

Summer School

Plasma Applications in Material Science

Greifswald, 15-26 August 2011

The summer school aims to promote the major aspects of plasma applications in material science. It addresses to undergraduate and graduate students from participating institutions with a strong background in natural science and engineering.



Introduction to Plasmas Science	R. Hippler	University of Greifswald, Institute of Physics
Introduction to Plasma Diagnostics	J. Meichsner	University of Greifswald, Institute of Physics
Basic aspects of plasma applications	M. Tichý	Charles University in Prague
Plasma Sources	H. Kersten	Christian-Albrechts-University to Kiel
Deposition plasmas	M. Holub	West Pomeranian University of Technology
	U. Helmersson	Linköping University, Plasma & Coatings Physics
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Material Diagnostics	H.-E. Wagner	University of Greifswald, Institute of Physics
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Plasma medicine I/II	R. Schneider	University of Greifswald, Institute of Physics
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Laboratory course	T. von Woedtke	University of Greifswald, Institute of Physics
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	J. Meichsner	
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Medical/clinical aspects of plasma applications	S. Reuter	University of Greifswald, Faculty of Medicine
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**Institute of Physics
and
Institute for Plasma Science and Technology (INP)**

Laboratory Course

Group		A	B	C	D	E	F
Monday 23.08.2010	14.00-15.30	Lab1	Lab2	Lab3	Lab4	Lab5	Lab6
	15.30-16.00	Coffee					
	16.00-17.30	Lab2	Lab3	Lab4	Lab5	Lab6	Lab1
Tuesday 24.08.2010	14.00-15.30	Lab3	Lab4	Lab5	Lab6	Lab1	Lab2
	15.30-16.00	Coffee					
	16.00-17.30	Lab4	Lab5	Lab6	Lab1	Lab2	Lab3
Thursday 26.08.2010	14.00-15.30	Lab5	Lab6	Lab1	Lab2	Lab3	Lab4
	15.30-16.00	Coffee					
	16.00-17.30	Lab6	Lab1	Lab2	Lab3	Lab4	Lab5

Lab1	Probe diagnostics	Steffen Drache	C0
Lab2	Optical Emission Spectroscopy and Mass Spectrometry	Vladimir Sushkov	C3
Lab3	Magnetron Plasma Source	Dr. Vit Stranak	C0
Lab4	X-ray Photoelectron Spectroscopy (XPS)	Dr. Abhijit Majumdar	C0
Lab5	Plasma Medicine I (Plasma Diagnostics)	Dr. Stefan Reuter	INP
Lab6	Plasma Medicine II (Cell Biology)	Dr. K. Masur	INP

Groups

A Antoniuk Paulina Bojarska Agata Czachorowski Daniel Gołński Łukasz
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B Marek Laca Pavol Habuda Anna Kolpakova Anton Serov
--

C Michał Kruczkowski Paweł Giza Marcin Stępnia Anna Kaczmarek

D Amir M. Ahadi Tim Brandt Thorben Kewitz Zohreh Khosravi

E Katarzyna Mydlowska Marcin Półbrat Arkadiusz Urbanowicz Ariel Lewandowski

F Petra Novotna Michaela Brunclikova Viktor Johansson
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R. Hippler

Lab1: Probe diagnostics

Steffen Drache, Institute of Physics (drache@physik.uni-greifswald.de)
Mario Hannemann, INP (hannemann@inp-greifswald.de)

- Performing the measurement
 - Conditions for a simple probe measurement
 - Material and geometry of probe
 - Probe bias and current measuring range
- Particularities of probe measurements in rf-discharges
 - Rf-distortion of the characteristic and the rf-compensation
- Simple evaluation of probe characteristics measured in DC, demonstration and visualization of the steps of evaluation
 - Maxwellian distribution – Non-Maxwellian distribution
 - Plasma potential $V_p = V(i'_{\max}) = V(i''=0)$
 - Electron retarding current from total current using ion saturation current according to cold ion approximation
 - Electron temperature from electron retarding current with $V < V_p$
 - Electron density from probe current at plasma potential
 - Electron energy distribution function, mean energy and electron density from second derivative of probe characteristic

1. Performing the measurement

An electrical single or Langmuir probe is a small auxiliary electrode immersed into the plasma. The voltage current characteristic is measured with respect to a big reference electrode (which is usually represented by the chamber). The evaluation of the I-V characteristic allows determination of internal plasma parameters as floating and plasma potential, electron temperature, electron and ion density, mean electron energy and electron energy distribution function [1, 2, 3].

1.1 Conditions for a simple probe measurement

- Isotropic plasma.
- The influence of electric and magnetic fields on charged carriers movement may be neglected.
- The charge carriers do not suffer collisions with neutrals in the probe sheath.
- *There is only one kind of positive and negative charge carriers. Especially no negative ions occur.*
- Fluctuation of plasma parameters do not occur.
- The probe material work function is constant along the probe surface and do not change during measurement.

1.2 Probe material and probe geometry

- Material

Material	Advantage	Disadvantage
Tungsten	High melting point (3350°C)	Low chemical resistivity
Platinum	High chemical resistivity	Low melting point (1770°C)

Platinum should be preferred, if price and low melting point can be accepted.

- Geometry

Geometry	Advantages	Disadvantages
Plane	Strong saturation, simple theory of saturation	More difficult assembly
Cylindrical	Medium saturation, simple assembly	complicate theory of saturation
Spherical	Simpler theory of saturation	Low saturation, more difficult assembly

Because of the simple assembly *cylindrical probes* are most commonly used. The medium saturation still leads to a significant zero cross of the second derivative of the probe characteristic. The complicated theory of ion saturation is not a problem, if an electron current evaluation of the characteristic is used. The probe radius should be not bigger than $0.025 \text{ mm} / p \text{ [mbar]}$ to avoid collisions between electrons and neutrals inside the space charge sheath around the probe.

