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ELECTRODEPOSITION OF RHENIUM ON TUNGSTEN HOT PLATE USED IN Q-PLASMA SOURCE

P.J. Paris

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Centre de Recherches en Physique des Plasmas
Association Euratom - Confédération Suisse
Ecole Polytechnique Fédérale de Lausanne
21, Av. des Bains, 1007 Lausanne-Switzerland

This brief note describes divers aspects of the technique used for rhenium plating the hot plate used for contact ionization of barium in a Q-plasma source.

The rhenium plating optimizes the probability of barium ionization. Special care has to be taken in order to deposit a uniform layer of rhenium, for this purpose a slow rotation is given to the plate during deposition.

In order to obtain a uniform radial plasma density profile in barium plasmas, special care is taken for best neutral atomic beam illumination of the hot plate, hot plate temperature uniformity is maintained by uniform electron flux from cathode and the work function of the hot plate ionizing material is made as near as possible to the ionization potential of barium.

The barium, whose melting point is 725°C, is vaporized in an oven and directed to the hot plate through a heated pipe which is terminated by a circular effuser used to spray uniformly the metallic barium vapor. The distance of the effuser slit to the hot plate is very important and the optimum distance was worked out (Fig. 1).

A conventional tungsten hot plate (work function = 4.52eV) is improved by rhenium plating (work function = 4.8 : 5.1eV) in order to increase the probability of ionizing barium (ionization potential = 5.21eV).

Very often the rhenium coating is made by evaporation of a rhenium slurry on the tungsten plate. This is not always possible to realize because of installation requirements. K.R. Stalder [1] reported on electrodeposition of rhenium for Q machine hot plates, we propose to mainly follow his procedure, with two additions. We introduce rotation of the hot plate during operation for achievement of more uniform layer deposition (Fig. 2), and the deposition time is lengthened.

I THE ELECTROLYTIC SOLUTION

The rhenium plating baths consist generally of aqueous solutions of potassium or ammonium perrhenates which differ in their content of various acid and salt additives. The solution is highly acidic [ph 1 $^{+}$1,5] and should be employed cautiously and under a ventilated hood.

To make 500ml of solution, one should follow the recipe as mentioned below :

a.- 5.0g of potassium perrhenate (K Re O_4) in 125ml of distilled water. This has to be heated up gently in order to dissolve the crystals.

b.- 3.35g of magnesium sulfate (Mg SO_4) in 125ml of distilled water.

c.- 13.5g of sulfanic acid (H_2 NSO_3H) in 125ml of distilled water.

d.- 12.5g of ammonium sulfate ($(NH_4)_2$ SO_4) in 125ml of distilled water.

All chemicals are dissolved in glass flasks, then they are mixed together in a glass flask which is hermetically closed to reduce the evaporation of the acidic solution. This solution contains Re^{+7} ions.

II THE PLATING PROCEDURE

1. Clean the tungsten hot plate (which is e-beam welded on a tantalum can) in a 5% concentration of boiling sodium hypochlorite - near to

standard commercial grade - for 10' to 15' minutes. This will be repeated until the aspect of the tungsten surface is uniform.

2. Rinse the tungsten plate in an ultrasonic bath of distilled water.

3. Prepare the solution in a glass beaker with magnetic stirrers; to dissolve the precipitate, heat the solution to 60°C - 80°C.

4. Place the hot plate and the rhenium electrode in the solution as shown in Figure 1(a). Then connect the hot plate (-) and the rhenium foil (+) to a stabilized DC power supply. Turn the driving motor on with low speed, 0,05 ÷ 1 turn per minute, so the plate rotates without making any turbulence in the electrolytic bath. The plating is done with 1 ÷ 2 volts and 0,1 ÷ 0,3A during 2 to 3 hours.

   The stirrers should remove gently the bubbles in order to plate uniformly. Also the hot plate is kept inclined and one should rotate it many times to get a uniform layer deposition.

   The foil of rhenium is 20mm x 20mm and 0.25mm thickness; for plating $1 cm^2$ with 1μ thickness of Re, 0.28mg of Re is needed.

   During plating, the surface becomes black. Nota Bene : if necessary, reverse current for few seconds to remove ruggedness of nonuniform plating.

5. Rinse hot plate under a gentle flow of distilled water, because the rhenium layer is still not well fixed.

6. Rinse rhenium foil with distilled water and keep in an oven at 50÷60°C.

7. Dry hot plate in the oven at 50°C : 60°C for one hour or until it is to be installed on the gun. Humid air would peal off the rhenium because of inclusion of tiny droplets of condensed water.

