



ISE 10

Sputter Ion Source

User's Guide

Version 1.1

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Please note: This documentation is available in English only.



Attention: Please read the safety information on pages 9 and 10 before using the instrument.

Related Manuals
NGISE 10 Technical Reference Manual
ISE RC Instruction Manual (optional)

Table 1: Related manuals.

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Conditions of CE Compliance

OMICRON instruments are designed for use in an indoor laboratory environment. For further specification of environmental requirements and proper use please refer to your quotation and the product related documentation (i.e. **all** manuals, see individual packing list).

The OMICRON **ISE 10 Sputter Ion Source** complies with CE directives as stated in your individual delivery documentation if used unaltered and according to the guidelines in the relevant manuals.

Limits of CE Compliance

This compliance stays valid if repair work is performed according to the guidelines in the relevant manual and using original OMICRON spare parts and replacements.

This compliance also stays valid if original OMICRON upgrades or extensions are installed to original OMICRON systems following the attached installation guidelines.

Exceptions

Omicron **cannot** guarantee compliance with CE directives for **components** in case of

- changes to the instrument **not authorised by OMICRON**, e.g. modifications, add-on's, or the addition of circuit boards or interfaces to computers supplied by OMICRON.

The customer is responsible for CE compliance of entire **experimental setups** according to the relevant CE directives in case of

- installation of OMICRON components to an on-site system or device (e.g. vacuum vessel),
- installation of OMICRON supplied circuit boards to an on-site computer,
- alterations and additions to the experimental setup not explicitly approved by OMICRON

even if performed by an OMICRON service representative.

Spare Parts

Omicron spare parts, accessories and replacements are not individually CE labelled since they can only be used in conjunction with other pieces of equipment.

1. Introduction

The ISE 10 ion source is designed to clean samples for surface analysis. A patented ion extraction lens enables high beam current for rapid sample cleaning. The ionisation is done by electron bombardment to allow a continuous variable beam current for the nA to μA regime. High beam energy for effective sputtering and low beam energy for sensitive samples are both possible. The broad ion beam with a flat top intensity guarantees uniform sputtering.

An extremely clean ion beam is ensured by a combination of features

- a non line-of-sight filament to avoid beam contamination
- gas inlet directly into the ionisation cage for a clean discharge
- additional pumping port to improve discharge purity
- DEGAS function to allow source cleaning prior to operation.

Ion Generation

The ion generation takes place inside a collision chamber of a special shape. Thermal electrons are emitted from a circular thorium oxide coated iridium ribbon filament. These are subsequently accelerated by an anode grid which has a potential of +120 V with respect to the filament. While travelling to the anode, the electrons ionise the neutral particles present in the volume between the filament (cathode) and the anode.

The anode is shaped in such a way as to permit the electrons to cross the anode volume many times. This increases the collision probability while at the same time avoiding the presence of an additional magnetic field.

The yield of the produced ions I^+ is proportional to the electron emission current I_E and the gas pressure inside the ion source:

$$I^+ = G \cdot I_E \cdot p_{\text{ISE}}$$

where G is an instrumental factor. For the ISE 10 this factor is $G = 5 \text{ mbar}^{-1}$.

The focusing parameters have to be set experimentally in relation with the desired ion source pressure value. Typical values are given in table 2.

I_E	I^+	p_{ISE}	p_{CHAMBER}
10 mA	15 μA	$8 \times 10^{-4} \text{ mbar}$	$5 \times 10^{-6} \text{ mbar}$

Table 2. Focusing parameters, typical values.

Ion Extraction

The ions are mainly produced in the filament plane and subsequently extracted from the source volume and accelerated to a pre-selected kinetic energy. The ion end energy can be arbitrarily selected between 0.1 keV and 5 keV.

An ion-optic lens is placed directly behind the extractor electrode and focuses the ions into a beam diameter in the range of 3 mm to 18 mm FWHM.

The flange is provided with three suspension springs which serve to align the source with the lens system. The shield, the anode, the extractor and the cathode are mounted to the source base. The ribbon cathode encloses the anode cage while the shield is also used as an electron repeller. Additionally, two segments of a single lens are mounted on the source base.

Filament (cathode) heating, reflector, anode and extractor have a dielectric strength of 10 kV against ground/earth.



Please note: The small conductivity of the aperture results in a pressure drop between the source volume and the experimental chamber of one or two orders of magnitude.

Normal Use

The **ISE 10 Sputter Ion Source** can be applied to the following functions

- sample surface cleaning, depth profile analysis, thin-etching of samples for electron microscopy experiments, etc.

The ISE 10 Sputter Ion Source shall always be used as part of a complete ISE 10 package consisting of

1. ISE 10 sputter ion source
2. NGISE 10 ion source power supply

The ISE 10 Sputter Ion Source shall always be used

- with original cable sets which are explicitly specified for this purpose
- within a suitable vacuum system
- under vacuum conditions (base pressure better than 1×10^{-6} mbar)
- with **all** cabling connected and secured, if applicable
- with **all** electronics equipment switched on
- in an indoor research laboratory environment
- by personnel qualified for operation of delicate scientific equipment
- in accordance with **all** related manuals.