1.3 Probe bias and range of measured current

The maximum electron temperature $V_e = kT_e/e_0$ is controlled, in principle, by the maximum voltage of the device. The probe bias V should be chosen in the range

$$V_f - 15V_e \leq V \leq V_f + 10V_e \quad (1)$$

The step width ΔV of the probe voltage controls the minimum measurable electron temperature:

$$\Delta V \leq 0.2V_e \quad (2)$$

The minimum and maximum measurable electron density is controlled by the minimum and maximum current measuring range of the probe measuring device:

Application	Minimum current measuring range	Maximum current measuring range
Simulation of plasmas of earth atmosphere	1 pA up to 1 nA	10 μ A
Afterglow plasmas	1 nA	1 mA
Technical plasmas	1 μ A	0.1 A up to 1 A

The probe has to be cleaned before measurement. The simplest method is heating up to bright red hot by drawing a high electron current.

2. Particularities of probe measurements in rf-discharges

2.1 Rf-distortions of the probe characteristic

Due to the varying plasma potential in rf-discharges an rf-voltage $v_{rf}(t) = v_0 v(t)$ with periodic time T occurs in the probe circuit which is superposed on the steady probe bias V leading to distortions of the probe characteristic. Then the probe current measured in an rf-discharge is the temporal average $\langle i(V, t) \rangle$ of the time dependent current $i(V, t) = i(V + v_{rf}(t))$. This distorted current is given by the convolution of the undistorted current with an apparatus function $a_{rf}(V)$ characteristically for the distorting signal [4, 16]:

$$\langle i(V, t) \rangle = \frac{1}{T} \int_{-T/2}^{T/2} i(V + v(t)) dt = \int_{-v_0}^{v_0} i(V - V') a_{rf}(V') dV' \quad (3)$$

For sinusoidal distortions $v_{rf}(t) = v_0 \cos(\omega t)$ the function $a_{rf}(V)$ is given by [4, 16]

$$a_{rf}^{\sin}(V) = \frac{1}{v_0 \pi} \begin{cases} \frac{1}{\sqrt{1 - (V/v_0)^2}} & \text{for } |V| \leq v_0 \\ 0 & \text{for } |V| > v_0 \end{cases} \quad (4)$$

This is a U-shaped curve. That means the function $a_{rf}^{\sin}(V)$ tends to infinity at the edges. The influence of rf-oscillations is more conspicuous in the derivatives of a probe characteristic than in the characteristic itself. The convolution of the undisturbed true second derivative with the U-shaped rf-apparatus function (4) shifts the minimum of the true derivative to more positive values by the amplitude v_0 of the rf-signal and the maximum is shifted to more negative values by this amplitude. Therefore the following relations are valid:

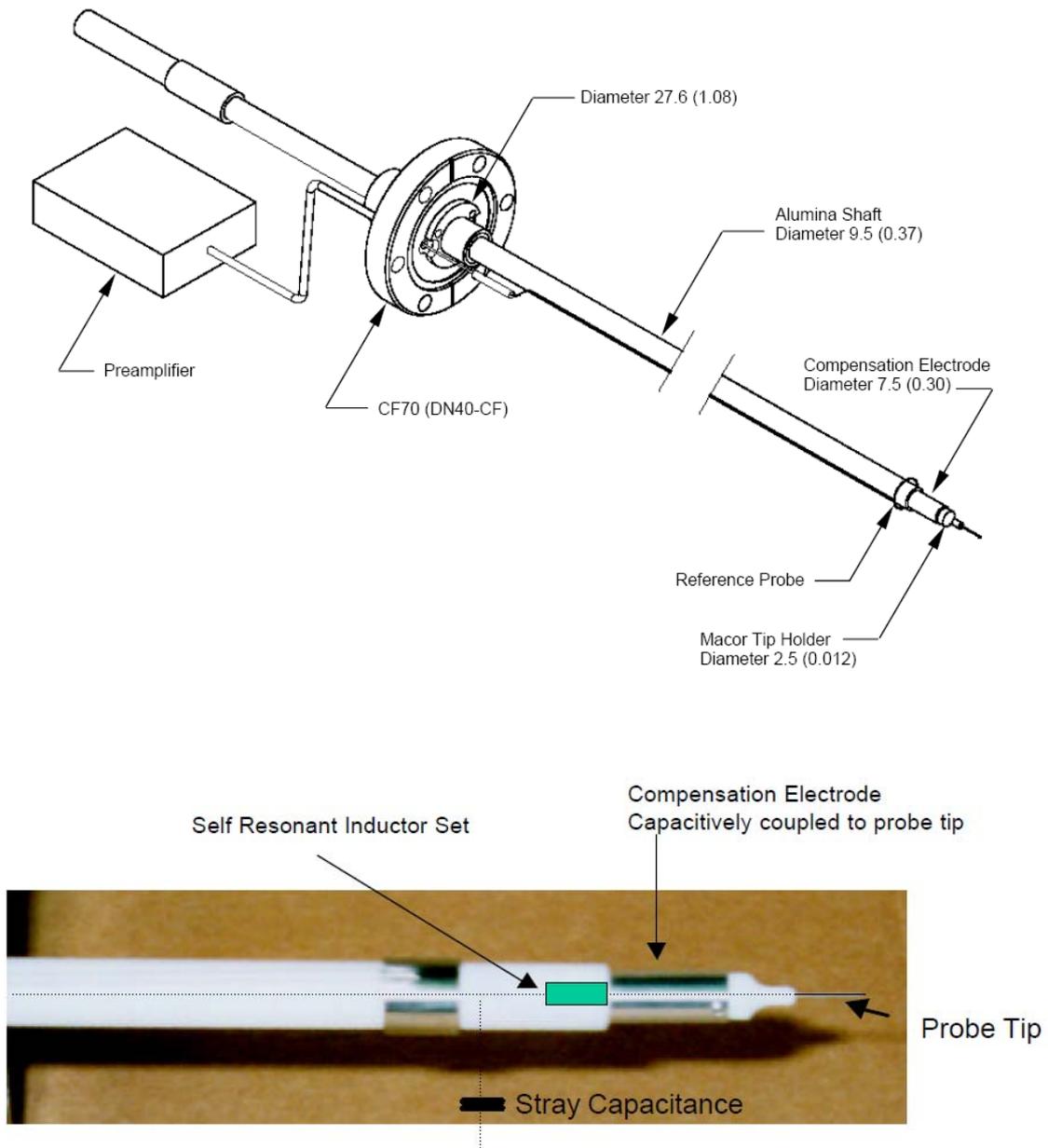
$$v_0 = (V(i''_{min}) - V(i''_{max}))/2 \quad (5)$$

