Hydrogen Production

Plasma reforming of hydrocarbons

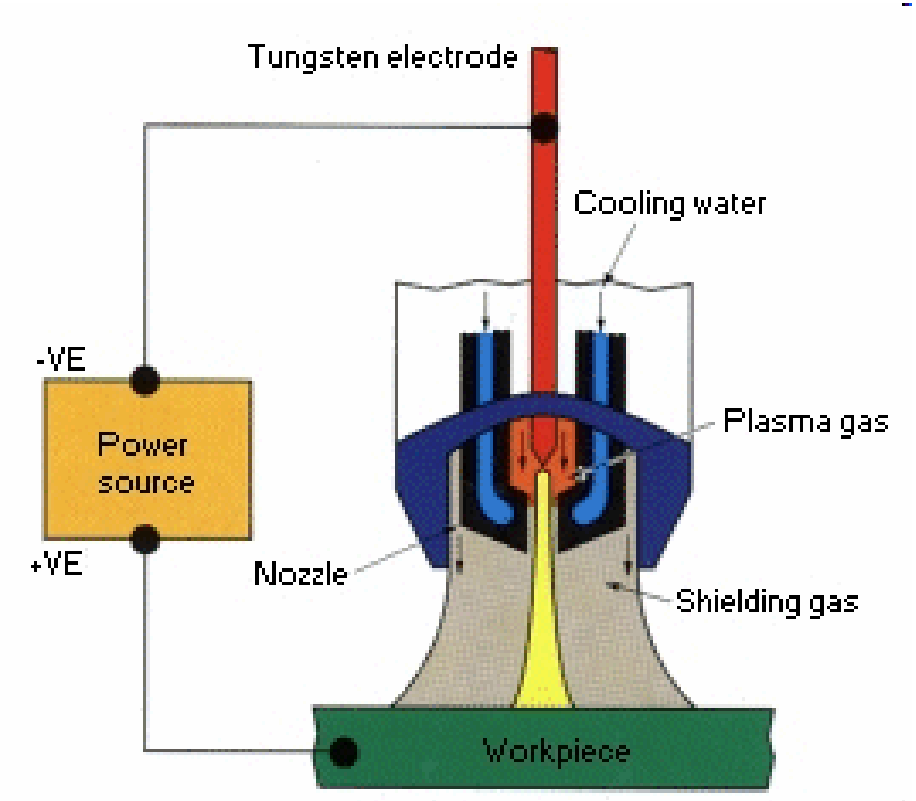
- Plasmatron
- Gliding arc
- Dielectric barrier discharge (DBD)
- Corona
- Microwave
- Pulsed discharge

Plasma as a Discharge

Many types of discharge

- Arc discharge (high pressure, high current, low voltage)
- Glow discharge (low P, medium C, medium V)
- Corona discharge (high P, low C, high V)

Arc Discharge



Corona Discharge in Chemistry

1. Surface modification
2. Introduction (grafting) of functional group
3. Adhesion
4. Surface Hardening and Wear Resistance
5. Reforming

…

What's a Corona Discharge

1. A field induced discharge at high pressure (ambient or higher)

2. Belongs to the broad range of high pressure discharge

3. Many different subcategories:
   Positive corona
   Negative corona
   AC corona
   Double dielectric barrier (DBD)
   Liquid phase (underwater) corona

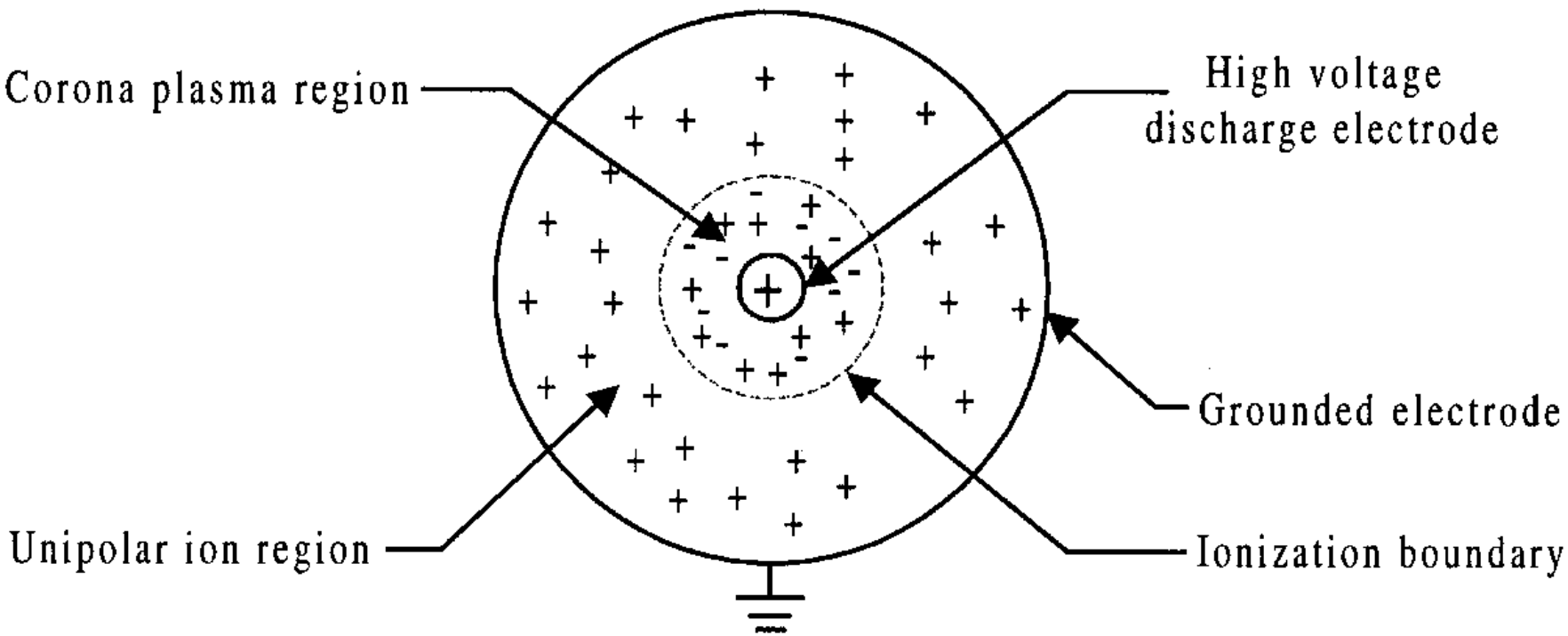
Corona Discharge: General Properties

1. Very low ionization fraction (10^{-8} or lower)

2. Electron density on the ***rough*** order of $10^{12}cm^{-3}$, give or take a few orders of magnitude, i.e., negative corona versus positive corona.