Please note: CE compliance for a combination of certified products can only be guaranteed with respect to the lowest level of certification. Example: when combining a CE-compliant instrument with a CE 96-compliant set of electronics, the combination can only be guaranteed CE 96 compliance.



Warning: Lethal Voltages!!

Adjustments and fault finding measurements as well as **installation procedures and repair work** may only be carried out by authorised personnel qualified to handle lethal voltages.



Attention: Please read the safety information before using the instrument.

2. Safety Information



Important:

- **Please read this manual and the safety information in all related manuals before installing or using the instrument.**
- The safety notes and regulations given in this and related documentation have to be observed at all times.
- Check for correct mains voltage before connecting any equipment.
- Do not cover any ventilation slits/holes so as to avoid overheating.
- The ISE 10 Sputter Ion Source may only be handled by authorised personnel.



Warning: Lethal Voltages!!

Adjustments and fault finding measurements may only be carried out by authorised personnel qualified to handle lethal voltages.

- Lethal voltages may present at parts of the ISE 10 Sputter Ion Source during operation.
- Lethal voltages are present inside the NGISE 10 control unit.



Always

- **All connectors which were originally supplied with fixing screws must always be used with their fixing screws attached and tightly secured.**
- **Always disconnect the mains supplies of all electrically connected units before**
 - connecting or disconnecting any cables
 - opening the vacuum chamber or a control unit case,
 - before touching any cable cores or open connectors,
 - before touching any part of the in-vacuum components.
- Leave for a few minutes after switching off for any stored energy to discharge.



Never

- Never exceed a pressure of 1.2 bar inside the vacuum chamber.
- the vacuum chamber pressure must not exceed 10^{-5} mbar at any time during bakeout.
- Never have in-vacuum components connected to their electronics in the corona pressure region, i.e. between 10 mbar and 10^{-3} mbar, so as to avoid damage due to corona discharge.



This product is only to be used:

- within a dedicated UHV system
- under ultra-high-vacuum conditions
- indoors, in laboratories meeting the following requirements:
 - altitude up to 2000 m,
 - temperatures between 5°C / 41°F and 40°C / 104°F (specifications guaranteed between 20°C / 68°F and 25°C / 77°F)
 - relative humidity less than 80% for temperatures up to 31°C / 88°F (decreasing linearly to 50% relative humidity at 40°C / 104°F)
 - pollution degree 1 or better (according to IEC 664),
 - overvoltage category II or better (according to IEC 664)
 - mains supply voltage fluctuations not to exceed $\pm 10\%$ of the nominal voltage

3. Installation

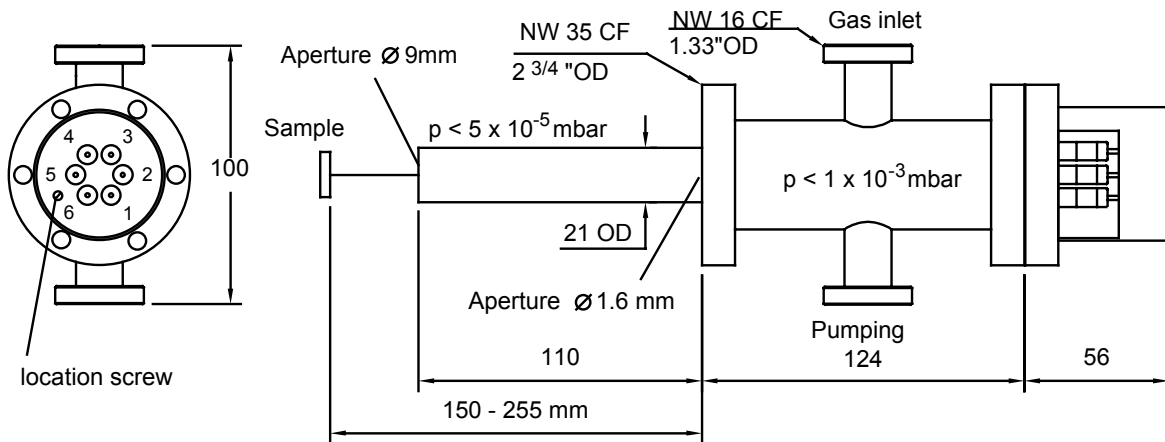


Figure 1. Outline dimensions of the ISE 10 sputter ion source. Pin connections: 1 = Repeller, 2 = Focus, 3 = Extractor, 4 = Anode, 5 = Filament(-), 6 = Filament(+).

The source is built into a NW 38 CF housing. Two NW 16 CF flanges are welded sidewise: one of them serves as a bypass line for separate pumping of the ion source, the other flange can be used as a gas inlet if fitted with an UHV leak valve (not supplied).

A suitable leak valve should have a minimum controllable flow rate of about 10^{-7} mbar-litre/sec, e.g. Fisons ZMD95 (not for oxygen!) or MDC precision UHV leak valve E-MLV-22. The 6-pin electrical feedthrough is mounted on a NW 38 CF flange.



Please note: In OMICRON systems the flange for ISE 10 has a sample-to-flange distance of 203 mm (Standard Analysis Chamber DWG10070, port #18 for ISE 10).