$$V_p = (V(i''_{min}) + V(i''_{max}))/2 \quad (6)$$

where $V(i''_{min})$ and $V(i''_{max})$ are the voltages of the minimum and maximum of the second derivative of the distorted characteristic and V_p is the plasma potential [4, 16].

2.2 Rf-compensation

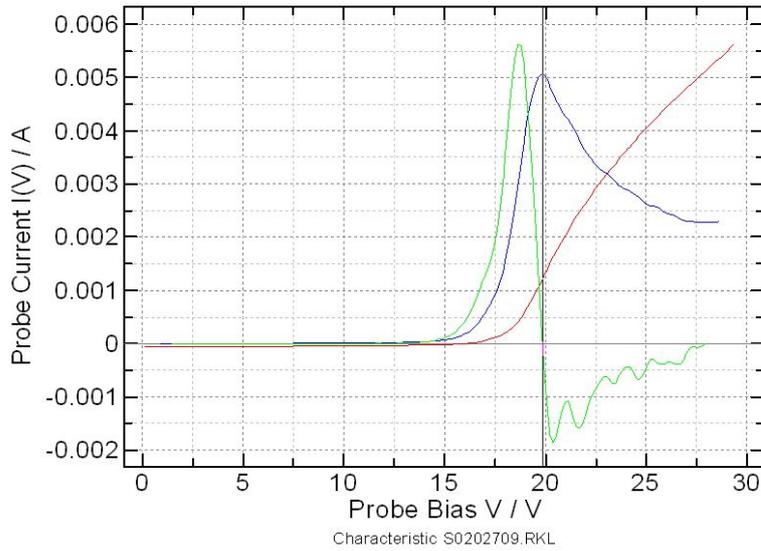
To avoid rf-distortions of the probe characteristic an rf-compensation is used. The probe tip is forced to follow the varying plasma potential either actively by driving the probe with an rf-voltage [5-8], or passively by increasing the impedance between probe and ground (inserting the passive LC resonant circuit tuned on rf-frequency) and reducing the probe to plasma sheath impedance (using a compensation electrode in contact with the plasma is capacitively coupled to the probe tip) [6, 9-12].



If the compensation is incomplete, a modified evaluation of the probe characteristic has to be used (look section 4.).

2.3 Probe measurement

Example measured in a capacitively coupled parallel plate ar-discharge ($p = 0.1$ mbar, $P = 30$ W).

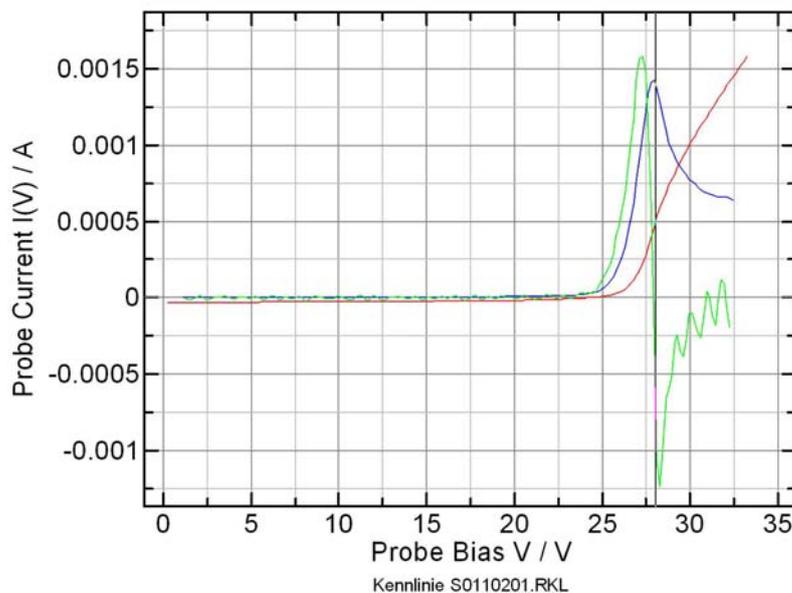


Simple electron current evaluation of probe characteristics measured in DC-discharges

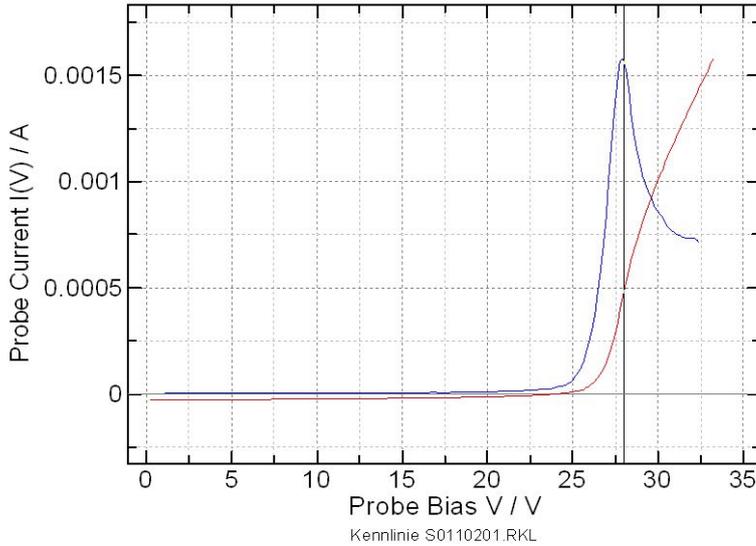
Example: Capacitively coupled discharge in argon, $p = 0.2$ mbar, $P = 10$ W