3. Highly non-equilibrium so a M-B distribution is not readily defined

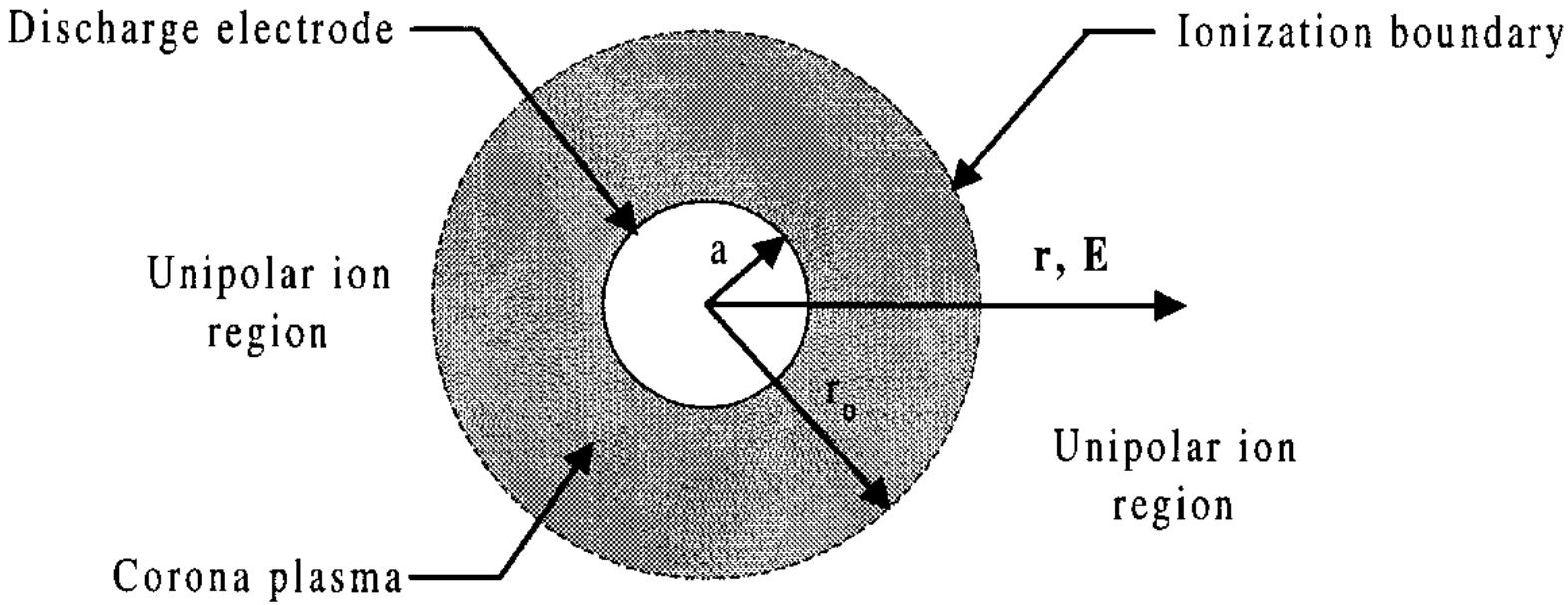
Corona Discharge: in Details



Positive dc corona discharge

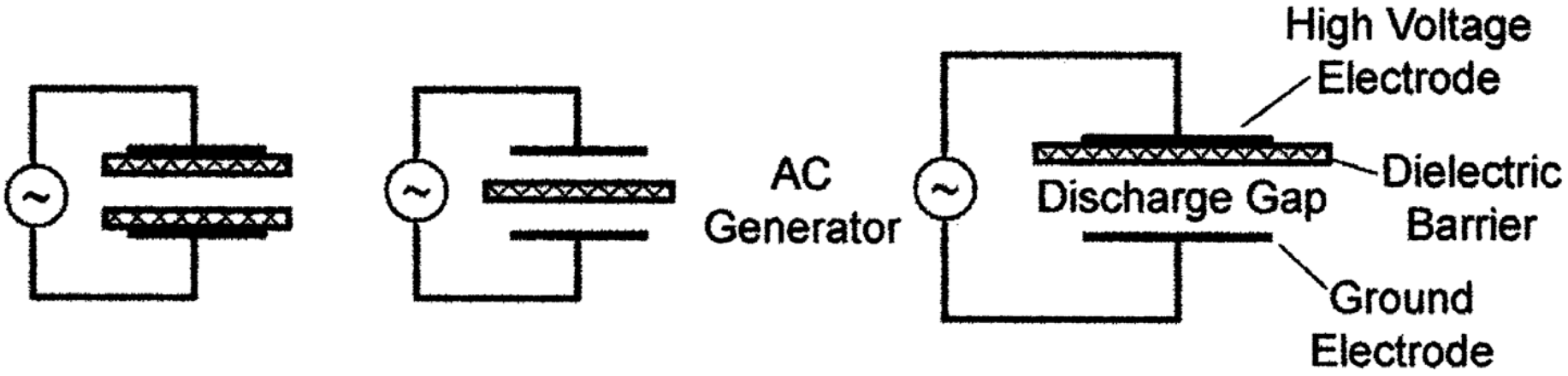
Quasi-Neutrality?

Corona Discharge: in Details

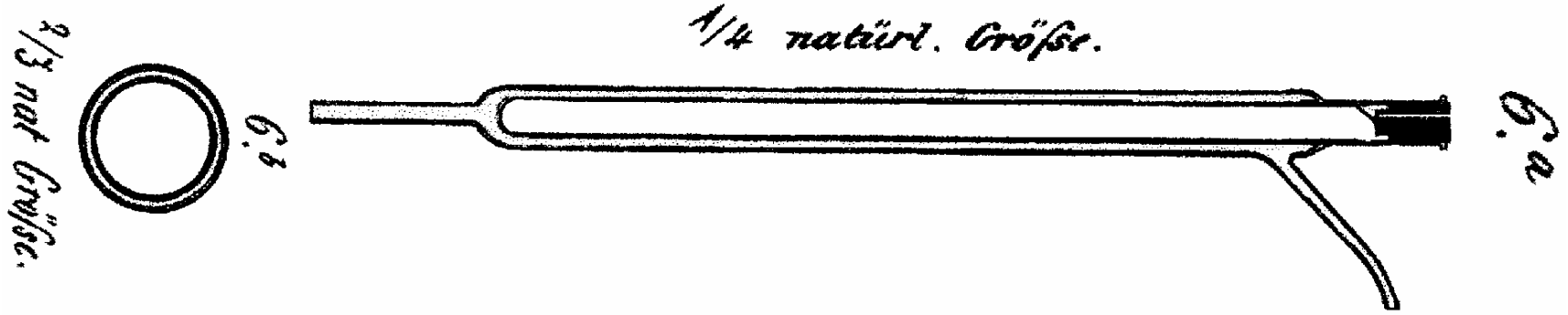


1. Corona plasma extends a short distance (2 to 10 wire radii)
2. The unipolar region is not a plasma rigorously

Dielectric Barrier Discharge (DBD)



