharge cavity** allow gases, both molecular and atomic, to escape into the vacuum chamber. The number and size of these holes drilled in the aperture broadly determine the flow of gas into the vacuum chamber. By varying the pressure in cavity and the RF power applied to the plasma, the intensity of the plasma and hence the dissociation efficiency can be altered.

The nature of the plasma confinement and the front aperture 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 DCAX series of sources, this residual ion current represents less than 0.001% of the total particle current in the beam. However, even such low current can be detrimental to film properties if sufficient point-defects are created. Consequently, the DCAX source can be equipped with optional **ion deflection plates** which act to remove the last vestige of ion current present in the beam.

Table 2 Summary of the optional accessories that may be included with the RF Atom Source.

Optional Accessory	Description
Deflection Plate HV Power Supply	This serves as an ion trap and includes a GENH 600-1.3 TDK Lambda DC power supply with 10m coax cable. This should be connected to the HV feedthrough on the main flange.
Gas Manifold	This is used to supply and control the gas flow rate to the source. This includes: <ul style="list-style-type: none"> • Stainless steel gas lines to the source and pump manifold • A mass flow controller(s) • Eurotherm PID Controller • Shut-off valves (supply, run and pump)
Plasma Emission Detector (PED)	Optical Spectrometer with optical fibre, or An optical emission sensor (OES) with filter connected to the Eurotherm with a coax cable. Refer to the separate manual.
Rotary Shutter	Manual or Electro-pneumatic
Control Software	The source can be operated remotely using the DCA control software (requires inputs-outputs to be supplied by DCA).
Valved Module	This isolates the source from the vacuum chamber using a separation gate valve. This includes: <ul style="list-style-type: none"> - pumping system (Pfeiffer HiPace300, DCU, and dry scroll pump) - Manual VAT gate valve - Mounting module to deposition chamber.

The RF Atom Source shall not be operated outside of the scope set out in this user manual. Interlocks may be implemented to protect the component/system from error conditions that may occur, and these should be enabled during normal operation.

Only use the RF Atom Source within the specified performance limits as described in these instructions.

3.2 Product Standard Features

Table 3 Standard features for the RF Atom Source. Some details may vary depending on the application.

Feature	DCAX-60	DCAX-30
Mounting Flange	NW100CF (6")	NW63CF (4")
Source OD	94.5 mm	60.3 mm
Chamber Port ID	98 mm (min.)	62 mm (min)
Water-cooling connection	6mm Swagelok	6mm Swagelok
Shutter mounting port	NW16CF	NW16CF
Optical Viewport	NW16CF	NW16CF
Gas connection	NW16CF	NW16CF
Deflection plates	Yes	Yes
Seren RF Generator	600W, 13.56MHz HR601/R601	600W, 13.56MHz HR601/R601
Comet RF Generator (#14180)	600W, 13.56MHz 136-ACNA-P25A-FN	600W, 13.56MHz 136-ACNA-P25A-FN
Seren RF Tuning Unit (automatic)	25-1037pF Load 5-100pF Tune	25-1037pF Load 50-500pF Tune
Comet RF Tuning Unit (automatic)	50-500pF Load 50-500pF Tune	50-500pF Load 50-500pF Tune

3.3 Cooling

The source can be run with up to 600W applied RF power. This power is applied to the discharge zone through an inductive coil which surrounds the discharge cavity. RF radiation can couple to metalwork situated close to the coil and indeed to the coil itself. It is therefore vital that the coil is internally cooled to avoid overheating.

⚠ WARNING

At high RF power, the RF coil will rapidly melt if water cooling is not running. It is therefore essential to ensure cooling water is running before operating the source.

To avoid coupling to other components, the source contains few structural elements in close proximity to the coil. This, together with extensive internal cooling, ensures a minimum of structural temperature rise and subsequent outgassing.

The source impedance must match the output impedance of the RF generator in order to couple power correctly. This impedance depends not only on the characteristics of the coil but also on the plasma conditions. It is therefore necessary to provide a mechanism to change the impedance of the source as plasma conditions change. This is accomplished by using a pair of variable vacuum-capacitors in a tuning network attached to the back of the source. These capacitors form part of the RF circuit and allow the impedance to be changed to match that of the RF power supply as conditions within the source change. As standard the DCAX source is delivered with an automatic tuning unit (Seren/Comet).

3.4 Gases

The source can be operated with oxygen, nitrogen, hydrogen, and numerous other gases. The table below shows gas compatibility with various materials from which the discharge cavity may be manufactured:

Cavity Material	Quartz	Alumina	PBN	AlN
Gases	Oxygen Nitrogen Hydrogen	Oxygen Nitrogen Hydrogen	Nitrogen Hydrogen	Nitrogen Hydrogen

The source can also be used with some organic gases such as methane, but these should generally be heavily diluted with hydrogen gas to avoid carbon deposits forming on the insides of the discharge cavity. **Please contact DCA for recommendations on non-standard gases.**

4 PREPERATION / INSTALLATION

4.1 First Inspection

DCA takes great care to ensure that your source is shipped in a fault free and ready to use condition. Nonetheless we recommend that the following simple checks are performed on receipt and unpacking of the source. Normal UHV practice should be employed when unpacking and handling the source (e.g. wearing of non-powdered gloves, use of clean degreased tools).

- Check the external packaging for any signs of damage or mishandling.
- Review the separate enclosed shipping list and ensure that all items listed have been supplied.
- Once the packaging has been removed, inspect the source for any signs of mechanical damage.