Installation Procedure

1. Slip a new copper gasket over the thin end of the ISE 10 and bolt it to the main UHV system.
2. Connect the gas inlet via the leak valve to one of the ports.
3. Connect the other port to a turbo pump or fit a blind flange. It is not recommended to connect this port directly to the main chamber.
4. Check all bolts before pumping down.

4. System Bakeout

A bakeout procedure should be performed whenever the system has been to atmospheric pressure, and at other times during extended periods at poor pressure, to improve the quality of the vacuum.

**Attention:**

The vacuum chamber pressure must not exceed 10^{-5} hPa at any time during bakeout.

All non-bakeable items in the bakeout zone, such as cables, pipes, preamplifiers etc. should be removed prior to bakeout. Viewports and ceramic feedthroughs should be covered with aluminium foil for protection.

The maximum bakeout temperature for the ISE 10 is 250°C , recommended bakeout time is 15 hours.

The maximum bakeout temperature for the complete vacuum system may be significantly lower (150°C) due to other components attached. Please consult your system manual before baking.

Take care to avoid localised hot spots.

If possible also pump and bake the gas inlet line.

Open the UHV leak valve during bakeout.

Degassing

It is recommended to degas the ion source upon first operation and whenever the ion source has not been used for a longer period of time. This reduces contamination of the ion beam.

- Press the button DEGAS. After 15 seconds the button lights up and the power supply starts to increase the emission current step-by-step until a current of about 14 mA is reached. This current will be constant for about 2 minutes. Then the STANDBY mode is activated.
- If the pressure rises above 5×10^{-4} mbar in the differential pumping stage of the ion source (or above 1×10^{-5} mbar in the system) during DEGAS, the degassing operation should be terminated by pressing the push-button STANDBY.
- The push-buttons OPERATE, UP, DOWN and HIGH VOLTAGE are disabled during the DEGAS operation.

5. Operation

Start-Up Procedure

- Perform a system bakeout if the ISE 10 has been newly installed or not been in use for a longer period of time.
- Flush the inert gas line.
- Connect the 6-pin plug to the ion source. Take care not to damage the ceramic feedthrough. Always fix the three locating screws to avoid mechanical stress on the feedthrough.
- Check the cabling and make sure that all electrical connections are correct.
- Switch on the NGISE 10 power supply = MAINS ON.

With MAINS ON the electronics goes into stand-by mode.

The control-LED of the emission I_E limit flashes. This is normal and serves as an optical indication for the stand-by mode.

The filament is heated with 3 A. The high voltages stay switched off.



Please note: The filament stays switched on and heated with at least 3 A as long as MAINS is ON.

- Degas the ion source if the ISE 10 has been newly installed or not been in use for a longer period of time.

Setting the Pressure

- Switch off the ion and titanium sublimation pump(s) or close the respective valves. Use a cleaned/baked turbo pump in order to avoid degrading the vacuum conditions.
- Now open the gas inlet and set a chamber pressure of about 5×10^{-6} mbar ion gauge reading of the experimental chamber, see test sheet.

The gas pressure determines the ion beam intensity and influences the diameter of the ion beam. The heat transfer in the source (the gas cools the cathode) and the achievable minimum pressure inside the vacuum chamber also depend on the pressure.

If the pressure p_{ISE} is too high the cathode will be contaminated and the insulating ceramics will be coated with a conductive layer.

If the pressure of the operating gas is much too high a possible gas discharge may rapidly contaminate the source and damage the power supply unit NGISE 10.

- Since p_{ISE} cannot be measured directly, a proportional pressure value measured somewhere else in the system (bypass line, main chamber) can be used to adjust the optimum pressure or the current I_{Energy} .

Operating the High Voltage

- Make sure that the sample is near ground potential.
- Switch to OPERATE and HV ON.
- Set the focusing voltage according to the test sheet.
- In order to avoid a discharge in the source choose a beam energy of less than 1 kV and $I_E = 0.1$ mA until the gas pressure has stabilised and $p_{\text{ISE}} < 1 \times 10^{-3}$ mbar in the gun (optimum argon pressure 8×10^{-4} mbar) and $p_{\text{CHAMBER}} \leq 5 \times 10^{-6}$ mbar in the experimental chamber).
- Any beam energy can now be chosen. Standard operating conditions are:

E	I_E	Extractor	Focus	I_0	Comments
5 keV	10 mA	4850 V	3.7 keV	15 μ A	flat intensity profile
5 keV	10 mA	850 V	3.97 keV	4.8 μ A	focused beam

Table 3. ISE 10 standard operating conditions. I_E = Electron emission current, set at the power supply. I_0 = Ion beam current, measured between sample and ground potential (or with a faraday cup). Voltage reading at the meter is keV, currents are mA units.