Quality of measurement: Second derivative

Red: Characteristic, **blue:** First derivative, **green:** second derivative



- Plasma potential: Voltage of maximum of first derivative, $V_p = V(i'_{\max}) = 27.95$ V (that is the zero cross of the second derivative)



- Electron temperature

If a Maxwellian electron energy distribution function occurs, than the electron retarding current is an exponential function:

$$i_{e,ret} = i_{e0} \exp(V / V_e) \quad \text{for } V \leq V_p \quad (7)$$

where V is the probe bias and V_e is the electron temperature T_e in voltage units ($V_e = kT_e/e_0$ (e_0 : elementary charge, k : Boltzmann constant)). i_{e0} is the electron current at plasma potential, that means the thermal electron current (S_p : probe surface, n_e : electron density, \bar{v}_e : mean electron energy, m_e : electron mass):

$$i_{e0} = S_p e_0 \frac{n_e}{4} \bar{v}_e = S_p e_0 n_e \sqrt{\frac{e_0 V_e}{2\pi m_e}} \quad (8)$$

Eq. (7) shows, that the electron temperature may be obtained from the slope of $\ln(i_{e,ret})$ for $V < V_p$. In this region the measured total probe current i_p is the sum of the electron retarding current and the ion saturation current: $i_p = i_{e,ret} + i_{i,sat}$, that means

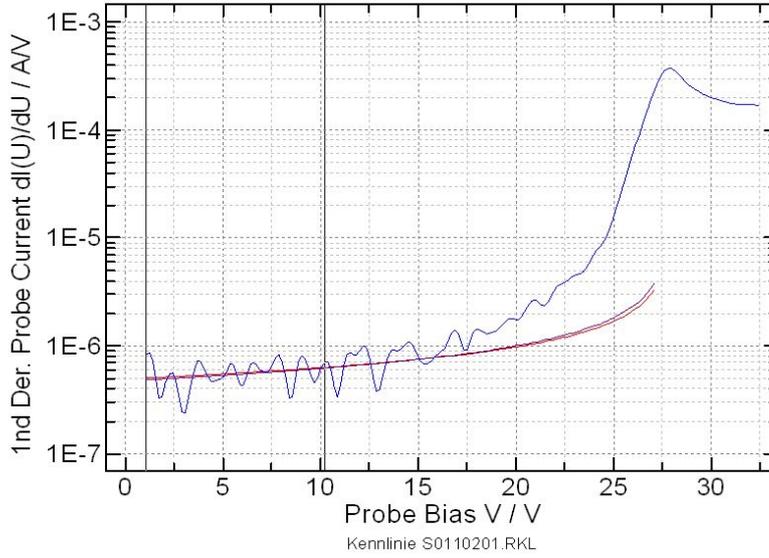
$$i_{e,ret} = i_p - i_{i,sat} \quad (9)$$

Approximation of ion saturation current

- $V \ll V_p$: Total measured probe current is pure ion saturation current in this region
- Cold ion approximation of probe current in this region by

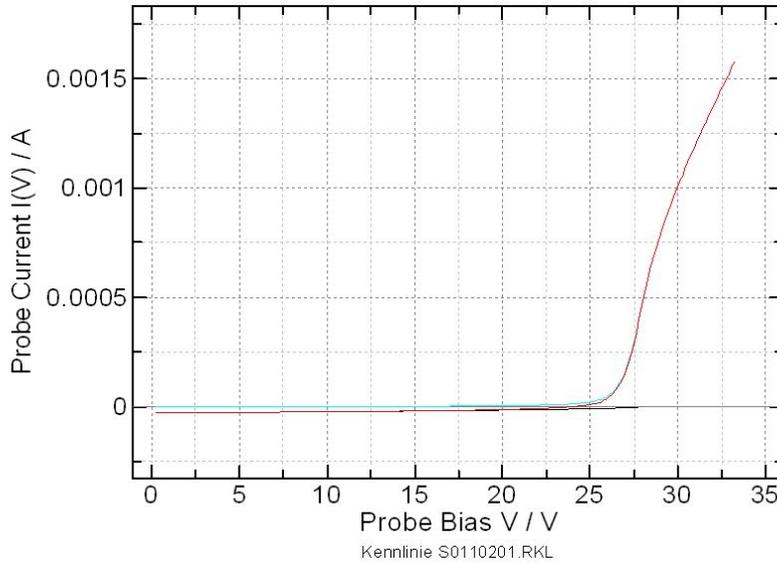
$$i_{i,sat} = a(V - V_p)^b \quad (10)$$

- Fixing of region of approximation using the logarithmic first derivative



Extrapolation of the approximated ion current to $V = V_p$ and calculation of electron retarding current according to eq. (9):

Red: Total probe current, **black:** extrapolated ion saturation current, **cyan:** electron retarding current



Calculation of electron temperature:

$$V_e \text{ from } \ln(i_{e, ret}) \text{ for } V < V_p \quad (11)$$

- Electron density

The thermal electron current is given approximately by the total probe current at plasma potential. Therefore the electron density is calculated according to eq. (8) by

$$n_e = \frac{i_p(V_p)}{S_p e_0} \sqrt{\frac{2\pi m_e}{e_0 V_e}} \quad (12)$$

- Non-Maxwellian eedf
The simple evaluation given above is possible only if a Maxwellian eedf occurs. In this case the semi logarithmic plots of the electron retarding current and of the second derivative $i_p''(V)$ of the probe current for $V < V_p$ are straight lines. If $i_p''(V)$ is a weak concave curve, then the simple evaluation is valid further on. Otherwise the mean energy and density of electrons as well as the eedf may be obtained from the second derivative of the probe characteristic for $V < V_p$ [2, 13, 14].