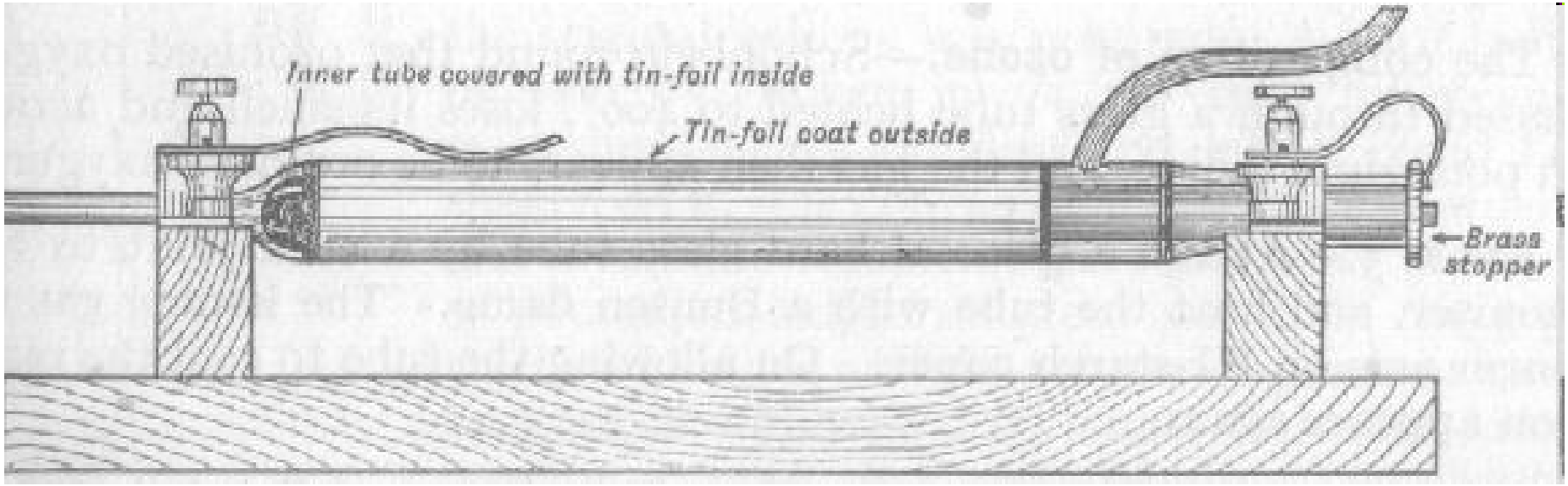
DBD, a bit of history



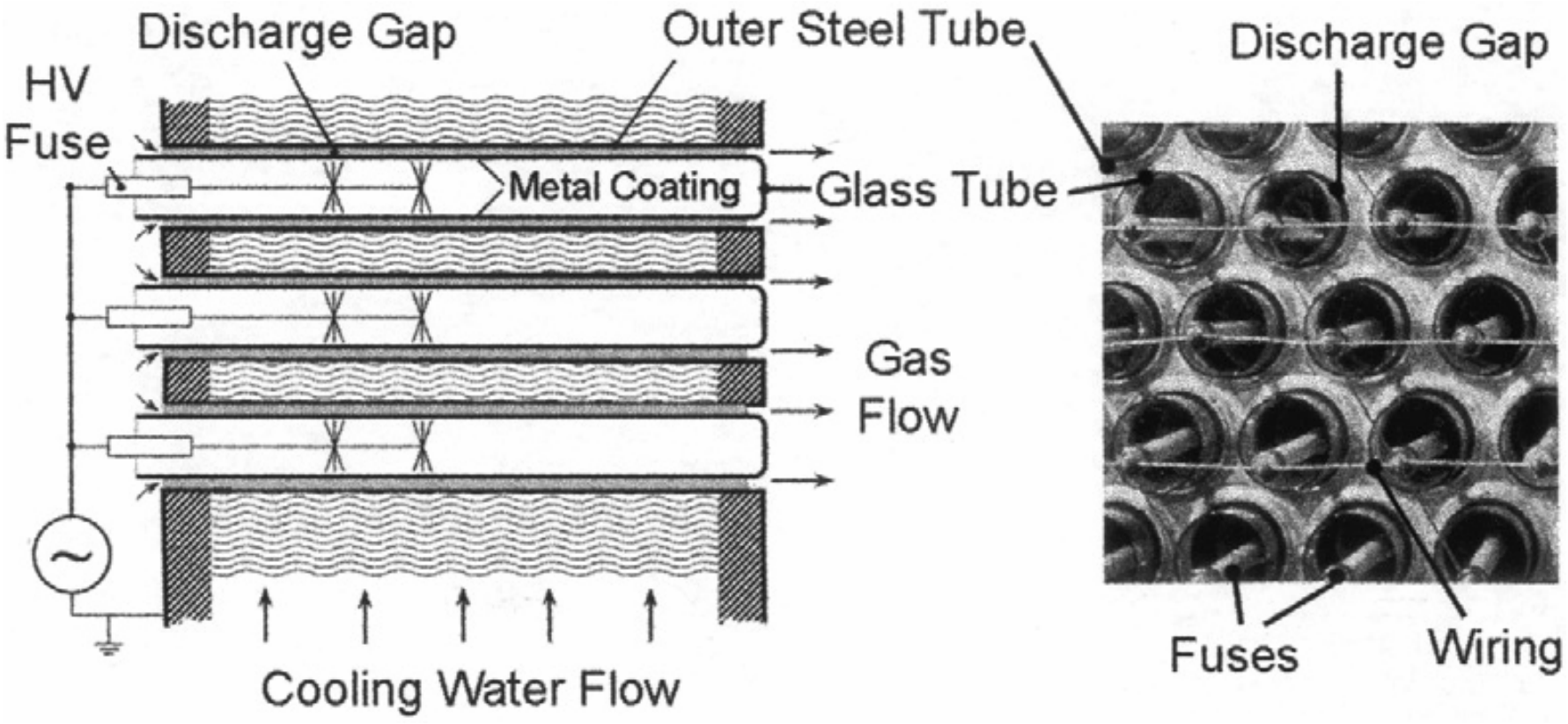
Werner von Siemens' Ozone Generator

Siemens' Ozone Generator

A bit of detail