NOTICE

The source may be shipped with the cavity packed separately to avoid damage during transit. If so, the cavity should be installed as detailed in sections respectively. If you have any questions relating to the condition of your source or the above checks, please contact DCA immediately.

4.2 Mounting

In order to mount the source, the tuning unit must be removed. Since the tuning unit should not be mounted on the source during bakeout above 100 °C, it is often advisable to leave the tuning unit off at this stage until after the bakeout has been completed. For instructions on removing and replacing the tuning unit see section 5.3.

Refer to section 3.2 for mounting flange and port dimensions.

4.3 Services

The RF Atom Source requires three services to operate: RF power, water, and gas.

4.3.1 RF Power

The RF power cable should be attached to the N-type input connector on the base of the tuning unit shown in

⚠ WARNING

CHECK that the RF supply and the vacuum chamber are properly grounded to a common earth. The RF feedthrough and water connection will reach high voltages during operation. BEFORE the power is switched on, all metal components must be enclosed by the earth shield provided.

4.3.2 Water

The water lines terminate in 6mm Swagelok connectors (Figure). The water inlet is located on the side of the manual tuning unit or in the case of an automatic unit is connected directly to the RF coil. Water flows through the RF coil, exits the main flange, re-enters the main flange to circulate through the top ring cooling jacket and then exits the main flange again.

⚠ CAUTION

CHECK that the water is connected correctly so that the direction of flow is through the RF coil first.

Although it is preferable to use de-ionised water to cool the source, it is acceptable to use clean mains water. If the mineral content in the water is too high it is possible that, over time, a deposit will build up in the plastic tubing used as an RF break in the water lines. If so, this plastic tubing should be replaced as power leakage can occur if a conductive path is formed.

⚠ WARNING

Water flow should be at least 0.6 l/min. We strongly advise customers to use a water flow meter which can be tied to the interlock circuit of the RF generator such that the RF power cannot be applied in the absence of water flow.

4.3.3 Gas

The gas connection terminates in a 'mini-ConFlat' flange. Ensure that there is no gas contamination and that there are no potential leaks in the gas line. Although the source is designed to operate with reactive gases, some forms of contamination may cause damage to the discharge cavity, such as oxygen contamination when using PBN discharge zone materials.

4.4 Bakeout

⚠ WARNING

STOP water-cooling to the RF Plasma Source and PUGRE the waterlines before starting the bakeout!

The source can be baked to 200 °C. Before bake-out, source must be prepared since not all components can withstand bake-out temperature. Follow these steps to be prepared for bake-out.

1. Purge the source from water. This means that ensure waterflow is on from water panel before setting cooling mode to "Purge".
2. Follow instructions from section 5.3 to remove matching unit.
3. Open shutter drive. This way coupling does not move that much when you take actuator out.
4. Remove shutter drive by taking out fixing screws (see Figure 1) and pull top cover with actuator out.
5. Shutter coupling consist of two pieces. Between these there is plastic damper (pink on colour). This needs to be out from bake-out so make sure to remove it if it stays on the chamber end.
6. Put drive with pneumatic hoses attached on a plastic bag and somewhere safe so that is not stepped on and it protected.
7. Follow these steps in reverse after bake-out.

NOTICE

You should consider marking shutter orientation for example with marker etc. on the actuator by drawing the line to shutter coupling or in some other way to know that you mount it the same way back. Depending on shutter orientation before removing coupling, shutter might move. You should open plasma shutter before taking it out and when moving it back in since this way shutter blade is facing down.

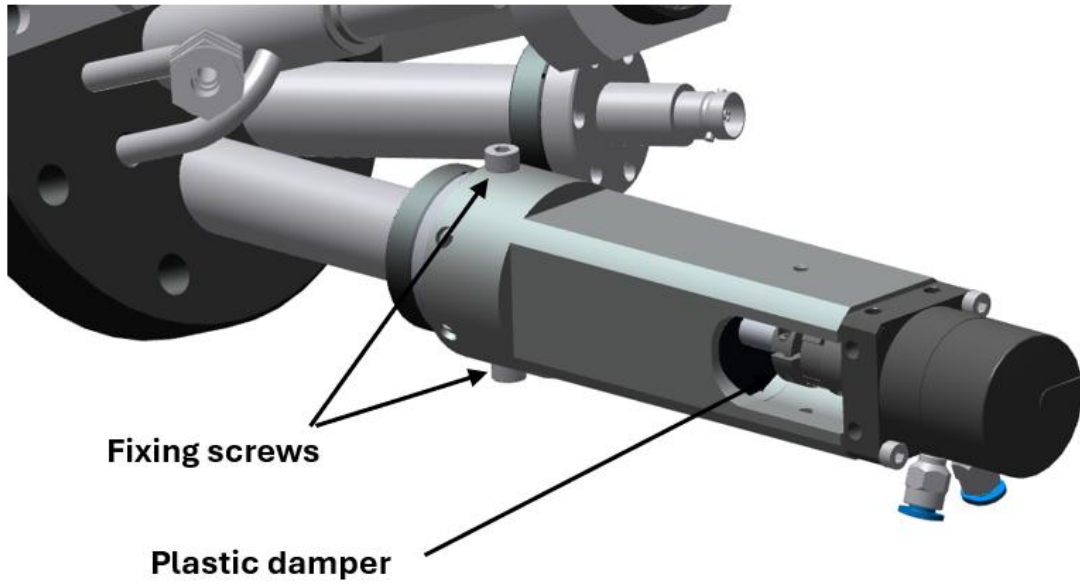


Figure 1 Image of shutter drive.