- By means of the dial FOCUS a beam diameter between 12 mm and 3 mm can be adjusted. The focusing voltage varies with ion energy.
- The optimum gas pressure and the settings for ENERGY, EXTRACTOR and FOCUS are determined for each source during the test procedure at OMICRON. The values are available from the test sheet.
- The stated pressure values are valid only for the UHV system on which the source was tested as they depend on the position of the gauge and on the setup of the vacuum system. In the on-site system the vacuum gauges may indicate different values even if the source is operated under optimum conditions.
- If the pressure in the source cannot be measured directly, it has to be estimated. The optimum pressure for the different operation modes can be determined by optimising the beam current. This can be done as follows: determine the sample-current as a function of gas pressure. This function shows a distinct current maximum at the optimum pressure setting.

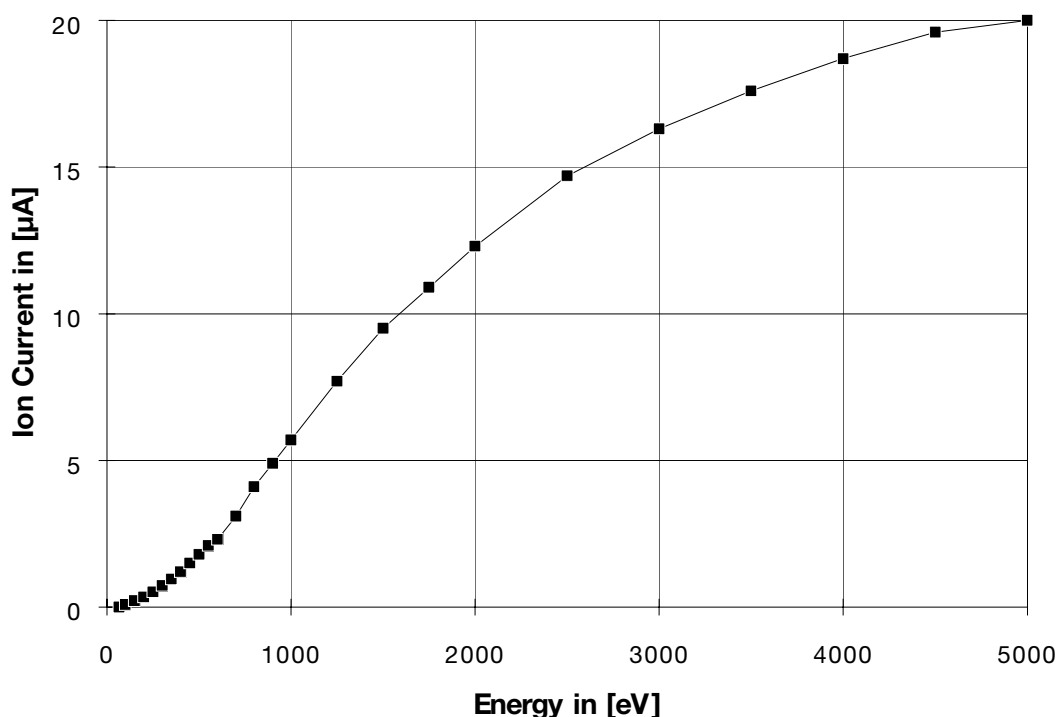



Figure 2. Maximum achievable ion current versus beam energy, schematic diagram.

Fine Tuning: Adjusting the Spot Size

The following targets can be used to inspect the spot diameter:

1. Fluorescent substance e.g. ZnO or fluorescent dye on a metal sample. Disadvantage: it is sputtered off the sample quite quickly.
2. Oxidised metal surface like Mg, Ta. Oxidized Ta shows a blue surface layer. Sputtering a hole into that layer gives a visible indication of the spot profile. Also, if the ion energy is more than 2 keV the fluorescing impact area can be seen through a viewport.
3. Metal target plated with some 100 Å of gold. A gold layer can be evaporated with the EFM 3 evaporator. Gold has an exceptionally high sputtering yield. So the ion beam perforates the gold layer in a reasonable period of time (i.e. ½ hour). Because of the gold colour on the background of a silvery metal the crater diameter can be seen easily. For a sputter rate S of 5 atoms/ion at 5 keV the number of layers removed per second dn/dt is ≈ 0.5 ML/s.
4. Quartz plate yields a fluorescent light spot where the ions hit the surface.
5. Mobile faraday cup with aperture diameter ≤ 1 mm. Suction voltage of -50 V to -90 V is recommended.

 **Please note:** High energy ions produce a lot of positive and negative secondary ions as well as electrons. A simple check by just measuring the current from a sample plate to ground may therefore give erratic results.