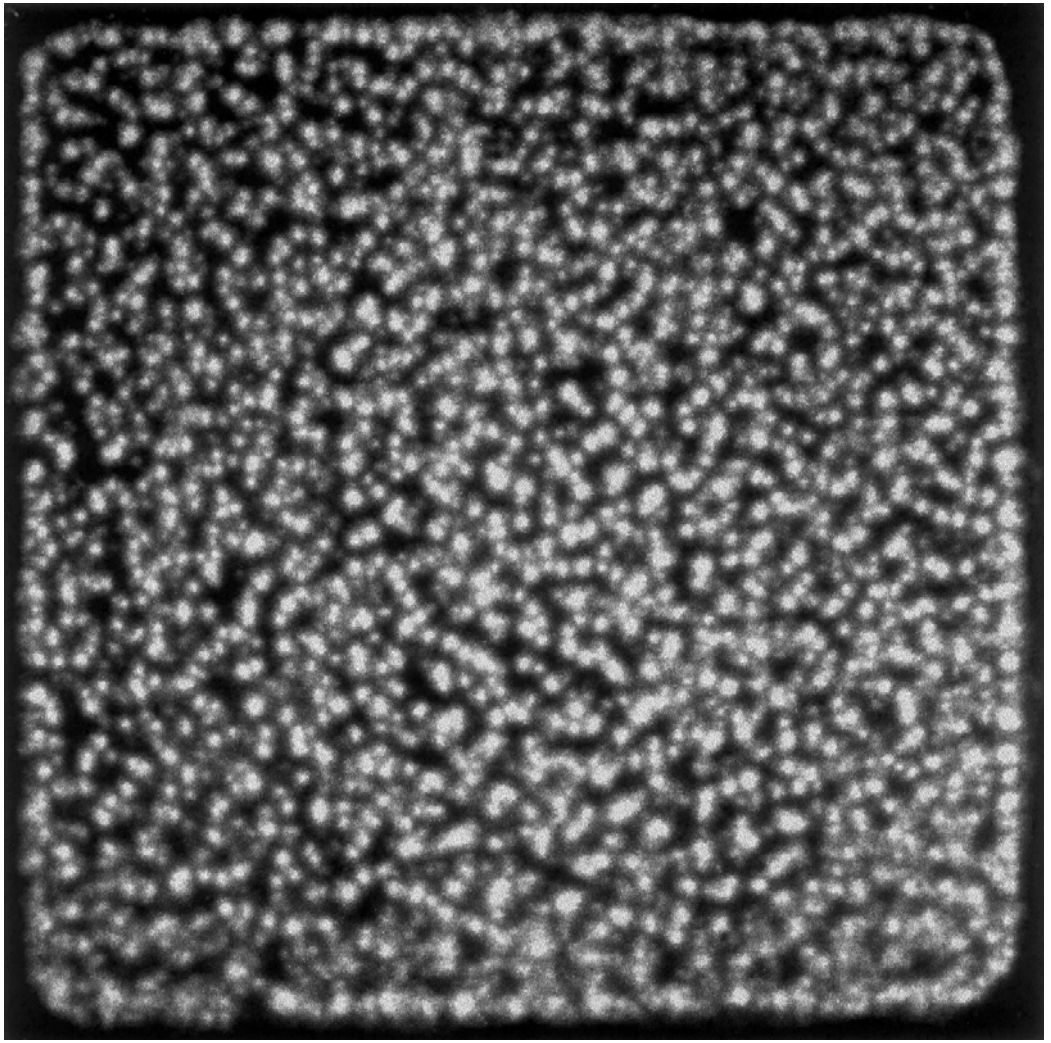
Modern Ozone Generator



Microdischarge

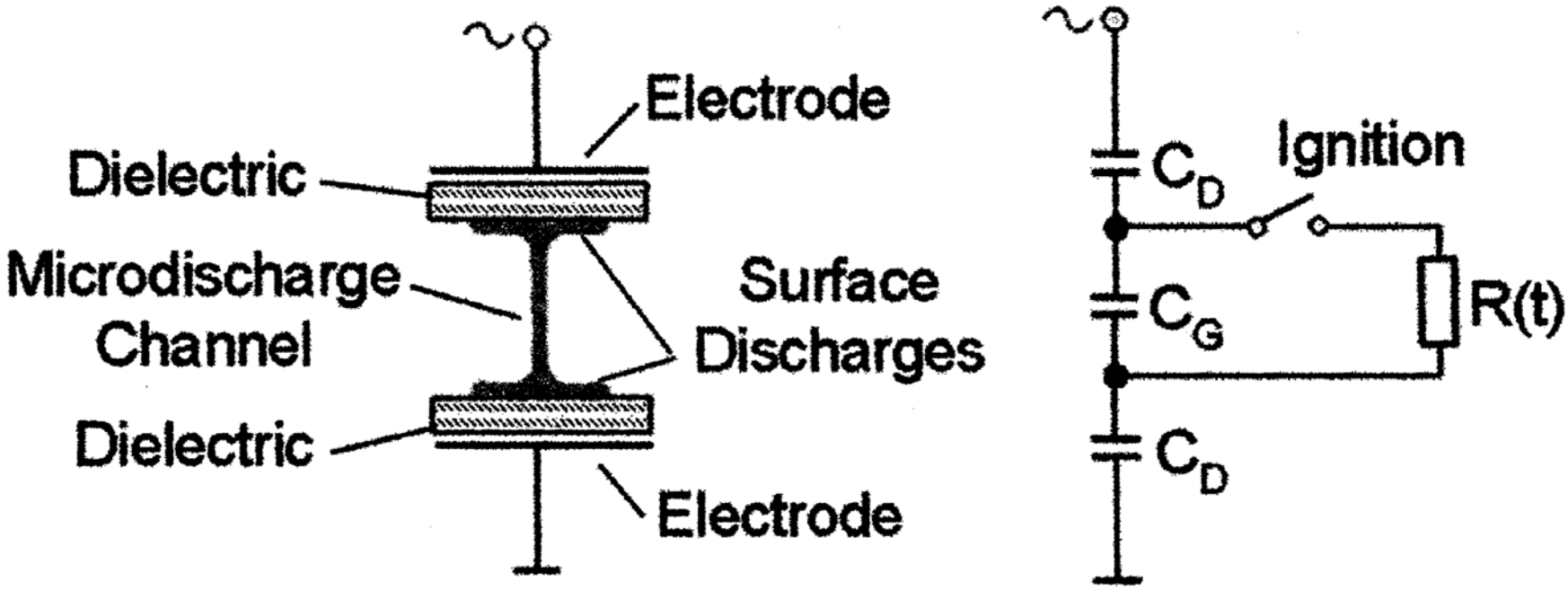
End-on view of microdischarges in atmospheric-pressure air