8. Install the hot plate on the gun, proceed by slowly outgassing under vacuum and heat up to normal operation temperature.

   This firing of the gun, finally will stabilize the plating on the tungsten disc, and therefore it will not be affected anymore by humid air when released in atmosphere. The colour, then, becomes silvery.

III CONCLUSION

This rhenium layers have shown good reliability over 5 to 8 months of full operation of the Q source in the LMP [2]. A density radial profile taken by laser induced fluorescence is shown on Fig. 3. Our precedure is different from the one used by K.R. Stalder in the sense that the thickness of the rhenium layer is much larger in our case, so working time is more relevant with the LMP Q-source. Also the layer is stable and uniformly deposited because of the rotation of the hot plate during processing.

References

[1] K.R. Stalder, "Electrodeposition of Rhenium for Q-machine hot Plates", Internal note of University of California at Irvine, Plasma Physics Group

[2] P.J. Paris and N. Rynn, "The LMP-Q, an improvement Barium plasma Q-machine" submitted for publication to Review of Scientific Instruments

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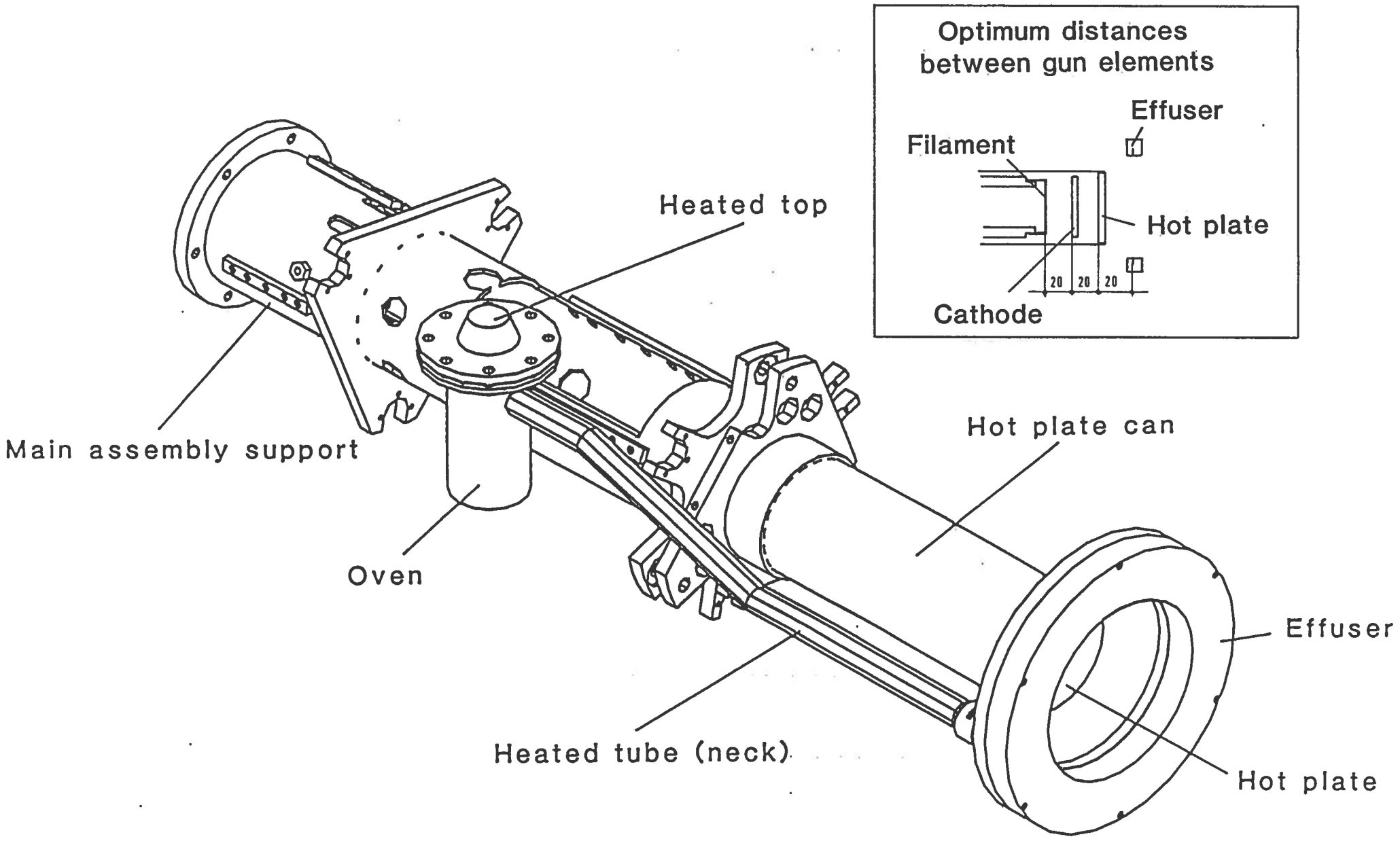