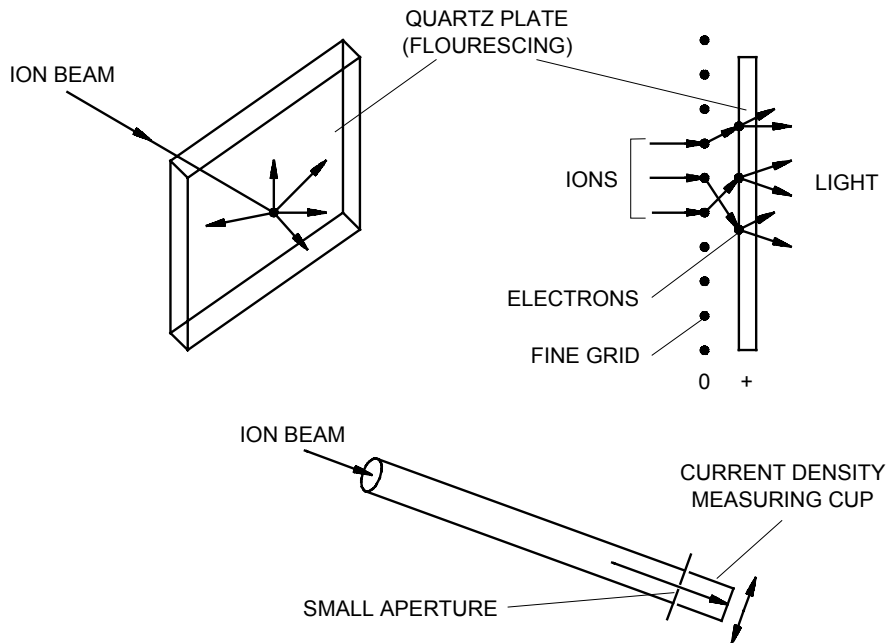


Figure 3. Techniques for observing an ion beam.

Switching Off

- Set the function switch to STAND BY.
- Set the emission to zero. (The potentiometer settings may be left as they are).
- Close the gas inlet valve.
- Switch off the ISE power supply.
- It is recommended to have the system pumped for some more hours with the help of a turbo pump, as an ion pump is not effective for noble gases.

Operation With Other Gases

The life time of the filament is about 2 years under normal operating conditions, i.e. electron emission 3 mA and using argon gas. With oxygen gas the filament life time decreases to about 6 months.

Oxygen may react with the hot filament support ring and produce volatile Mo oxides. Although the source can generally be used for oxygen it should, in this case, be operated with emission currents as low as possible (max 3 mA for the sake of cathode lifetime) and oxygen pressures below 2×10^{-4} mbar.

- The pressure values (vacuum gauge or I_E) are the same as for argon while the obtainable sample current is somewhat lower (about 50%).

Hydrogen as source gas gives a 60 % higher current.

The cleaning procedures for various samples can be found in [8].

6. Maintenance



Warning: Lethal Voltages!!

Adjustments and fault finding measurements as well as installation procedures and repair work may only be carried out by authorised personnel qualified to handle lethal voltages.

Filament Replacement

Necessary tools: Allen wrench 0.9 mm, spanner 4 mm, a pair of tweezers.

1. Slacken the locating screws of the 6-pin current feedthrough (NW 38 CF flange) and remove it together with the source.
2. Slacken the Allen screws at EXTRACTOR and FOCUS with an 0.9 mm wrench.
3. Slacken both M2 nuts with a 4 mm open-ended spanner.
4. Remove the source and carefully lift up the lens system. The cap fitting might be rather tight. If necessary, use a clean screw driver or a similar tool to lever the lens system up.
5. Slacken both Allen screws with an 0.9 mm wrench
6. Remove the cathode from the supporting pins.
7. Replace it with the new cathode at a height of 7 mm (distance between centre of cathode ribbon and support plate).
8. Reassemble in reverse order.

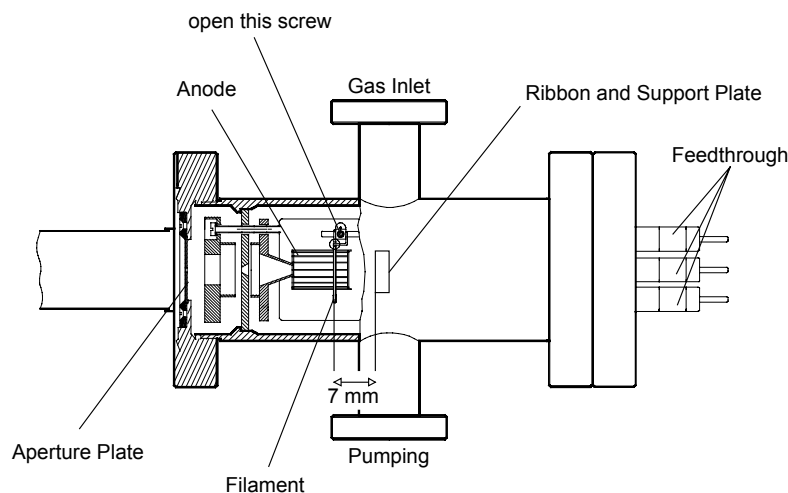


Figure 4. View of ion gun interior, schematic diagram.

Replacement of Aperture Plate

1. Remove the aperture tube by slackening the 2 screws in the NW 38 CF flange.
2. Slacken both M2 x 4 screws and remove the tantalum aperture plate.
3. Insert the new aperture plate (the bevelled rim of the plate must face the bevelled rim of the plate holder).
4. Reassemble in reverse order.

Leak Current

The operating time of the source is limited by the degrading of the cathode and the ceramic insulators inside the source.

The high voltage supplies for the source are current limited to 200 μA . I_{Energy} can be used for pressure adjustment and monitoring.