Size:
6 cm X 6 cm



Microdischarge (MD)

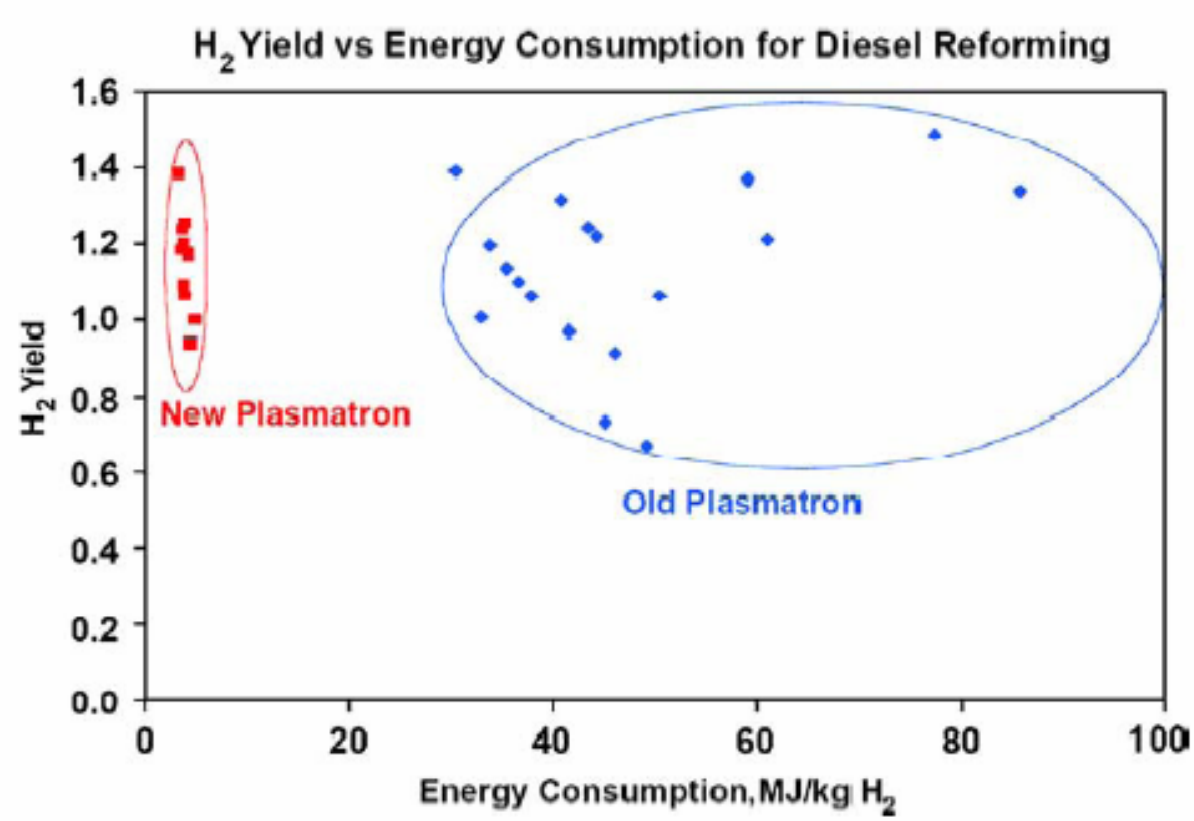
MD is an arc in tiny size



Plasma as a catalyst

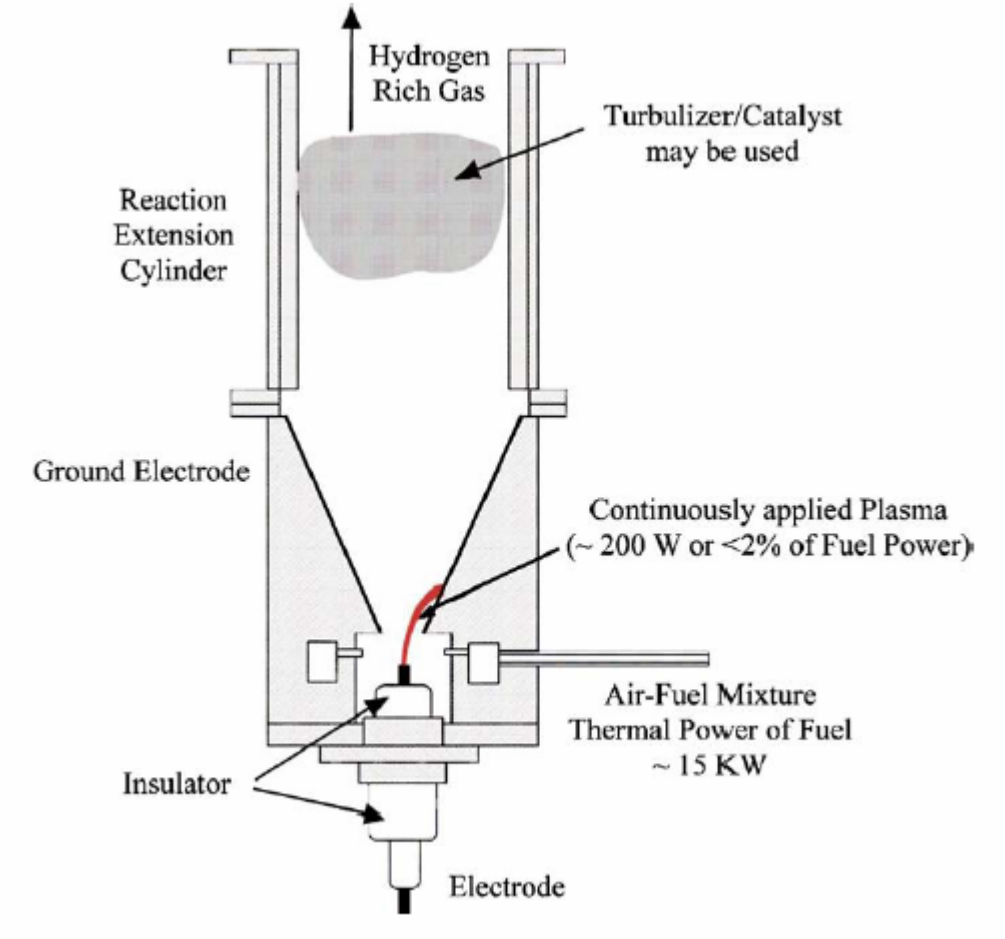
1) Thermal plasma (electrons are as hot as ions)

2) Non-thermal plasma (electrons are hotter)

