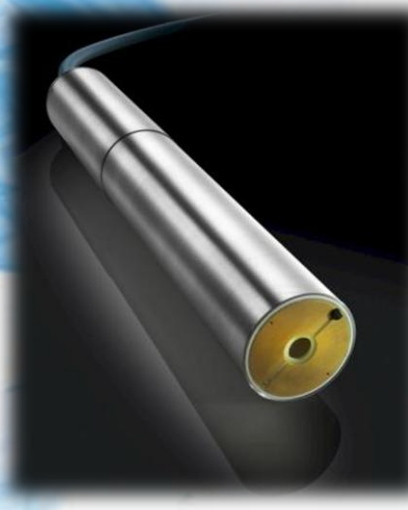
Measuring and Calculation of Positive Corona Currents Using Comsol Multiphysics

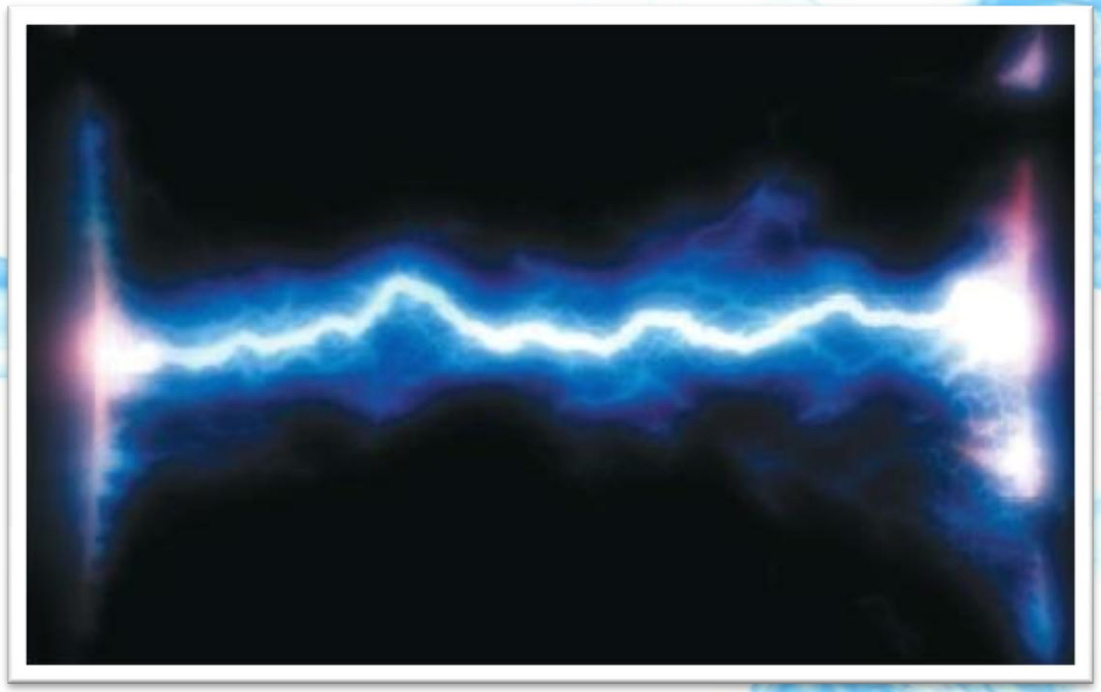


GUNYTRONIC GASFLOW SENSORIC SYSTEMS we know the flow

Physics of Corona Discharge

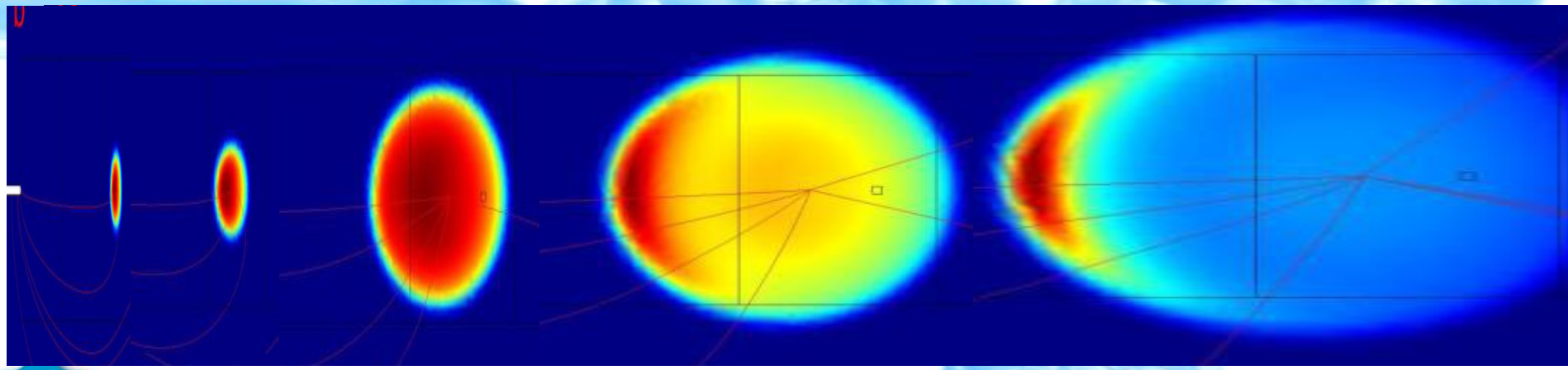
- Air always contains a varying amount of electrons due to cosmic radiation
- This causes a slight negative electric field in lower atmossphere (~ 140 V/m)
- If this natural electric field becomes stronger one can observe the well established phenomena