Please take into account that the leak currents will increase with the operating time of the source. These currents are included in the I_{Energy} indication. The leak currents have therefore to be checked from time to time and to be added to the stated I_{Energy} for the optimum pressure.

If you want to find out whether the leak current is caused by the source or by the electronics, remove the cable from the source and read I_{Energy} at 5 kV. If I_{Energy} is clearly smaller with the cable removed the source is the cause of the leak current.



Attention: Switch off the high voltage before connecting or disconnecting any cables.

If the degraded insulators cause currents near this limit, i.e. if the resistance across the insulators is less than 25 $\text{M}\Omega$, the ceramics have to be cleaned or exchanged.

Spare Parts Available

- Yttrium oxide coated filament "ISE FIL"
- Aperture
- Ceramics

7. Differential Pumping

Gas Inlet

High purity gas should be used, e.g. Ar 5.0. To reduce impurities (usually water) the gas line should be leak tested and baked (under vacuum) before use.

The line should be kept under vacuum if possible and always be flushed with the sputter gas immediately before use. Figure 5 shows a suitable arrangement for the gas line.

The pressure in front the gas inlet valve into the system should be reduced to about 1.5 bar to help with measuring exact gas doses.

A roughing pump should be available to pump the gas inlet tubes before filling them with gas, see figure 5. This is necessary to have a clean sputter gas.

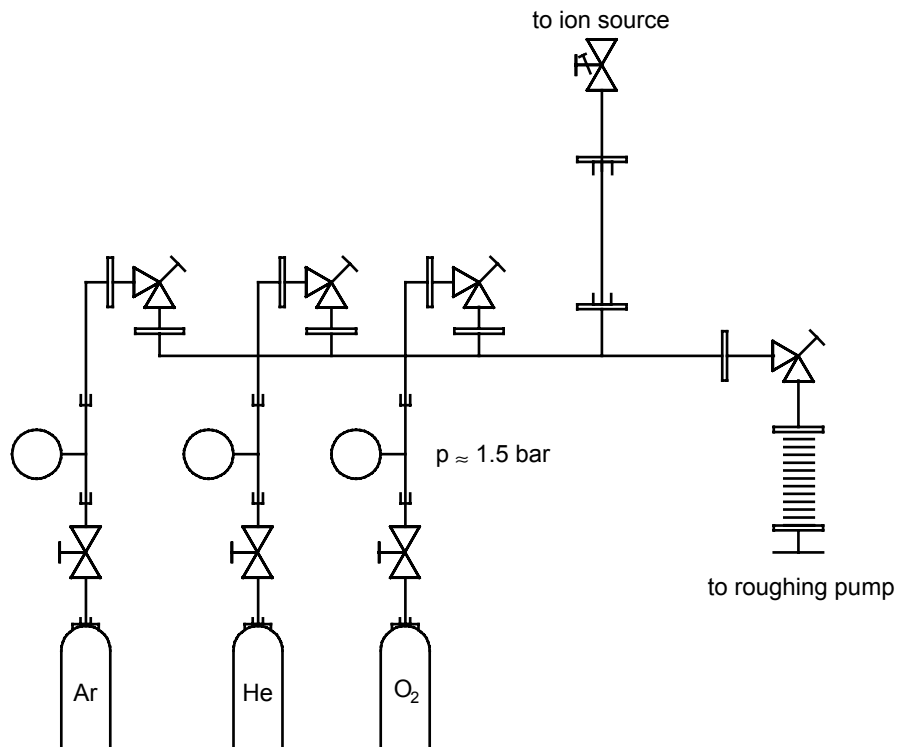


Figure 5. Gas inlet system "ISE G3".



Please note: If a very clean ion beam is required, an additional pump (e.g. a 50 l/s turbo pump) may be connected to the pumping port of the ISE 10.

8. Trouble Shooting



Warning: Lethal Voltages!!

Adjustments and fault finding measurements as well as **installation procedures and repair work** may only be carried out by authorised personnel qualified to handle lethal voltages.

Symptom	Possible cause / What to do
No ion current:	<ul style="list-style-type: none"> • Power supply disconnected or not switched on. • Multi-way cable not connected. Switch power off and reconnect. • Filament burned out. Test for continuity.
Discharge in power supply:	Switch off ion source and power supply. Disconnect all cables from the ion source (Attention: do not touch the inside of the plug!), switch power supply on and increase voltage. If no sparking occurs now, the sparking noise in the power supply results from a problem in the ion source.
Discharge in ion source:	Pressure too high. Switch to STANDBY immediately and reset pressure to a lower value.
Repeated filament burn-out	Check gas purity using a quadrupole mass spectrometer.