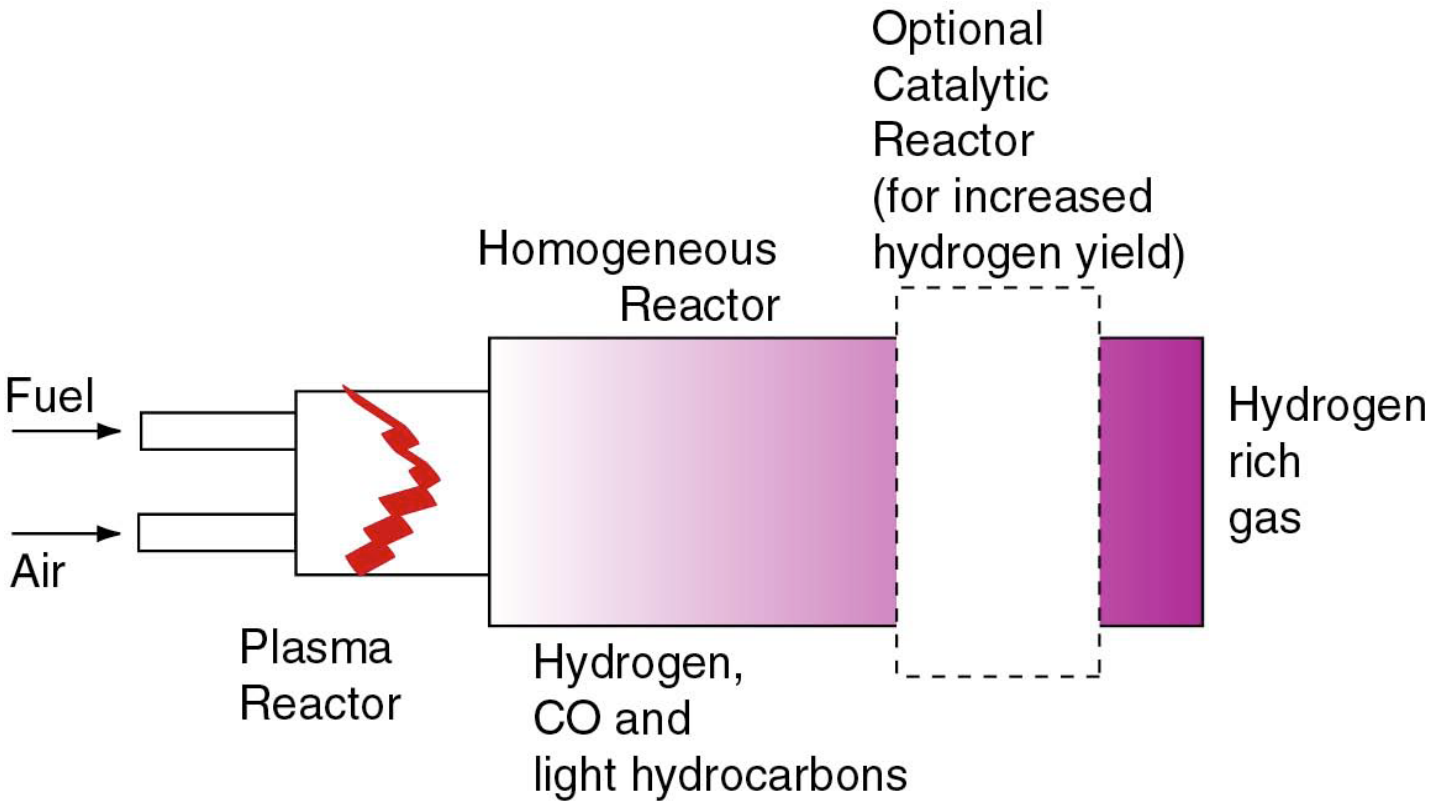


Plasmatron reforming

- Plasmatron: An arc discharging device



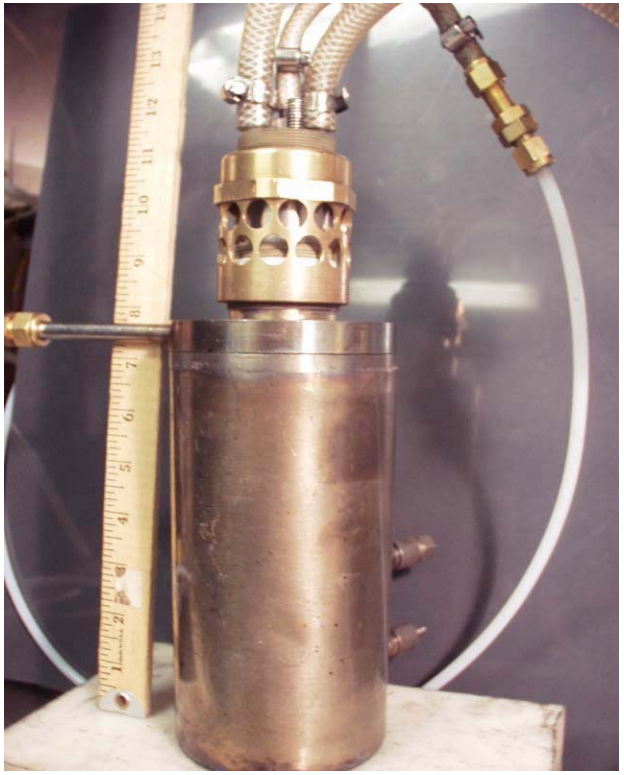
Plasmatron reforming

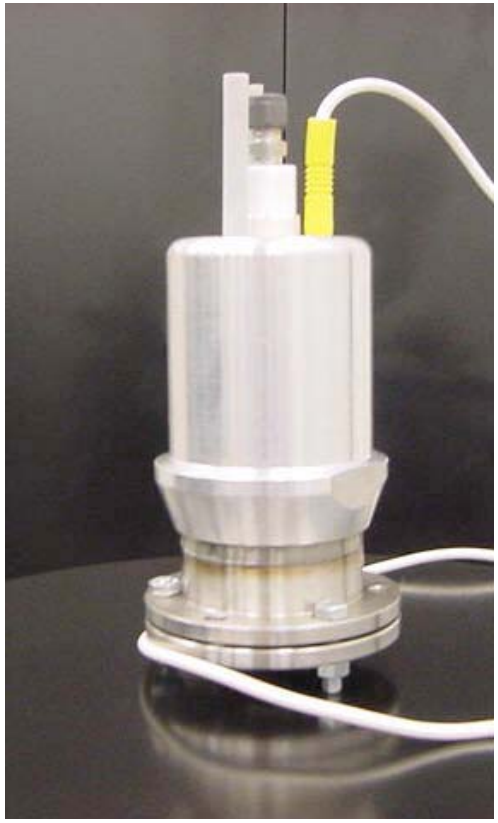


Principle of operation

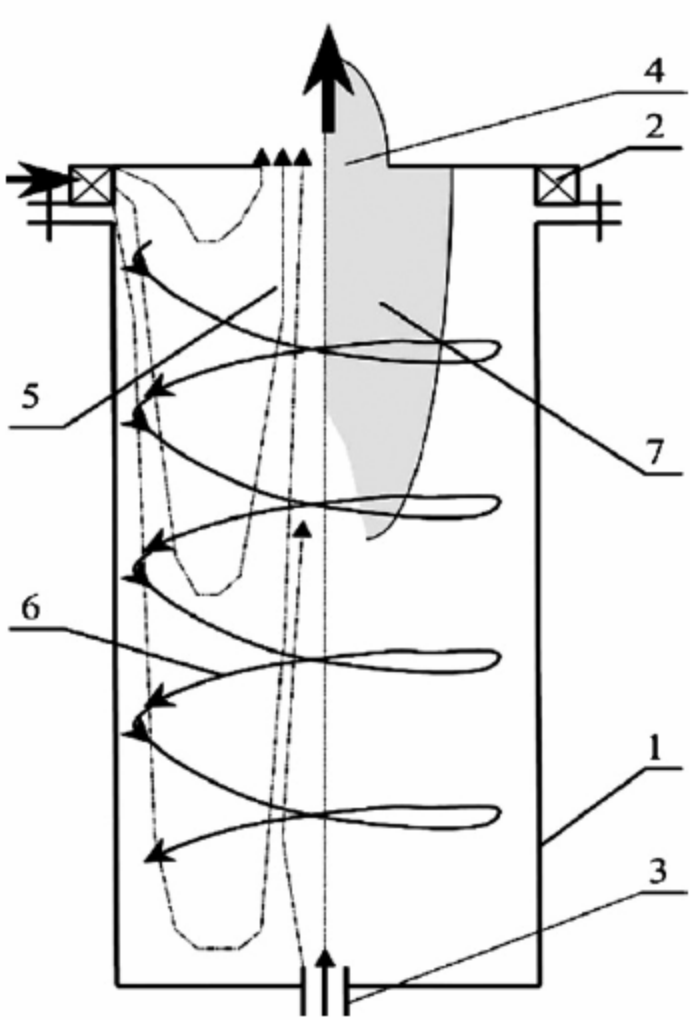
Plasmatron reforming

- Real device





Gliding arc discharge