5 ASSEMBLY/DISASSEMBLY

⚠ WARNING

BEFORE any maintenance operations are attempted, ensure all cables are removed from the source.

5.1 Source Construction

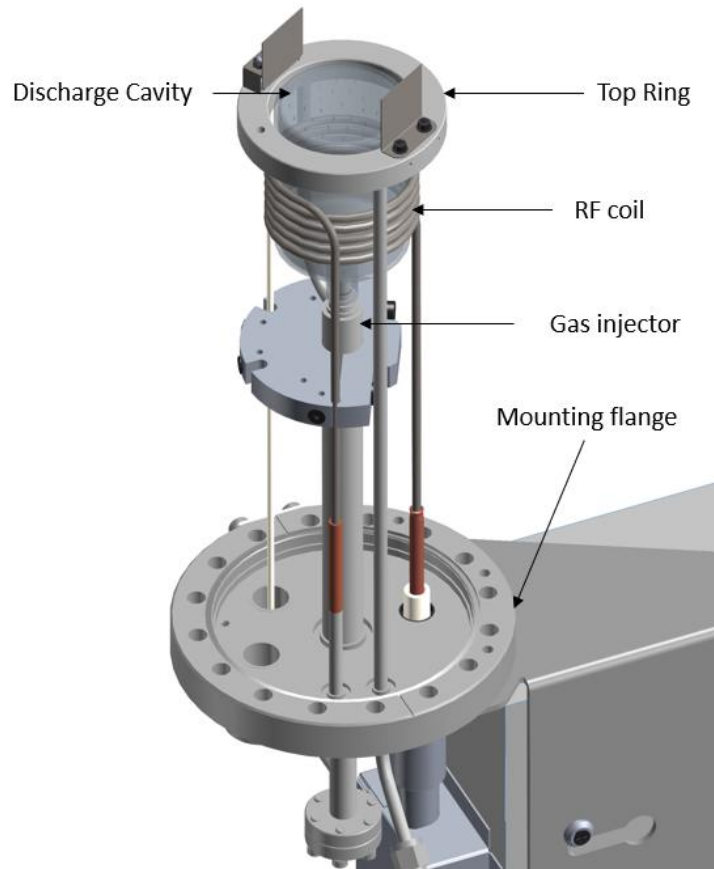


Figure 2 RF Atom Source with the shielding and adapter removed.

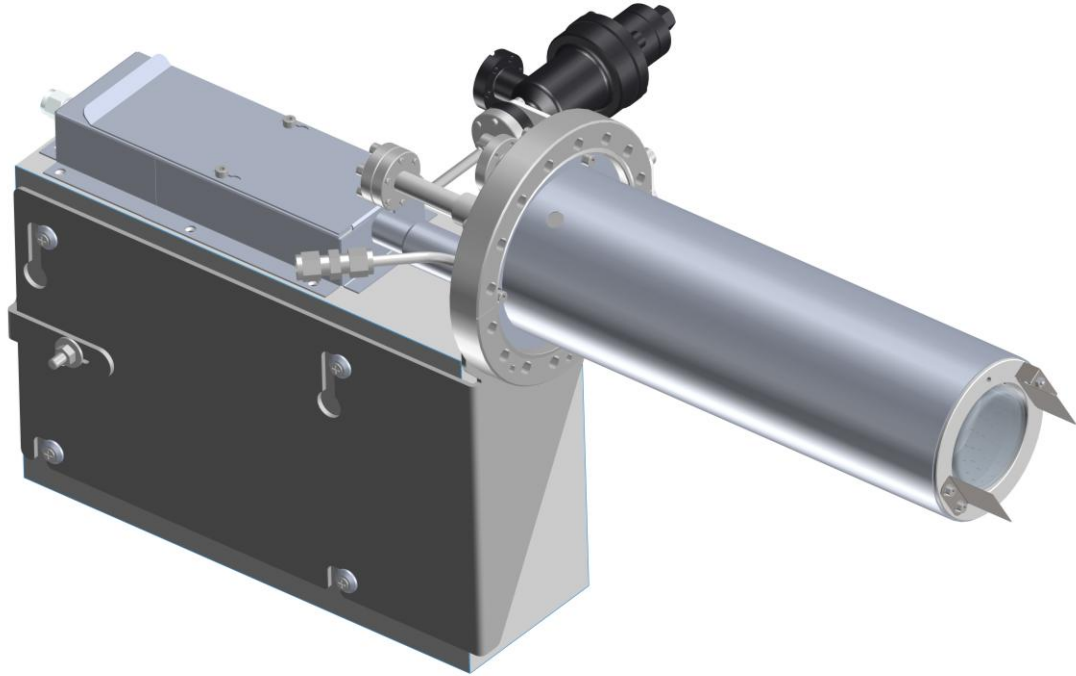


Figure 3 DCAX-60 RF Atom Source with outer shields mounted.

