POSITIVE COLUMN CONSTRICTION IN CESIUM PLASMA DISCHARGE

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A lot of papers were published by different authors on positive column with the purpose to explain the constriction phenomena.

There are many proposed mechanisms to explain surprisingly well one and the same phenomenon - the positive column constriction.

One of the most popular explanation of the constriction is the inhomogeneous heating of the gas in the discharge tube, with the subsequent change in the radial charge density distribution /1/.

This thermal effect is considered in /2/ to be not important.Indeed,the measured pressure at which the column constriction appears for various noble gases is smaller for pulsed discharge than for the steady discharge,in spite of the fact that the thermal effects are smaller in the former.

In a previous paper /3/ we have theoretically considered the possible contribution of the atomic to molecular ion conversion process,on the radial charge density distribution in the positive column. According to our paper,due to the higher mobility of the molecular ions than that of atomic ones,the radial charge density decreases faster than Schottky distribution.The solution for the distribution of the radial charge density n,is:

$$n=n_0\left[J_0(\varrho)+\frac{2\gamma}{\beta\delta}J_2(\varrho)+\frac{1}{2}\left(\frac{2\gamma}{\beta\delta}\right)^2 J_4(\varrho)+\dots\right] \quad (1)$$

which is a fast convergent series for small values of the coefficient $2\gamma/\beta\delta$.In eq.1,n_0 is the charge density at the positive column axis,r is the radial distance from the axis and $\varrho=\delta^{1/2}.r$.Coefficients β, γ and δ are given by the relations:

$$\beta=e(\mu_e D_{p_1}+\mu_{p_1}D_e)/(\mu_e+\mu_{p_1})$$

$$\gamma=e\alpha\left[\mu_e/(\mu_e+\mu_{p_1})\right]\left[D_{p_2}-D_{p_1}\right]/D_{p_2}$$

$$\delta=\beta^{-1}(e\nu_i-\gamma)$$

where μ and D are the mobility and the diffusion coefficient,respectively,indices e,p_1 and p_2 reffering to the values concerning electrons,atomic and molecular ions,respectively.The conversion frequency α is defined as $\alpha=k_cN^2$,where N is the neutral atoms density and k_c the transformation coefficient of atomic ions into molecular ions.The parameter ν_i is the ionization frequency for atomic ions.

The conversion effect is strongly dependent on the cesium pressure and is described by the equation:

$$\frac{dN^+_{mol}}{dt}=k_cN^+_{at}N^2_{at} \quad (2)$$

where N^+_{at},N^+_{mol} and N_{at} are respectively the densities of the atomic ions,molecular ions and neutral atoms.

In the TABLE I the values of k_c for some gases and vapours are given /4/.

TABLE I

	k_c $(10^{-31}cm^6/s)$	p_c (torr)	$k_c\sqrt{p_c}$
He	.9	100	9.0
Ne	.7	75	6.0
Ar	2.0	13.5	7.34
Kr	2.7	9.0	8.1
Xe	3.6	5.0	8.0
Cs	150.0	$2.8x10^{-2}$	

with p_c the pressure above which the constriction appears,its values being taken from /2/.

We can introduce now the empirical coefficient $C=k_c\sqrt{p_c}$,which can be considered as a constant of the positive column constriction phenomena.Indeed,C has practically the same value for all gases considered. Using the value of C=8.0 and taking into account the value of k_c for cesium vapours, we computed the value of the expected cesium vapour pressure for the positive column constriction.

This expected value for cesium is: $k_c=2.8\times10^{-2}$ torr.

EXPERIMENTAL SET-UP AND RESULTS.

The experimental device is shown schematically in Fig.1. The cathode is a moli-

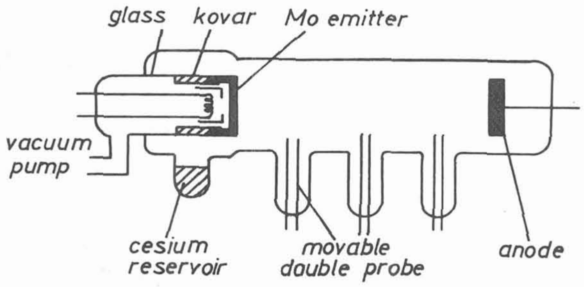

Fig.1. The experimental device

bdenum disc of 25 mm diameter heated by electron bombardment. The cathode is surrounded by a ceramic insulator, except the front planar surface. The anode is a stainless-steel disc at a distance of 300 mm from the cathode. The experimental tube is provided with a number of movable double probes. The positions of the probes were measured optically from the distance of 1.5 m from the tube.

The whole device is mounted inside an oven, which insures the necessary temperature to obtain the needed cesium vapour pressure.

In Fig.2 are given some of the obtained values for the normalized charge density versus the normalized distance r/R from the axis of the tube (where R is the radius of the tube). The charge density at the axis is n_o. The experimental points were taken for two values of the cesium pressure: $p_1=2.8\times10^{-2}$ and $p_2=9\times10^{-2}$ torr, corresponding to the temperature of the cesium reservoir of 175 and 240°C, respectively. On the same figure are given two more curves: the Schottky curve and the computed curve for the radial charge density distribution using the equation inferred by us in /3/, but for a small conversion coef-

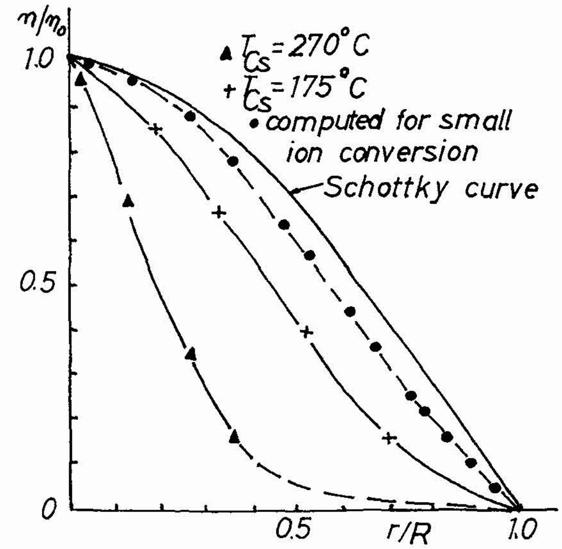

Fig.2. The normalized charge density versus the normalized distance r/R.

ficient (low pressure of the cesium vapour).

The obtained results can be compared with the value obtained for $p_{c(Cesium)}$, according to the empirical relation $C=k_c\sqrt{p_c}$. The agreement is quite good.

We may conclude that, as it has been poited out in our previous paper too, the ion conversion effect has to be taken into account in the explanation of the positive column constriction.

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