Electric Breakdown

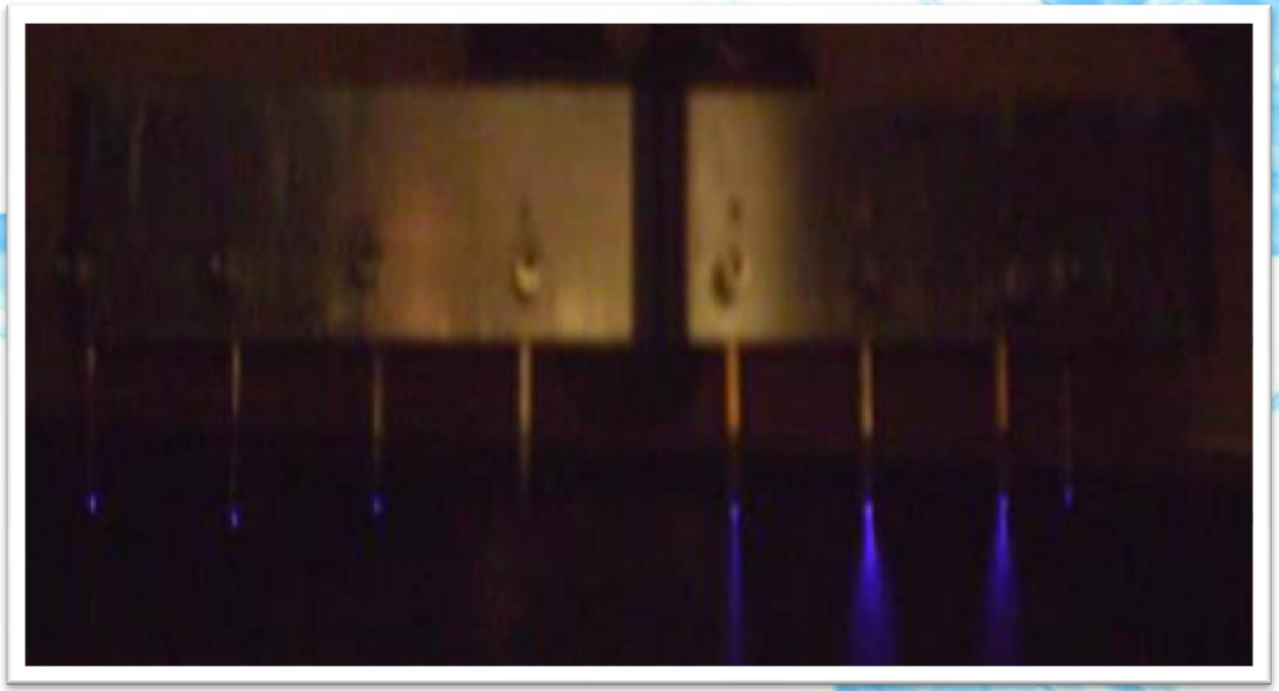


Glow Discharge