Literature

- [1] Chen., F. F.: In: *Plasma Diagnostic Techniques*, Huddleston, R. H. and Leonard, S. L. eds., Academic, New York (1965)
- [2] Swift, J. D.; Schwar, M. J. R.: *Electric Probes for Plasma Diagnostics*. London Iliffe Books Ltd. 1970
- [3] Chung, P. M. et al.: *Electric Probes in Stationary and Flowing Plasmas*. Springer, New York, Heidelberg, Berlin (1975)
- [4] Hannemann, M: Czechoslovak J. Phys. **56** (2006), Suppl. B, B740
- [5] Braithwaite, N. St. J. et al.: J. Phys E: Sci. Instrum. **20** (1987) 1046
- [6] Annaratone, B. M. et al.: Meas. Sci. Technol. **2** (1991) 795
- [7] Dyson, A. et al.: Meas. Sci. Technol. **11** (2000) 554
- [8] Voronin, S. et al., Meas. Sci. Technol. **15** (2004) 2375
- [9] Gagne, R. R. J., Cantin, A.: J. Appl. Phys. **43** (1972) 2639
- [10] Chatterton, P. A. et al.: Vacuum **42** (1991) 489
- [11] Flender, U. et al.: Plasma Sources Sci. Technol. **5** (1996) 61
- [12] Spatenka, P., Brunnhofer, V., Meas. Sci. Technol. **7** (1996) 1065
- [13] Druyvesteyn, M. J.: Z. Phys. **64** (1930) 781
- [14] Hannemann, M. et al.: Plasma Sources Sci. Technol. **9** (2000), 387
- [15] Sabadil, H. Et al.: Plasma Chem. Plasma Proc. **8** 425 (1988)
- [16] Hannemann, M.: Contrib. Plasma Phys. **48** 446 (2008)

Lab2: Optical Emission Spectroscopy (OES) and Mass Spectrometry

V. Sushkov

Experimental Setup:

Asymmetric, capacitively coupled radio frequency plasma

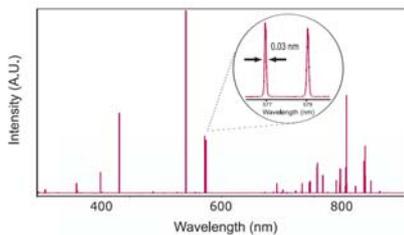
Discharge Parameters:

- Plasma Power: 10 ... 100 W
- Pressure: 1 ... 10 Pa
- Gas flow: 20 sccm
- Gas: Argon/Oxygen

Optical Emission Spectroscopy

Spectrograph: Shamrock 750

Utilizes a wavelength-dispersive element (grating) which determines the resolution, and a light sensitive element (e.g., camera) which is connected to a PC.



*“Ultimate Resolution
for more detail
and clarity”*



Mass Spectrometry

Mass Spectrometer: Pfeiffer SPM 200 (J. Koprio et al., Vacuum 41, 2106 (1990))

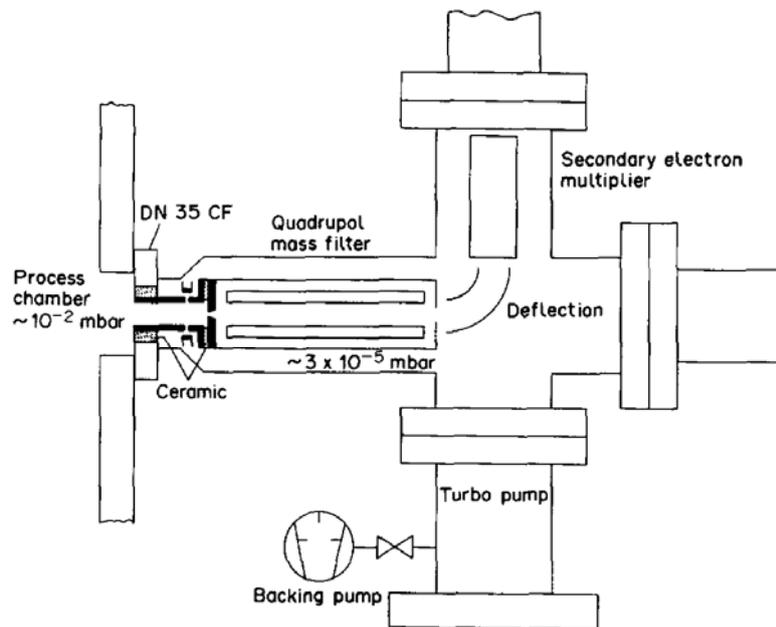


Figure 1. Schematic view of the 'high pressure' mass spectrometer mounted to a process chamber.

