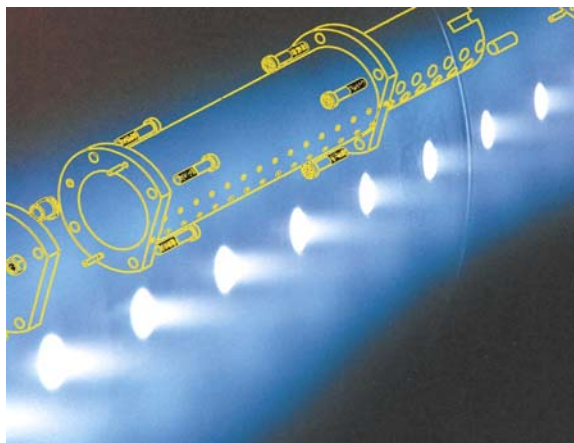


13.56 MHz Hollow Cathode Plasma Source HCD-L 300



General Principle

Hollow Cathode Discharges (HCD) represent a very effective and yet comparatively simple, low cost effective means of high density, low temperature plasma generation.

The Hollow Cathode Effect

Consider two parallel metallic plates in a vacuum chamber filled with a low-pressure gas. For a given plate separation d and pressure p there exists an optimum product $d \times p$ such that the plasma ignition voltage (or power) becomes minimum (so-called **Paschen-Law**). This voltage is applied to the two plates one of which is usually grounded (often being the vacuum chamber wall). A plasma excited in such a way has a comparatively low density being insufficient for advanced plasma processing.

If the negatively biased electrode is formed as a cavity or cylindrical cathode structure the conservation of particles and photons leads to a drastically increased ionisation and/or emission.

To understand the working principle it is in order to look a little closer to the underlying physics. Usually the so-called plasma potential is the most positive of the whole set-up including the vacuum chamber walls.

As a consequence the negatively charged electrons tend to be confined to the plasma. To be more precise, this holds only for the lower energy electron population representing a substantial fraction of all electrons.

In the case of a hollow cathode a negatively biased cavity or cylindrical tube encloses the plasma. Electrons within this plasma are constantly being repelled when approaching the hollow cathode walls: An oscillatory motion of the electrons results yielding greatly improved ionisation rates and thereby higher plasma densities (Fig. 1).

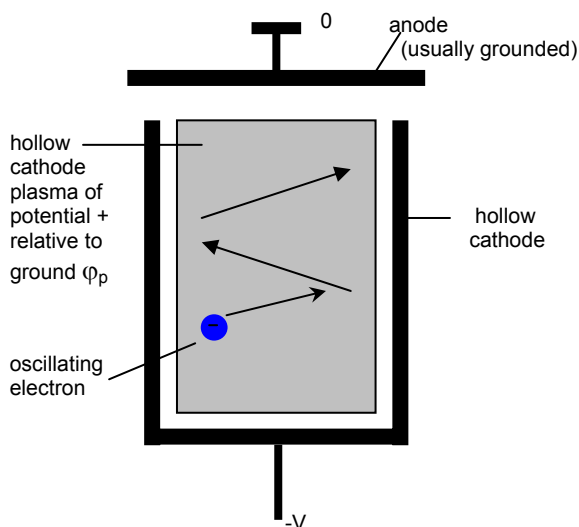


Fig. 1: Principle of a dc-hollow cathode discharge

The discharge is driven by direct current (dc). In the remote plasma processing mode the hollow cathode plasma shown is often referred to as the "primary plasma".

To avoid detrimental charge-up effects of the anode and cathode walls due to unwanted deposition and/or oxidation medium frequency or rf-plasma excitation is preferred. Here the frequency of 13.56 MHz plays an important role with respect to improved performance and higher plasma densities achievable.

The 13.56 MHz rf-plasma source **HCD-L** meets these requirements.

HCD: hollow cathode discharge

Fig.1 relates to a dc-hollow cathode discharge. The dc-power coupling works very well when using only chemically non reactive gases such as argon (Ar) or helium (He). However, the addition of film forming monomers possibly blocks the dc-current flow after a thin, electrically non-conducting polymer film forms on one of the source electrodes. As a consequence, the dc discharge may be extinct. RF excited discharges are much more insensitive to these unwanted contaminations. Furthermore, due to the specific capacitive coupling used a well balanced and symmetric power flow is guaranteed for each individual plasma jet.

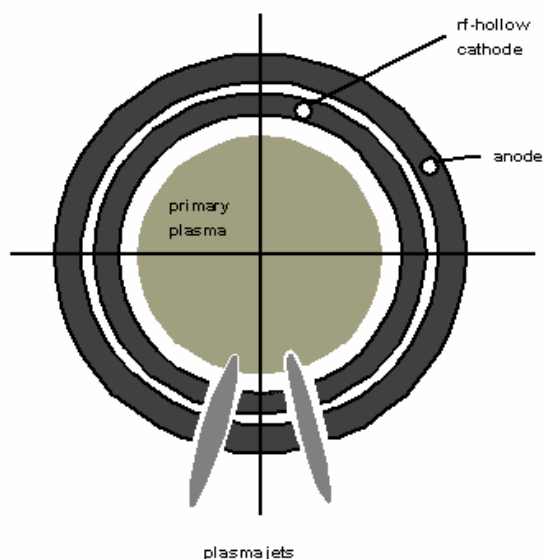


Fig.2: Schematic cross section through a HCD-L

Shown are two cylindrical tubes aligned coaxially. The inner tube is rf-powered enclosing the primary plasma; the outer tube is electrically grounded. Two rows of holes are arranged along the cylinder axis forming the high intensity primary plasma jets consisting of ions, electrons and excited species.

Concept of the HCD-L

The plasma source **HCD-L** employs the hollow cathode effect as described above. Basically the **HCD-L** is of cylindrical symmetry featuring two aluminum cylinders of different diameters. These cylinders are inserted into each other and aligned coaxially (Fig. 2).

Both cylinders are electrically isolated from each other. The inner cylinder is connected to the rf-power generator; the outer cylinder is grounded. Along the cylindrical axis multiple holes are drilled into the inner and outer cylinder allowing plasma jets to be extracted after the primary plasma has been excited in the hollow cathode. A proprietary internal cathode structure guarantees a homogenous jet formation over extended source lengths.

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