3D presentation of the gun with vaporizing barium subsystem

Fig. 1

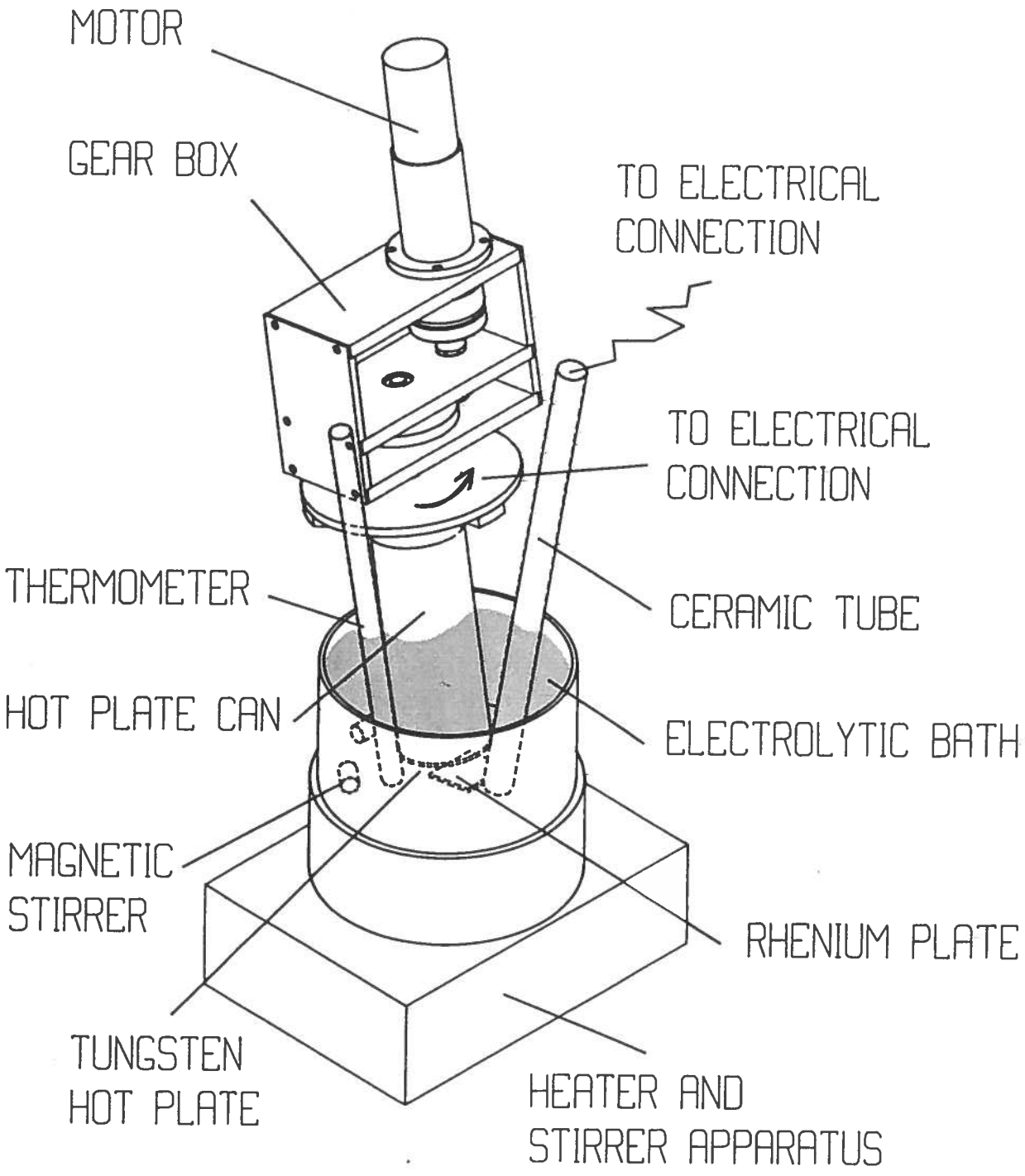

Fig. 2

RHENIUM PLATING SET UP

