English summary of the thesis

1. We built a plasma diagnostic system which is unique in ECR ion sources [1]. The system contains:
   - a movable, cylindrically shaped (3 mm length, 0.4 mm diameter) electrostatic probe, made of tungsten.
   - a mechanism to push and rotate the probe independently; in consequence, the probe can reach on-line, the surface of a given radius cylinder; changing of the radius can be made off-line, changing or resizing the probe.
   - a special bipolar power supply capable of biasing the probe on positive and negative voltages either, and enable smooth transitions between these two voltage region.

2. Starting from the analysis of the plasma sheath, which is formed as a consequence of the plasma-wall interaction, I established a new theoretical model for the probe voltage-current characteristics evaluation [1]. The model supplements the deficiency of the available theoretical models, namely that it takes into account multiply charged ions. For plasma parameter determination, the ion-current region of the characteristics can be used. In this region multiply charge ions of different elements are collected, hence it can be evaluated correctly only using the new theoretical model. Two cases can be distinguished:

- SCMC (Single-Component Multiply Charged approximation) – assumes clean ECR plasma containing only the ions of the main gas
- MCMC (Multi-Component Multiply Charged approximation) – assumes real ECR plasma containing the residual gas and/or mixing-gas ion, too.

3. We used simultaneously the Langmuir-probe and a movable crucible to test the ability of the probe as on-line diagnostic tool. We investigated *Zn* plasma production using a plasma-heated crucible, which prepared the way for further metallic plasma and fullerene experiments [2]. The moment when the crucible reached the melting temperature of the metal was set to be established. That moment is well signaled by the apparition of the metal ions in the plasma. We concluded from the evolution of the probe voltage-current characteristics, that on-line monitoring of the probe current in the ion or electron saturation current region is appropriate for displaying the above mentioned phenomenon [3].

4. The diagnostic measurements carried out at the 14 GHz Frankfurt-ECRIS have shown, that the most important feature of the biased-disk operation is the modification of the potential distribution

of the plasma caused by the bias of the probe. This way the probe creates favorable ion extraction conditions. This effect can be attributed to the adjustment of the axial electron loss of the plasma by repelling them back toward the hot plasma regions [4].

5. The Langmuir-probe has been applied for the first time ever to diagnose the hot plasma regions of an ECR ion source. The measurements were carried out at the 14.5 Ghz ATOMKI-ECRIS. I measured probe voltage-current characteristics successfully, without burning the probe or it insulation. The shape of the curves were totally different from the usual ones, and were reproducible. They present a pronounced minimum in the ion current region (of the order of mA's, which is 3 order of magnitude higher than the ion saturation current measured in the cold region of the plasma). A qualitative explanation of the curves has been given.

6. Profiting of the possibilities given by the grades of freedom of the probe, I measured diverse series of probe characteristics and calculated the corresponding electron density profiles. All measurements were carried out in the cold regions of the ECR plasma.

a) Asimuthal electron density profiles measured in low charged plasma.

- The probe holder has been put on the axes of the source, hence its sensitive area could be rotated on a circle around the source axes. The electron density has been measured in one of the branches of the injection side star (due to the circular symmetry of the system, the density in the other branches of the star is expected to be the same). It can be stated that plasma can be found within the branches of the star and the electron density increases by approximately one order of magnitude from the edges of the star toward the middle of it (n_{edge}~10^{10}el/cm^3, n_{middle}~10^{11}el/cm^3) [1].
- Starting from a point which is far away from the resonant zone, the electron density has been measured using the above described way in many axial planes. All planes presented the same electron density distribution as described above, however, increases the angular region where the branches of the star are located and the maximal electron density reached in the middle of a branch increases also. This is the first direct electron density distribution measurement carried out in an ECR plasma.

b) Axial electron density profiles measured in low and middle-charged plasmas.

- The holder of the probe has been put off-axes, while the sensitive area of it was on the axes of the ion source. Electron density distributions have been measured in different plasmas, moving the probe on the axes of the source. Each axial profile presented the same tendency: the electron density increases as the probe approaches to the resonant zone. The increase is also one order of magnitude [1,5]

- The electron densities have been calculated using three models: the simple plasma model available in the special literature and the SCMC and MCMC models mentioned in the section 3. It can be stated, that as the mean charge of the plasma ion component is getting higher (which increases when higher charge states are optimized for extraction), the difference between the original simple plasma model and the MCMC (or SCMC) is getting higher either (optimized charge states 1+, 3+, 5+ and 8+, electron density increases with a factor of 1.11, 1.55, 1.77 and 2.77, respectively). Using MCMC, higher electron densities has been obtained comparing to the simple plasma model, which is reasonable, because increasing mean charge of the plasma ion component means more negative electrons for quasineutrality to be maintained. This means for realistic plasma investigation MCMC model can and must be used [1,5].
- Voltage-current characteristics has been measured in the cold plasma region, when the biase-disk was On and Off, respectively. The aim of the experiment was to determine the effect of the biased-disk on the cold plasma regions. Calculating the electron densities using the simple and the MCMC models, I found that switching On/Off the probe voltage results an increase/decrease not higher than the error limit of the calculation method. One can conclude that application of a biased electrode doesn't increase the electron density of the cold plasma region (which is connected to the hot plasma region). The emitted electrons are quickly lost on the wall of the chamber, meanwhile probably the depth of the plasma potential dip is modified, which influences the ion lifetime and extraction conditions [5].

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