Appendix

Literature

Oxygen Beam

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Depth Profiling

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General Sputtering

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ISS:

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Sample Cleaning

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Diagrams

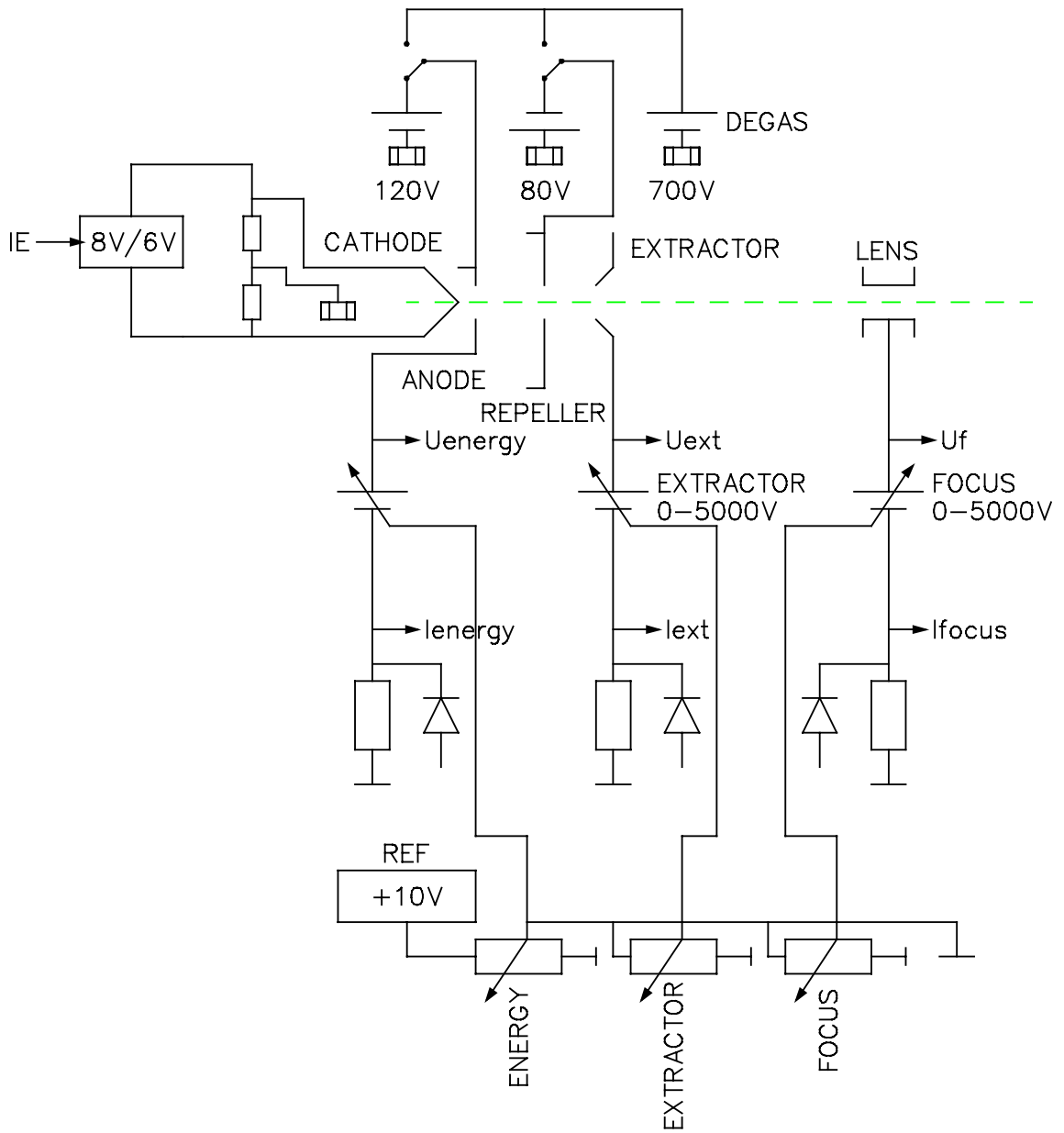


Figure 6. Block diagram ISE 10.