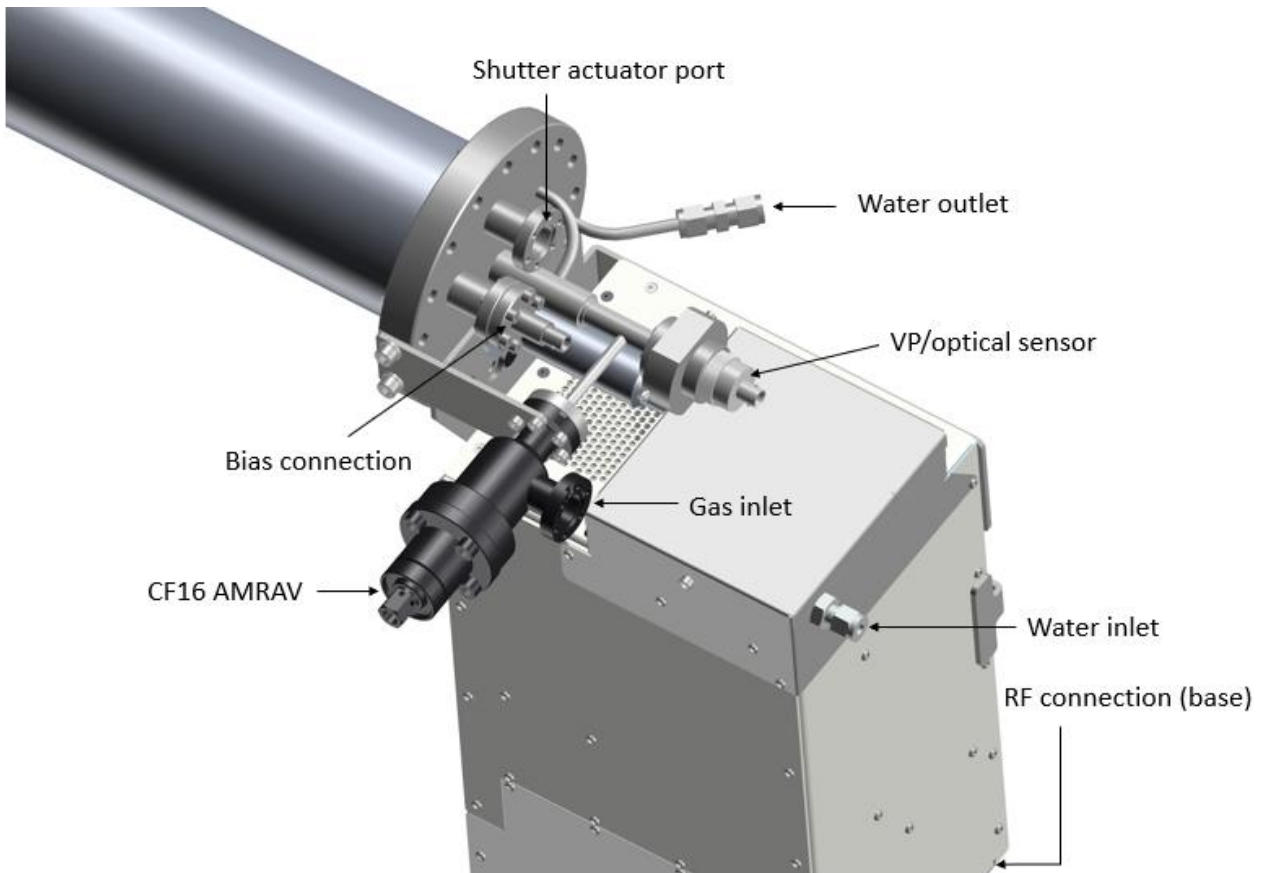


Figure 4 Automatic tuning unit with connections to the RF Atom Source.

5.2 Changing the Discharge Cavity

When replacing a discharge cavity or installing a new one:

1. Remove old cavity if need by following these steps in reverse.
2. Carefully feed the discharge cavity in through the top ring and the RF coil. In some cases, the cavity hole pattern may be non-uniform and is designed to be mounted in a certain direction – check with DCA for additional instructions.
3. The hole in the centre of the stem should fit over the gas injector (Figure 2).
4. Once it has been located correctly, push the discharge cavity down until the stem sits firmly on the bottom of the gas injector.
5. Secure the cavity in place with the clamp(s) to prevent displacement under high-flow conditions. Clamping may vary, but in latest DCA design, there is a ring that holds cavity in place and clamps secure ring.

5.3 Removing the Automatic Tuning Unit

To remove the automatic tuning unit, first make sure power is off from electric rack and remove all cables from tuning unit and then:

1. Remove the RF shield by undoing the fastenings.
2. Loosen and remove the M4 bolt in the RF connector block. Remove the top half of the connector block.
3. Undo the 6mm Swagelok connector between the RF Connector and the water-cooling line. Note, leave adapter attached to the RF connector. Gently undo connection between adapter and plastic tube.
4. Undo the 6mm Swagelok connector at the water outlet on the main flange.
5. Undo and remove bolts (x4) securing the tuning unit to the mounting bracket. Note that mounting bracket is also attached with bolts, and this can be also removed if needed while source is mounted by removing bolts underneath matching unit.
6. Gently lift until you can fit nothing unit holding bolts through mounting bracket, ensuring that the RF connector is not stressed while doing so.
7. Follow the reverse procedure to mount the tuning unit.