3. GAT reactor principle (University of Illinois, USA)

Combination of vortex motion and arc discharge, sort of like a cyclone widely used in ChE

Gliding arc discharge, variations

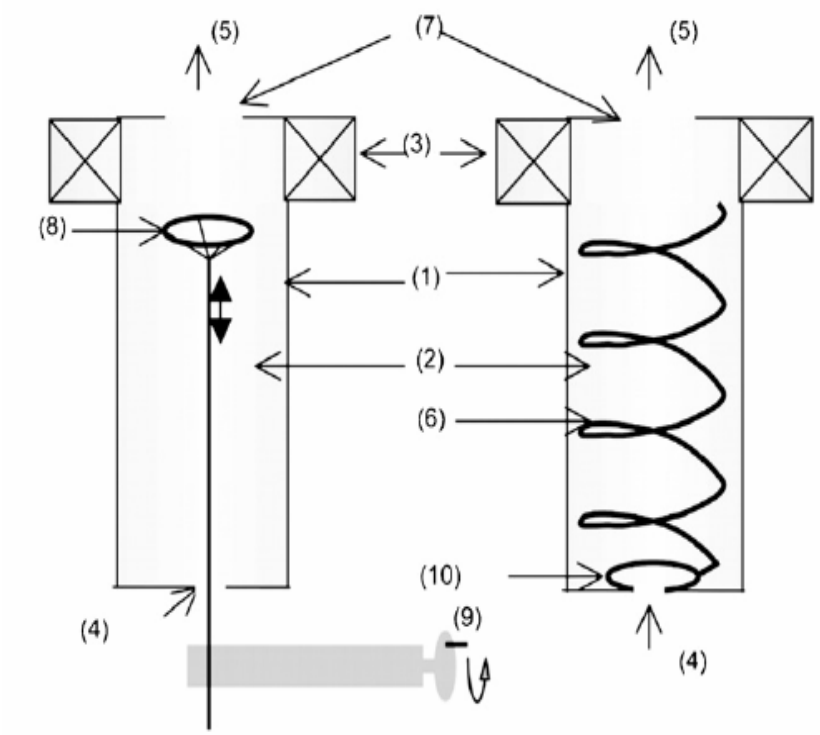


Fig. 4. Reverse vortex reactor design for GAT stabilization: (a) movable ring electrode and (b) spiral configurations [7].