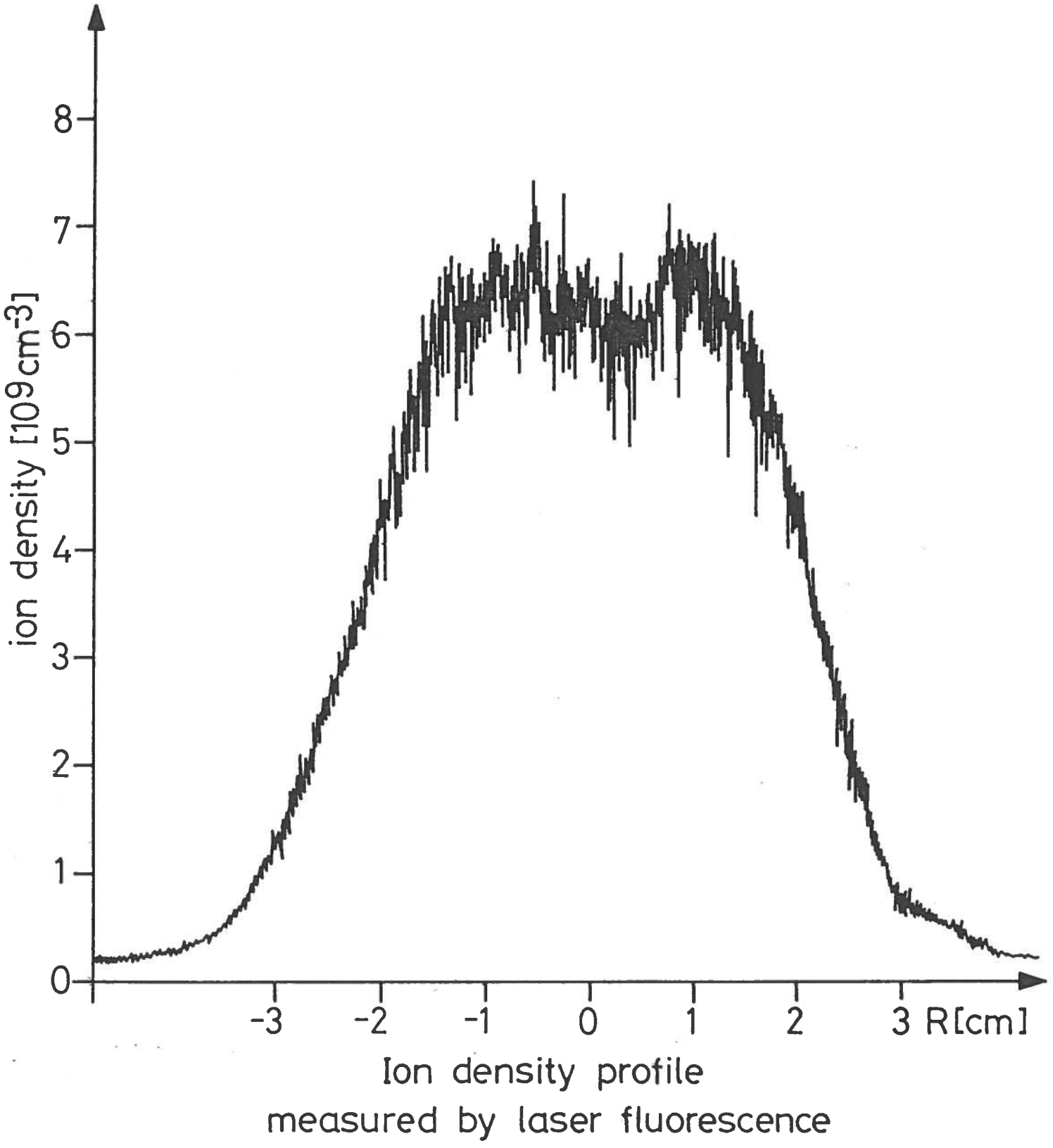
ion density [10⁹cm⁻³]
8
7
6
5
4
3
2
1
0
-3
-2
-1
0
1
2
3 R[cm]
Ion density profile
measured by laser fluorescence

Fig. 3