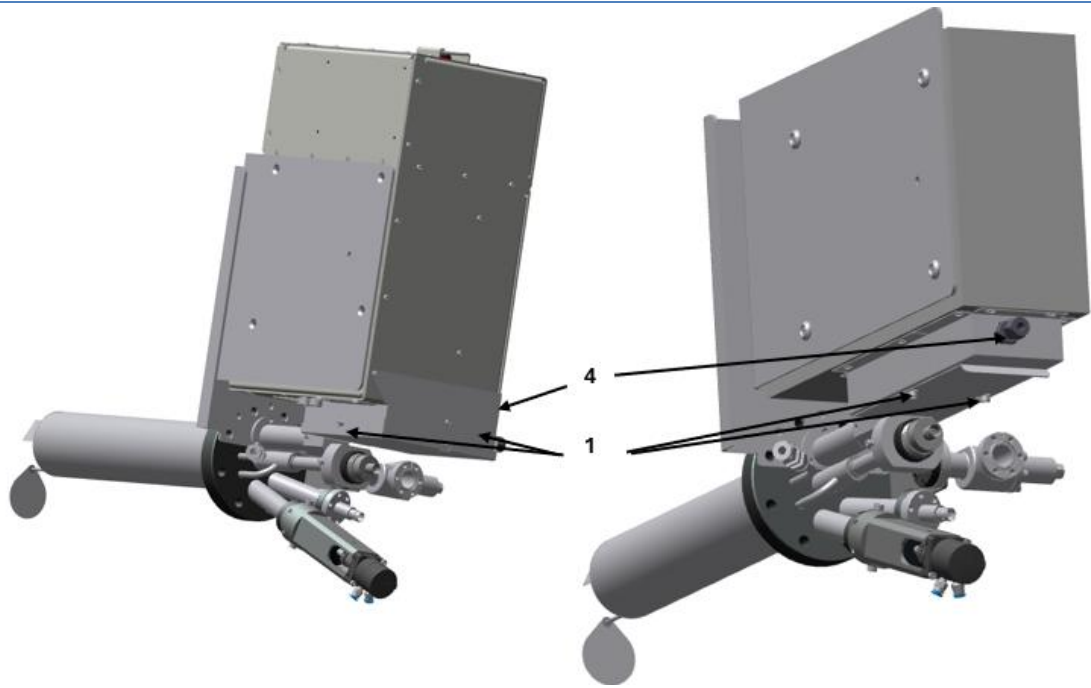


Figure 5 Automatic tuning unit with connections to the RF Atom Source 1/2. Image on the left is with Comet and on the right is with Seren matching unit.

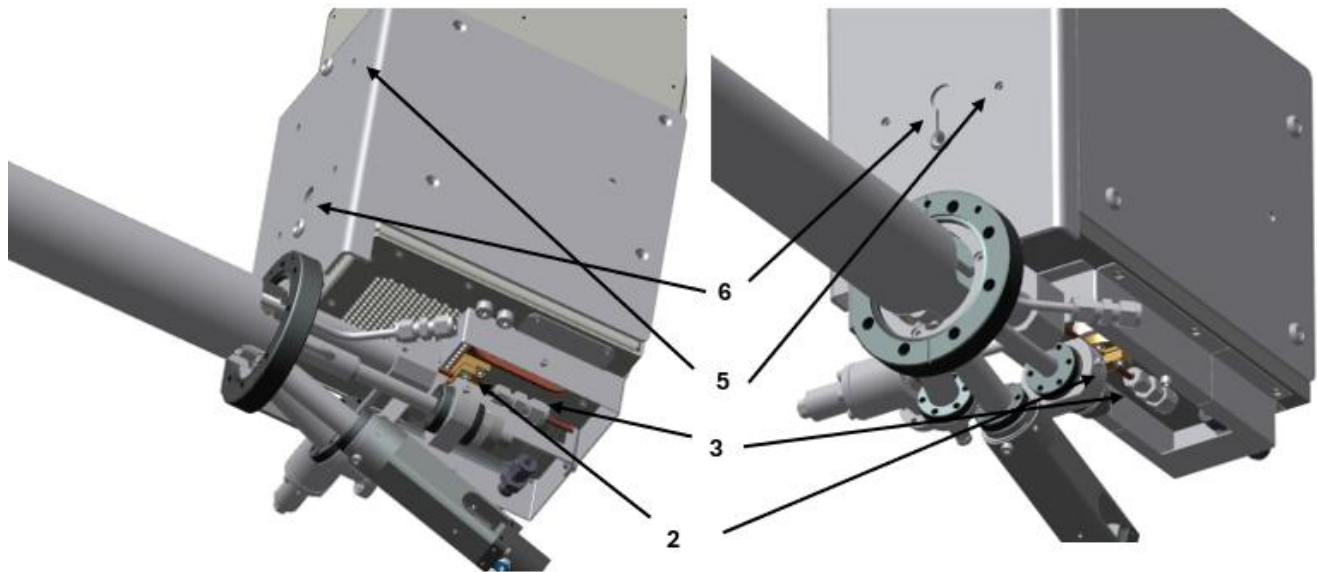


Figure 6 Automatic tuning unit with connections to the RF Atom Source 2/2. Image on the left is with Comet and on the right is with Seren matching unit.

6 OPERATION

6.1 Overview

The DCAX RF atom source is designed to dissociate molecules in a plasma and allow the neutral components of the gas mix (dissociated and undissociated) to travel to the substrate. To grow high quality films, it is desirable to have (i) a high dissociated fraction, (ii) low average energy in the beam and (iii) zero ion content. There are four parameters which affect the beam quality, and each is discussed below:

6.1.1 Aperture Hole Size

As the size of the holes in the cavity increases in aspect ratio (or reduce in diameter for a fixed aperture thickness) the fraction of ionized particles in the beam reduces and the average energy of the neutral beam reduces. However, reducing the hole size also narrows the beam and to a limited extent, reduces the dissociated fraction in the beam. For small substrates or large source-substrate distances it is therefore always desirable to use small holes in the aperture (0.2 or 0.3mm diameter). However, if uniformity is a priority, larger holes should be considered.