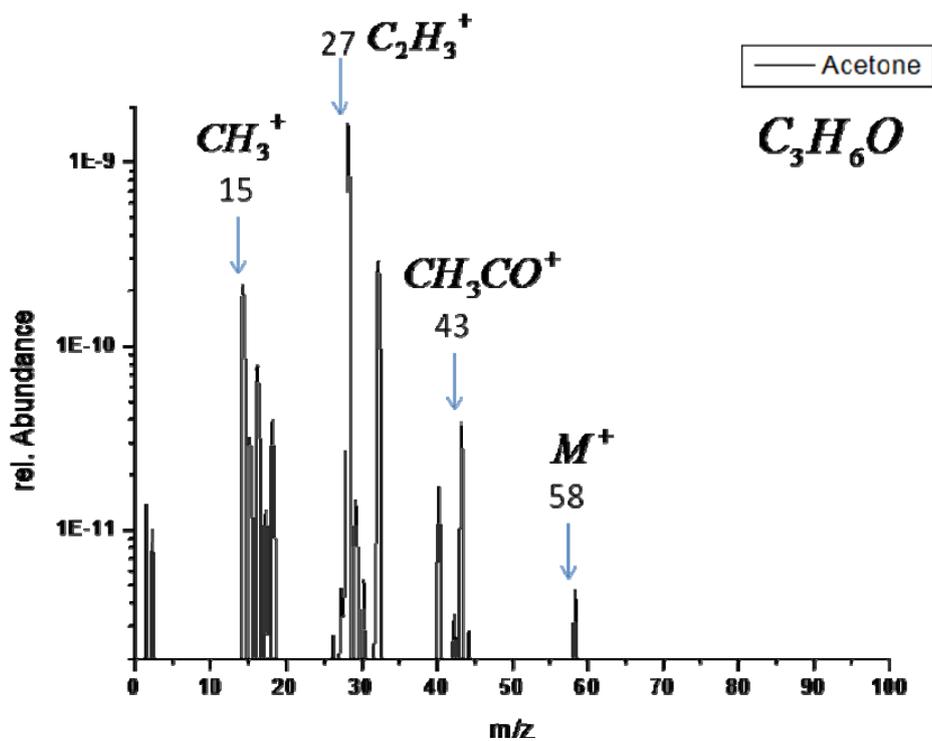


Figure: Sample spectrum of acetone

Lab 3: Magnetron plasma source

Dr. V. Stranak

Devices called magnetrons are primarily used for physical vapour deposition (PVD) processes. Magnetron principles are known for a long time since 1978 from works by [1,2] in planar or cylindrical configuration, respectively. Magnetron sputtering deposition sources are now widely used in industry because of their simple technology, economic acceptability and easy alterable physical conditions. Magnetron technology as well as magnetron plasma diagnostic is, however, continuously developing because new advanced films with prescribed physical and functional properties are needed.

A typical planar magnetron sputtering system consists of a planar cathode (sputtering source or target) parallel to an anode surface (usually grounded), which serves as a substrate holder. The cathode assembly consists of the source material, dependent on the deposited layer, directly connected with the backing power electrode. Magnets are placed below backing electrode. The structure of the magnetron is shown in Fig.1.

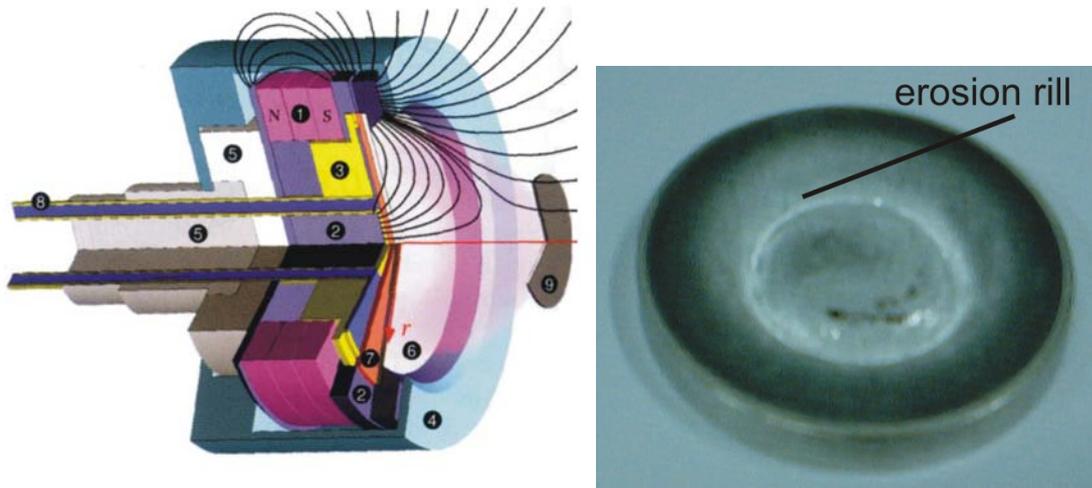


Fig.1. The cross-section of the magnetron (1 magnets, 2 magnetic circuit and target clamp, 3 coolant chamber, 4 shielding, 5 insulator, 6 target, 7 cooper meant, 8 water tube cooling, 9 substrate) and photo of real used Ti target with visible erosion rill.

If the negative voltage is applied on the cathode and the pressure is low enough, a glow discharge is formed. Negative particles (mainly electrons) of a dc glow discharge are trapped by external magnetic field, which in a certain region above the cathode runs parallel to the cathode surface. Such configuration increases electron density in a localized zone. The increased electron concentration leads to higher ion production through ionisation collisions. Radial current distribution is peaked at the radius at which the magnetic field is tangent to the cathode plate [3]. Relatively strong electric field between the positive glow plasma and the cathode accelerates ions towards the cathode, where they sputter the cathode material. The most intensive sputtering of the target is visible as an erosion rill called race-track; see Fig.1.

The external magnetic field is essential feature of magnetrons. Planar magnetrons can be operated with two types of magnetic fields corresponding to balanced (BLM) [3] and unbalanced (UNB) mode [4], see Fig.2. Generally, it is difficult to precisely distinguish between modes. The characteristic feature of balanced mode is magnetic field lines well confined around the cathode. The electron loss is reduced to minimum. The basic principle of the unbalanced magnetron is to allow release of electrons from the magnetic trap in order to create ionization away from the magnetron cathode near by substrate. Sheridan et al. showed that electrons escape from plasma up the "chimney" along the axis of cathode in UNB magnetron [5]. On the contrary, their earlier simulations [6] show that electrons in BLM magnetrons escape radially outward.