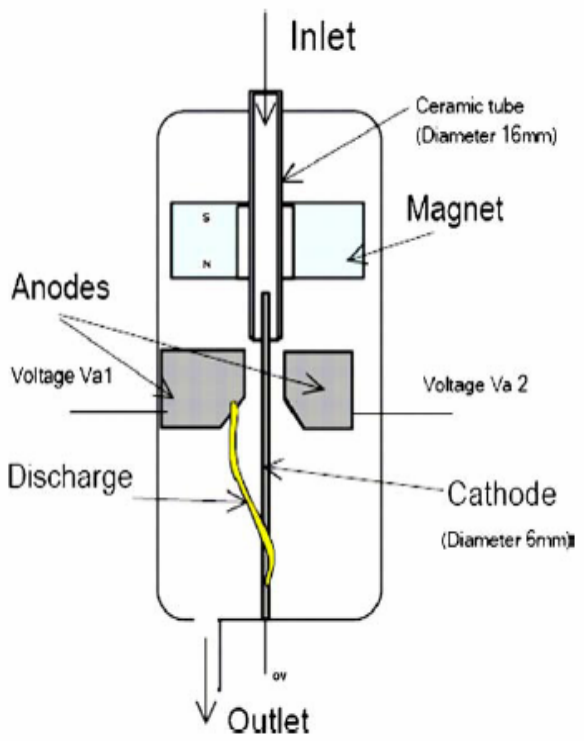
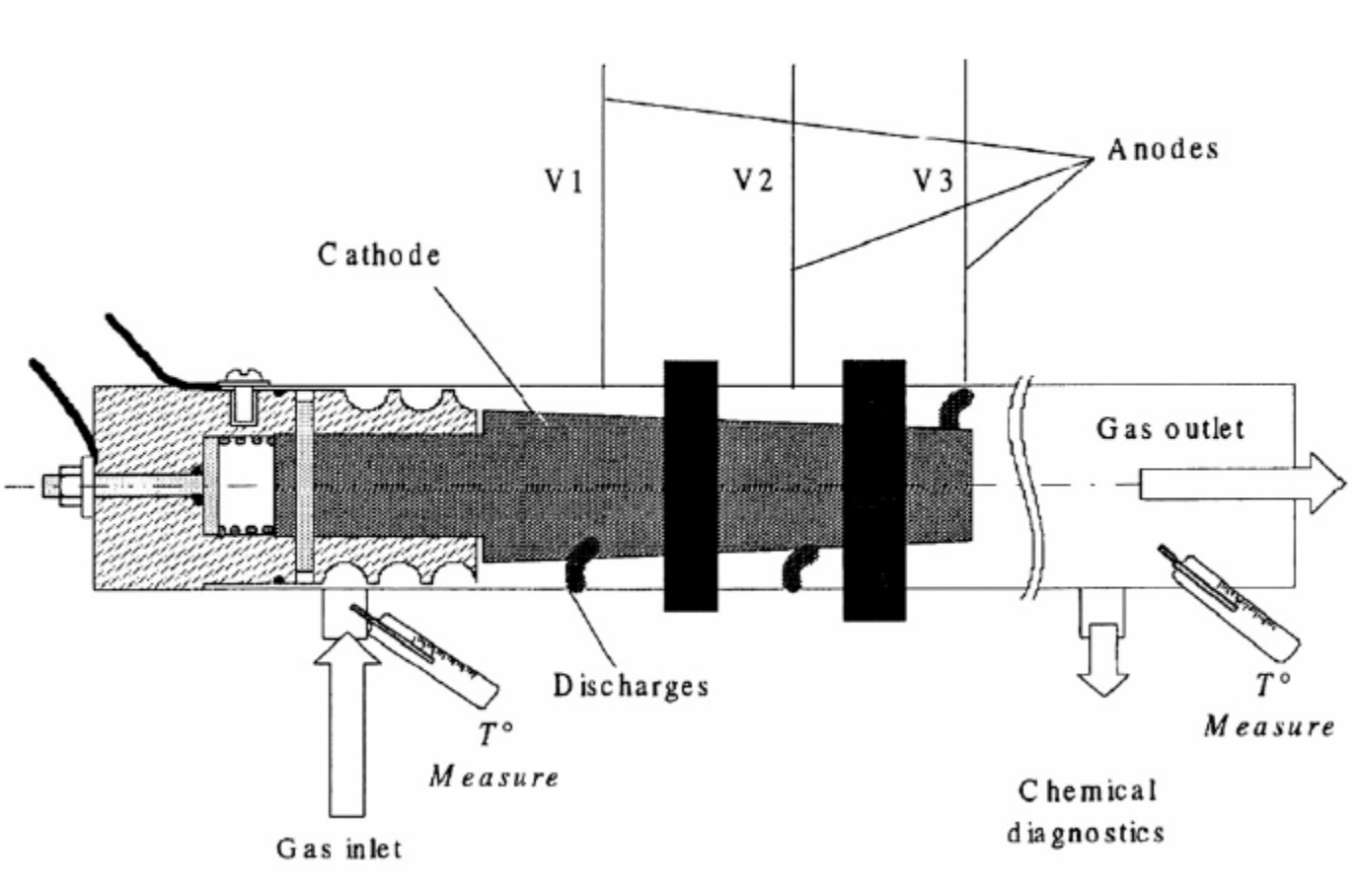


Fig. 6. Scheme of magnetic blow-out glidarc reactor (GREMI, France) [39] (acknowledgment to International Plasma Chemistry Society).

Rotarc discharge



DBD reforming

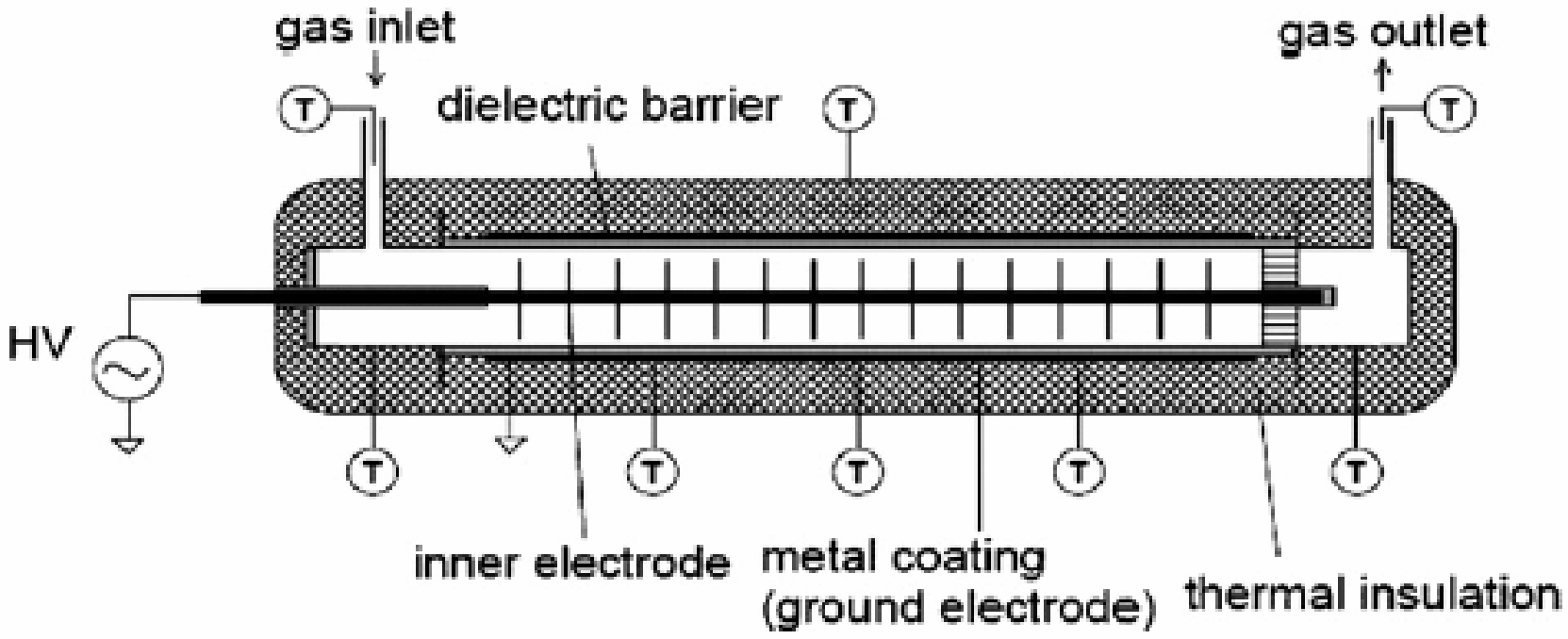


Fig. 8. Scheme of DBD reactor (Siemens AG, Germany) [13].