6.1.2 Gas Flow

Gas flow determines the pressure within the discharge zone for a given aperture. This pressure determines plasma conditions which have a heavy influence on the beam constituency. There is a pressure at which the dissociation reaches a maximum, and it is generally advisable to run the source at or above this pressure (this optimum can be found by using the plasma emission detector). If the source is run below this pressure the percentage ion content in the beam and the average energy of the neutral beam increases rapidly. Although the ion deflection plates are designed to remove the ion content, it is nevertheless good practice to maintain a low natural ion current. Note that the optimum pressure point shifts to higher values as the RF power is increased.

6.1.3 RF Power

The relationship between RF power and dissociation is close to linear. It is therefore most convenient to use RF power to make small changes to the growth rate or atom flux to the sample rather than any other parameter. If large changes are required and these changes are to be made rapidly, varying the RF power may introduce thermal stress to the discharge cavity. This is particularly the case when using an alumina discharge cavity. Increasing the RF power will also increase the plasma temperature and hence the average energy of the beam.

6.1.4 Tuning

Tuning affects the value of RF power applied to the plasma. Hence it has a similar effect to RF power as detailed above. The source should always be tuned to present a minimum in reflected power.

6.2 Start-Up Procedure

BEFORE start-up ensure that:

1. **The RF and HV (if ion deflection plates fitted) power supplies and the vacuum chamber are properly grounded to a common earth.**
2. The RF cable is attached the tuning unit.
3. The HV connector for the ion-deflection plates (if fitted) is attached.
4. The gas line is connected.
5. The RF connector is clamped in the RF connector block.
6. **THE TUNING UNIT LID AND RF SHIELDS ARE IN PLACE AND SECURED**
7. **WATER COOLING IS FLOWING AT A MINIMUM OF 0.6 LITRES PER MINUTE**

If plasma source is not used before, lines between chamber and gas panel might not be in good vacuum. To ensure it is safe to open AMRAV between gas line and plasma source, you can do the following.

1. Open “pump” valve and make sure rough pump is on. This means that rough pump is pumping the volume.
2. Then set MFC flow to max while keeping “pump” valve open but “supply” valve remains closed. This will pump MFC for other gases to make sure that only supplied gas will be used.
3. You can see that MFC flowrate stats to drop down. When flow is at 0, MFC has been pumped.
 - a. You can also clean gas line by opening line from the bottle and keeping MFC at maximum. Then you can open “supply valve”. This means line is filled with supplied gas and it is all pumped by rough pump. You can also use other methods to flush the line.
4. Make sure “supply” valve is closed and while keeping “pump” valve open, open “run” valve. This will pump line between gas panel and chamber to rough vacuum.
5. After a while, you can slowly open AMRAV between chamber and gas panel. While doing so, remember to monitor chamber pressure. If there are no big spikes while opening, you can close all gas supply valves, put MFC to 0 and open valve completely. If you will use plasma source, continue to section 6.2.1. If not, you can leave plasma in this stage if you plan to use it soon. It is advised to keep AMRAV closed if you do not plan to use the source.

6.2.1 Gas Flow

Introduce gas to the required flow. See the guide below:

Gas Flow

The gas flow through the source must be such as to result in a pressure sufficient to sustain a plasma within the discharge zone. The flow required to be within the ‘pressure band’ of the plasma is determined by the conductance of the exit aperture. Within the pressure band there is also an optimum pressure at which maximum dissociation is achieved. As a guideline, the following values can be used:

For a single 0.2mm diameter hole, the flow is approximately 0.01 sccm.

For a single 0.3mm diameter hole, the flow is approximately 0.025 sccm

For a single 0.5mm diameter hole, the flow is approximately 0.1 sccm.

(For example, a 3 x 0.2mm aperture will run at approximately 0.03 sccm).

If the source is supplied with a DCA Instruments gas manifold, the gas line is connected to the source via an MFC for the specified gas(es). The gas flow can be set locally via the Eurotherm or remotely via the DCA control software (if applicable).

1. Make sure that gas supply from the bottle is open
2. Set a suitable initial flow rate. A typical starting gas flow for starting oxygen/nitrogen/hydrogen applications is between 0.5 -1.0 sccm.
3. Make sure that AMRAV between chamber and gas panel is open, all manual valves are open and that you have the system in a stage that gas line is under vacuum all the way until “run” valve in gas panel.
4. Open “pump” valve and make sure rough pump is on.
5. Open “supply” valve. There will be pressure spike while MFC tries to tune flow, and it is good that rough pump pumps this away rather than chamber pumps.
6. When flow is settled, you can open “run” valve and then close “pump” valve. Now gas is flowing to the chamber.
7. See that chamber pressure is at desired level and tune flowrate if needed. Now you can operate plasma.

6.2.2 RF Power

NOTICE

For a full description of the RF power supply, please read the Seren/Comet Operating Manual.