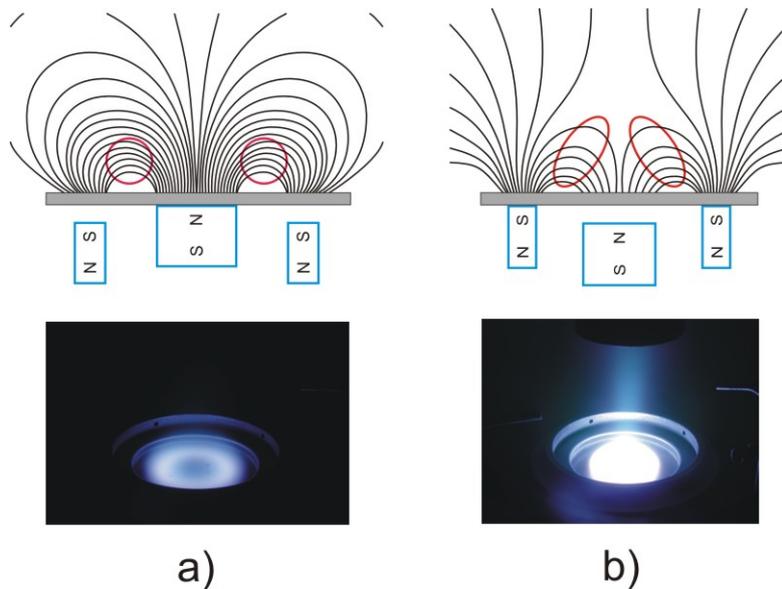


Fig.2. The magnetic field lines and photos of magnetron discharge operated in a) balanced, b) unbalanced mode.

Generally it is difficult to characterize physical and technical parameters of magnetrons because of wide range of their experimental modifications. However, typical overall parameters of dc planar magnetrons are specified below. Negative voltage bias in order of several hundreds volts (usually up to -1.000 V) is applied on the cathode - the target. The diameter of the circularly shaped target is usually from 60 up to 200 mm with the thickness about 7-10 mm. Target is made of material to be deposited - mainly Ti, In, Ta, Al, Cu, Zr and other species. As buffer gases are frequently used inert gases (e.g. Ar) with reactive component(s) (e.g. O₂, N₂,) for creation of -oxide or -nitride layers.

With the view to increase efficiency of technological depositions the conventional magnetrons are converted to pulsed systems. This means that the instant discharge current in the active pulse can be very high but the average discharge current is low and has similar magnitude as in the systems working in continuous mode. The next important reason of using pulse magnetrons is discharging of dielectric layer or clusters formed on the cathode target during reactive sputtering process of dielectric films. The modulation frequency is typically selected in a wide range from 100 Hz up to 350 kHz. Another way how to increase efficiency or quality of the deposited layers lie in using large, shape-complicated targets (e.g. rectangular), additional ionisation component (RF, MW), movement of substrate during deposition etc.

[1] R. K. Waits, J. Vac. Sci. Technol. **15(2)**, (1978), 179.

[2] J. A. Thornton, J. Vac. Sci. Technol. **15(2)**, (1978), 171.

[3] A. E. Wendt, M. A. Lieberman, H. Meuth, J. Vac. Sci. Technol. **A6(3)**, (1988), 1827.

[4] B. Window, N. Savvides, J. Vac. Sci. Technol. **A4(3)**, (1986), 196.

[5] T. E. Sheridan, M. J. Goeckner, J. Goree, J. Vac. Sci. Technol. **A8(1)**, (1990), 30.

[6] J. E. Miranda, M. J. Goeckner, J. Goree, T. E. Sheridan, J. Vac. Sci. Technol. **A(8)**, (1990), 1627.

Lab 4: X-ray Photoelectron Spectroscopy (XPS)

Dr. Abhijit Majumdar

1. Basics

XPS (X-ray Photoelectron Spectroscopy), which is also known as ESCA (Electron Spectroscopy for Chemical Analysis), is a widely used technique for surface analyses. The advantage of XPS compared to other surface analysis techniques is that it provides information about the chemical composition of the surface as well as about chemical boundaries. The detection limit is roughly 1%.

The method is based on the emission of photoelectrons from the examined sample, which is exposed to x-ray radiation with the energy $h\nu$. Commonly used x-ray sources are Mg K α (1253,6 eV) and Al K α (1486,6 eV).

The kinetic energy E_k of the electrons is given by the difference between photon energy and binding energy at surface E_b :

$$E_k = h\nu - E_b. \quad (1)$$

Since every element has a unique set of binding energies XPS can be used to identify elements in a surface and determine their concentration. Additionally very often the chemical boundaries can be detected.

The information depth of XPS measurements is limited by the mean free path length λ_e of the photoelectrons (few nm) and is independent of the significantly bigger incidence depth of the x-rays (1...10 μm). Only electrons leaving the surface without collisions carry the element's characteristic kinetic energy and contribute to a sharp peak in the spectrum. Otherwise they raise the level of the background at binding energies higher than the peak energy.

2. Data interpretation

An XPS-spectrum is showing the number of electrons versus binding energy at surface (or kinetic energy).

A typical XPS-spectrum of a Si-wafer (100) is shown in Fig. 1. In this overview spectrum one can see the peaks caused by the electrons of the O 1s-, O 2s-, C 1s-, Si 2s- and Si-2p-levels.

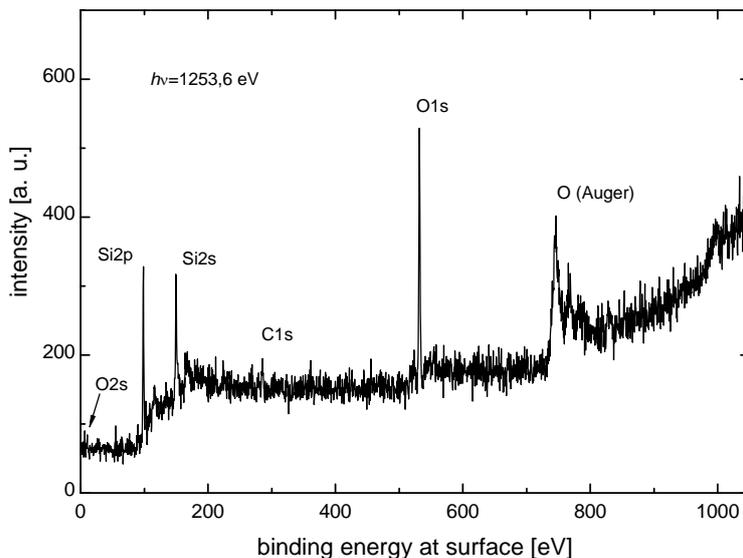


Fig. 1 Typical XPS-spectrum of a Si-wafer.