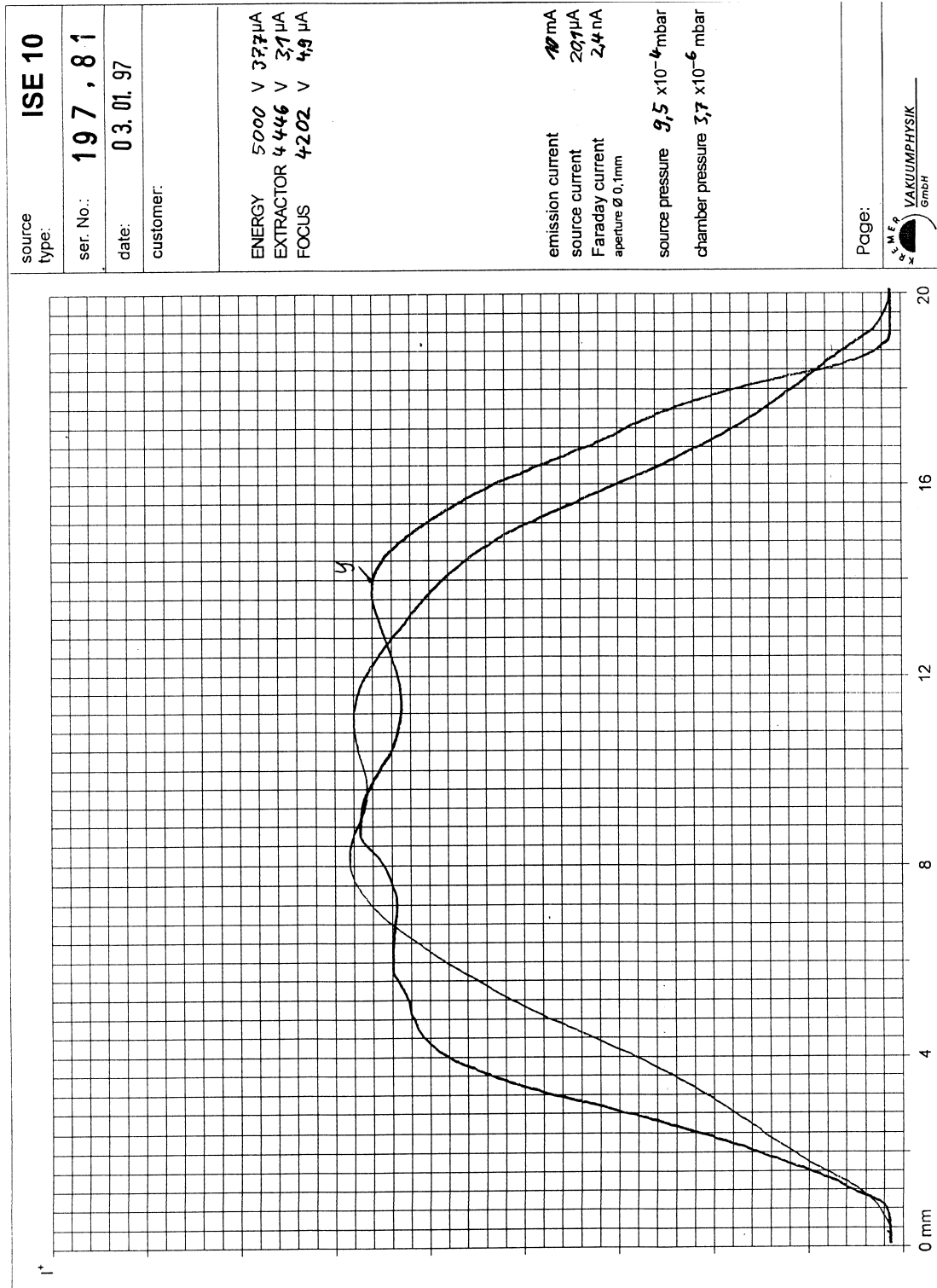


Figure 7. Typical sputter mode spot profile.

Service at Omicron

Should your equipment **require service**

- Please **contact Omicron** headquarters or your local Omicron representative to discuss the problem. An up-to-date address list is available on our website under

<http://www.omicron.de/om-adr.html>

or via e-mail reply service under

contact.info@omicron.de.

- Make sure all necessary information is supplied. Always **note the serial number(s)** of your instrument and related equipment (e.g. head, electronics, preamp...) of your instrument or have it at hand when calling.

If you have to **send any equipment back to Omicron**

- Please contact **Omicron headquarters** before shipping any equipment.
- Place the instrument in a polythene bag.
- **Reuse the original packaging and transport locks.**
- Take out a **transport insurance policy.**

For ALL vacuum equipment:

- Include a filled-in and signed copy of the "Declaration of Decontamination" form which can be found at the back of the equipment manual.



No repair of vacuum equipment without a legally binding signed decontamination declaration !

- Wear suitable cotton or polythene gloves when handling the equipment.
- **Re-insert all transport locks** (if applicable).
- Cover the instrument with aluminium foil and/or place it in a polythene bag. Make sure no dust or packaging materials can contaminate the instrument
- Make sure the **plastic transport cylinder** (if applicable) **is clean.**
- Fix the instrument to its plastic cylinder (if applicable).

Service FAX Reply

To
OMICRON NanoTechnology GmbH
Test and Service Department
Limburger Straße 75
65232 Taunusstein
Germany
Tel: +49 - 61 28 - 987 230
FAX: +49 - 61 28 - 987 33 230

From
.....
.....
.....
.....
.....
Tel:
FAX:

Type of Instrument
Serial Number
Purchasing Date
(Last Service Date)

Problem:

Date:

Signature:

Decontamination Declaration

If performing repair or maintenance work on instruments which have come into contact with substances detrimental to health, please observe the relevant regulations.

If returning instruments to us for repair or maintenance work, please follow the instructions below:

- **Contaminated units** (radioactively, chemically etc.) must be decontaminated in accordance with the radiation protection regulations before they are returned.
- **Units returned** for repair or maintenance must bear a clearly visible note "free from harmful substances". This note must also be provided on the delivery note and accompanying letter.
- Please use the attached attestation declaration at the end of this manual.
- **"Harmful substances"** are defined in European Community Countries as "materials and preparations in accordance with the EEC Specification dated 18 September 1979, Article 2" and in the USA as "materials in accordance with the Code of Federal Regulations (CFR) 40 Part 173.240 Definition and Preparation".

No repair will be carried out without a legally binding signed declaration !

Useful OMICRON Contacts

An up-to-date address list is available on our website under

<http://www.omicron.de/om-adr.html>

or via e-mail reply service under

contact.info@omicron.de.

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