8. Switch on the RF power supply at the main power switch on the back panel and the main switch on the front panel.
9. Increase the RF power to 50W using the front-panel dial.
10. Check that there is a suitable gas flow, e.g. 0.5-1.0 sccm to the source (see section 6.1.2).
11. Push the ‘RF ON’ button on the front-panel.
12. Tune the source (see 6.1.4) to minimize the reflected power.
13. Increase the RF power to 150W.

At this point (with gas flow and RF power supplied), there should be a plasma in the discharge zone, this should be visible either through the front aperture or through the viewport in the back of the source.

If there is no plasma, it may be necessary to increase the gas flow slightly or to raise the power.

There are two plasma modes, Low Brightness (LB) and High Brightness (HB). The correct mode for operation is High Brightness. Low brightness is a dull glow while High brightness is an intense light, which can be uncomfortable to view through the front of the source (**NOTE: the plasma should NOT be viewed with the naked eye for extended periods**). If the source is in LB mode, the gas flow should be reduced slightly, or the power increased.

When the source jumps into HB mode, the source impedance will change significantly and, as a result, the source will have to be re-tuned. The tuning characteristics will be slightly ‘softer’ when a HB plasma is present.

NOTICE

Care should be taken when retuning the source, particularly at high RF power, as rapid movements of the dial can so change the tuning that the plasma extinguishes and exposes the discharge cavity to thermal shock.

NOTICE

If a *plasma emission detector* is installed, the user should adjust the gas flow to give the maximum optical signal. If it is not installed, the user should ensure that the gas flow used is not at either limit of the 'pressure band' by adjusting the flow upwards and downwards from the setpoint by at least 20% and ensuring that the plasma does not extinguish.

6.2.3 Tuning

As standard, an automatic RF tuning unit is supplied with the RF atom Source. It is however possible to also use a manual tuning unit or manual mode (for the automatic tuning unit).

Manual tuning unit

The source is factory set with the tuning capacitors close to the turning point. Although each capacitor has a full range of close to 18 turns (see product specifications Table 3) the adjustments made to tune the source are only small fractions of a turn. The user should adjust both capacitors until the reflected power is as close to zero as possible or at most at 1% of the forward power.

- (i) To tune when close to the tuning point, the user should turn one capacitor until the reflected power is at a minimum. Then turn the same capacitor a little further in the same direction to increase the reflected power again by a few Watts. Then turn the other capacitor in the opposite sense (i.e. counter-clockwise if the first capacitor was turned clockwise) and again turn it a little beyond the minimum. Then repeat the procedure. In this way the tuning point can be reached rapidly.
- (ii) To tune when the capacitors have been accidentally moved far from the tuning point, the user should wind both capacitors fully clockwise. Then turn the LOAD (left hand capacitor) capacitor counter-clockwise four and a half turns and the TUNE (right hand capacitor) ten turns counter-clockwise. This will bring the capacitors close to the tuning point. Now move each in turn until it becomes apparent that a minimum can be found. Then proceed as in step (i) above.

Automatic tuning unit

Ensure that the Seren/Comet tuning unit controller is switched on and the 'auto' mode is selected for both Load and Tune capacitors. In this condition, the tuning unit should automatically tune without further intervention from the

user. The automatic tuning should not take longer than ~ 10s. If it continues beyond this, the RF power should be turned off, and the gas flow and/or power should be adjusted before attempting to tune again.

For full instructions on the use of the tuning unit controller please refer to the Seren/Comet manual.

6.2.4 Operating Conditions

Once the HB plasma is present, the power may be increased to the desired level. The user should take the following precautions:

1. Raise the power 100W every five minutes with alumina, AlN or quartz discharge cavity or 150W every five minutes with a PBN discharge cavity.
2. Re-tune the source carefully when the power is changed to bring the reflected power down to a minimum.
3. If a plasma emission detector is installed, re-adjust the gas flow to give a maximum in the optical signal.
4. Only adjust gas flow by small amounts and gradually at high power to avoid the risk of the plasma extinguishing.

⚠ CAUTION

If the plasma extinguishes at high power, severe thermal stress is placed upon the discharge cavity and can, in some extreme cases, lead to cracks appearing in the discharge cavity. If the user has a suspicion that such cracks have been generated, the source should not be used again until after an internal inspection. Failure to do so can lead to damage to the RF coil.

6.3 Shut-Down Procedure

When the source has been running at high power, following the correct procedure is vital to ensure the source does not suffer thermal stress during shutdown.

1. Reduce the power by 50W every 10 minutes between 600 and 400W and every 5 minutes between 400 and 100W.
2. At every adjustment of power, retune the source carefully and slowly. Rapid movements of the tuning dials can cause the plasma to extinguish.
3. When the power has been reduced to 100W, leave it at this power for 20 minutes before switching of the RF power.
4. Shut off the gas flow.
5. If the system is to be vented to air, leave the source for at least 30 minutes with the cooling water flowing.