The interpretation of an XPS-spectrum starts with identifying the peaks of the elements C and O which can be found on almost any sample. After this the strongest lines and their auxiliary are identified. From their energetic positions it is possible to assign them to the elements in the layer surface by comparing the peak positions with reference measurements from literature. The assignment of a peak position to an element is not always definite. Under certain circumstances it is possible to assign more than one element to one single peak. To definitely identify an element it is necessary to detect all associated peaks.

In addition to element identification it is very often possible **to detect the chemical boundaries** if the participating elements have different electronegativities. In this case a chemical binding leads to a shift of the electronegativities resulting in a shift of the assigned XPS-peak, the so-called *chemical shift*. For example, the Si 2p Peak of a pure Si surface can be found at $E_b = 99,15$ eV. If the surface is oxidised, silicone appears as SiO₂ and the (or an additional) 2p peak is situated at $E_b \approx 103,4$ eV (see Fig. 2).

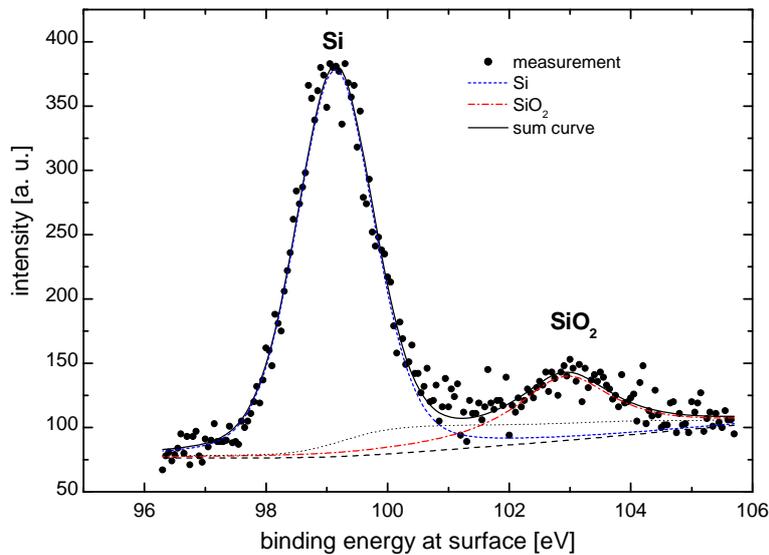


Fig. 2 Detailed XPS-spectrum of the Si 2p Peaks of a Si-wafer

A quantitative analysis of the layer composition is possible via the peak areas. Because of the element dependent emission probability of a secondary electron the peak areas have to be normalised using sensitivity factors (*ASF*). By means of the normalised peak areas the quantitative layer composition can be calculated by:

$$C_j = \frac{A_j / ASF_j}{\sum_i A_i / ASF_i} \quad (2)$$

(C_j – concentration of element j , $A_{i,j}$ – peak area of element i or j , $ASF_{i,j}$ – sensitivity factor of element i or j)

Lab5: Plasma Medicine I (Plasma Diagnostics)

Dr. S. Reuter

Leibniz Institute for Plasma Science and Technology (INP) Greifswald

In the lab courses offered in plasma medicine, the interaction of cold physical plasmas with biological cells is investigated. Two interdisciplinary lab courses are offered, a plasma diagnostics part (infrared absorption spectroscopy, and optical emission spectroscopy) and a cell biological part (cell viability, cytotoxicity, proliferation, etc.).

Plasma diagnostics

In the lab course plasma diagnostics in plasma medicine the influence of water addition to the feed gas of different plasma sources is investigated. For this, a precise detection of water content of the gas (here argon) is necessary. Water is absorbing electromagnetic radiation in the infrared spectral region, so that infrared absorption spectroscopy can easily be applied. By this method, the humidity in the system can be measured dynamically with high sensitivity. The water dissociated in the plasmas changes the plasma chemistry and thus the relative densities of reactive oxygen and nitrogen species relevant for plasma medicine. For a parameter variation the feed gas argon is enriched with different water contents. The humidity is measured and the influence on the spectral emission in the ultraviolet wavelength region is determined with high resolution optical emission spectroscopy. These measurements yield qualitative information on excited nitrogen molecules and OH radicals, which contribute predominately to the efficiency of plasma treatment of biological cells.

Lab6: Plasma Medicine II (Cell Biology)

Dr. K. Masur

Leibniz Institute for Plasma Science and Technology (INP) Greifswald

In the lab courses offered in plasma medicine, the interaction of cold physical plasmas with biological cells is investigated. Two interdisciplinary lab courses are offered, a plasma diagnostics part (infrared absorption spectroscopy, and optical emission spectroscopy) and a cell biological part (cell viability, cytotoxicity, proliferation, etc.).

Cell viability/cytotoxicity

In the lab course diagnostics in plasma medicine the influence of water addition to the feed gas of different plasma sources on cellular activities such as viability/cytotoxicity will be investigated. For this, a precise detection of reactive oxygen species (ROS) is necessary. Cell culture media is absorbing those ROS, so that the cells will take up the ROS, so that the overall content of intracellular ROS consumption will be determined by H₂DCF-DA measurements via fluorescence detection. Especially the OH radicals deriving from the gas humidity affect the plasma treated cells mostly. In combination with the OES results from the plasma diagnostics – this course will evaluate the effects of ROS in general – and OH radicals in special – on cell viability and cytotoxicity, respectively. Therefore, a specific cell viability test employing the alamar blue dye will be used – and connected to the data from the experimental data from the plasma diagnostics.

For that it will be necessary to seed and cultivate the cells one day before the plasma treatment. On the second day there will be the argon plasma treatment with different admixture of humidity, followed by the incubation with ROS containing culture media. And on the third day there will be the addition of alamar blue dye – to determine the cell viability in comparison to untreated cells.