7 TROUBLESHOOTING

Problem	Solution
<p>The source tunes but there is no plasma</p>	<ul style="list-style-type: none"> (i) Adjust the gas flow (see the guide in section 6.1.2). Do not allow the chamber pressure to rise above 10⁻³ torr at any time. If the HB plasma strikes at a flow significantly higher than that indicated in the guide or higher than in previous operation, there may be a gas leak in the source. The most likely explanation is a crack in the discharge cavity. If the user has a suspicion that there is a crack in the discharge cavity, the source should not be operated any further until an inspection of the discharge cavity is made. (ii) If the source does not strike a HB plasma despite adjusting the gas flow, the RF power can be increased to 200W (but should not be increased any higher). The gas flow should then be adjusted again. If it is still not possible to strike a HB plasma seek advice from DCA.
<p>The source does not tune – Manual Tuning Unit</p>	<ul style="list-style-type: none"> (i) It is possible that the tuning dials have been moved far from their respective tuning points. See section 6.1.4 for a tuning guide. (ii) If the source appears to be tuning, but either tuning dial reaches the end of its range before a minimum is reached, the source impedance has changed dramatically, and inspection is required. First, check all external connections to ensure that there is no RF touchdown to earth. Also ensure that the capacitors appear to be turning (that there is slight resistance when turning the dials). In addition, check the RF feedthrough - ensure that there is no marking, and that the ceramic appears to be in good condition. If there does not appear to be a problem externally, there may be an RF touchdown inside the source. With the source removed from the vacuum chamber, take out the discharge cavity as detailed in section 5.2. Then look inside the source and check that the RF coil is not touching the water-cooling lines and is free on all sides. If this does not cure the problem, please contact DCA.
<p>The source does not tune – Automatic Tuning Unit</p>	<ul style="list-style-type: none"> (i) If the capacitors were far from their pre-set tuning positions when RF power was applied, it may be that one or other of the capacitors has been driven in the wrong direction to its minimum (or maximum) value. Switch the capacitors to 'manual' operation and drive both capacitors to their pre-set values (factory set during source testing) and then return both capacitors to automatic mode. (ii) If the source appears to be tuning, but either tuning dial reaches the end of its range before a minimum is reached, the source impedance has changed dramatically, and inspection is required. First, check all external connections to ensure that there is no RF touchdown to earth. Also ensure that the capacitors appear to be turning (the motors can be heard to turn when the capacitors are

	<p>turned in manual mode). In addition, check the RF feedthrough - ensure that there is no marking, and that the ceramic appears to be in good condition. If there does not appear to be a problem externally, there may be an RF touchdown inside the source. With the source removed from the vacuum chamber, take out the discharge cavity as detailed in section 3.2. Then look inside the source and check that the RF coil is not touching the water-cooling lines and is free on all sides. If this still does not cure the problem, please contact DCA.</p>
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8 WARRANTY

- I. DCA Instruments warrants that the DCAX RF Atom Source is free from defects in material and workmanship for a period of 12 months from the completed installation date.

- II. DCA Instruments shall incur no liability under this warranty if
 - a. the allegedly defective goods are not returned prepaid to DCA Instruments within thirty (30) days of the discovery of the alleged defect and in accordance with DCA Instruments' repair procedures; or
 - b. DCA Instruments' tests disclose that the alleged defect is not due to defects in material or workmanship.

- III. DCA Instruments' liability shall be limited to either repair or replacement of the defective goods, at DCA Instruments' option.

- IV. DCA Instruments makes no express or implied warranties regarding the quality, merchantability, or fitness for a particular purpose beyond those that appear in the applicable DCA Instruments user's documentation. DCA Instruments shall not be responsible for consequential, incidental or punitive damage, including, but not limited to, loss of profits or damages to business or business relations. This warranty is in lieu of all other warranties.

- V. Upon expiration of the system warranty, DCA Instruments will release the source code under the following strict conditions:
 - a. DCA Instruments software support will be limited to the version written and delivered by DCA Instruments.
 - b. The source code is not circulated outside the lab.
 - c. No support or upgrade will be offered by DCA Instruments to any and all MBE control software modified by the customer.

APPENDIX I - SUPPLIED ACCESSORIES, CONSUMABLES, AND SPARE PARTS

For ordering accessories, consumables and/or spare parts, please contact:

DCA Instruments Oy
 Aerotie 6, 20360, Turku, Finland
sales@dca.fi
 +358 2 238 2500

Supplied accessories

NOTE: Not all the following accessories are supplied with the source.

Manufacturer	Item Description	Model
Brooks	Mass flow controller (MFC)	
Comet	RF Generator & RF Tuning Unit	
DCA Instruments	DCAX- RF Source	DCAX-30 DCAX-60
Edwards	Dry Scroll Pump	nXDS10i/nXDS6i
Eurotherm	PID Controller	3500 Series
MKS	Mass flow controller (MFC)	
Pfeiffer Vacuum	Dry Scroll pump	HiScroll6
TDK-Lambda	Power supplies	Genesys Programmable DC PSU
Seren	RF Generator & RF Tuning Unit	

Consumables

DCA #	Item	Description
CAVITY		
11038	Quartz discharge bulb 37x0.5 holes	DCAX-60
14228	Quartz discharge bulb 37x0.5 holes	DCAX-30
36164	PBN discharge bulb 41x0.5 holes	DCAX-60
38675	PBN discharge bulb 37x0.5 holes	DCAX-30
	Custom Hole Pattern and Materials	Available on request

Spare/replacement parts

DCA #	Item	Description
GASKETS		
10075	GASKET DN16CF	COPPER SILVERED
10077	GASKET DN40CF	COPPER SILVERED
10081	GASKET DN63CF	COPPER SILVERED
10084	GASKET DN100CF	COPPER SILVERED
GV BONNET SEAL		
12836	VAT SEAL BONNET RECT 63216-01	LARGE FOR GV 10840-CE (DN100)
12837	VAT SEAL BONNET RECT 93160-01	LARGE FOR GV 10844-CE (DN160)