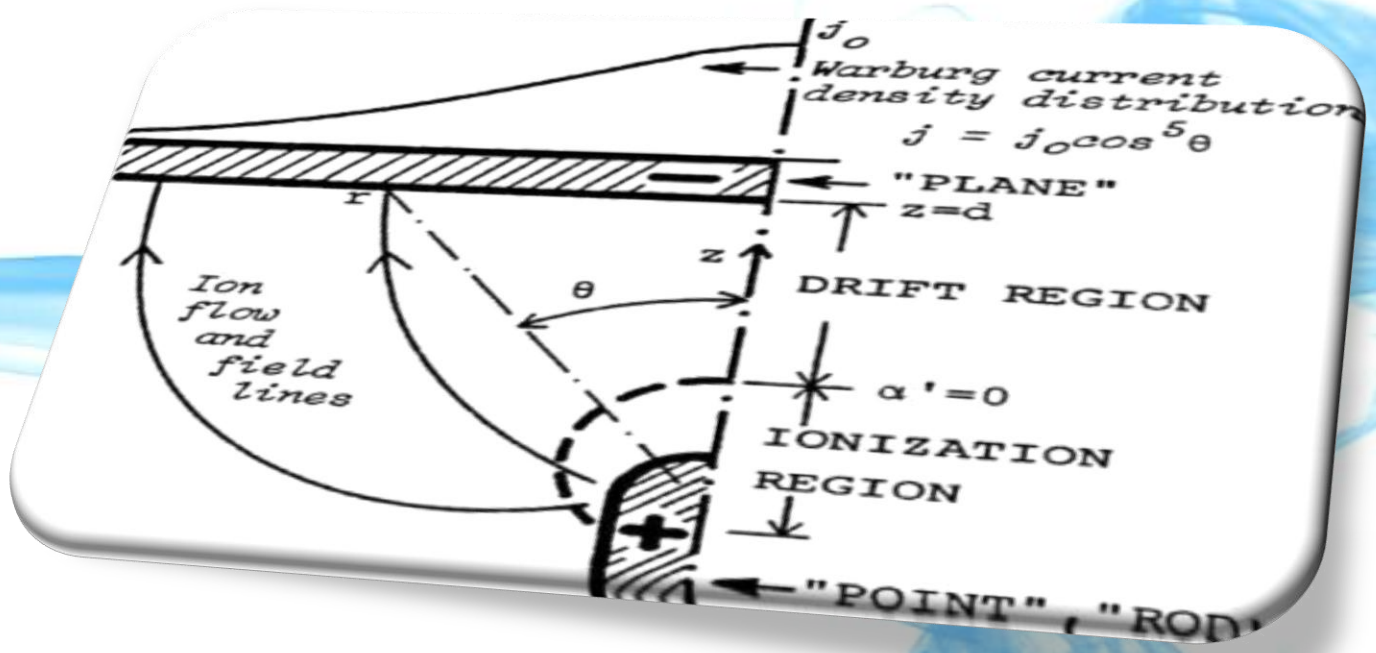
Streamer Discharge will be presented in the poster session…



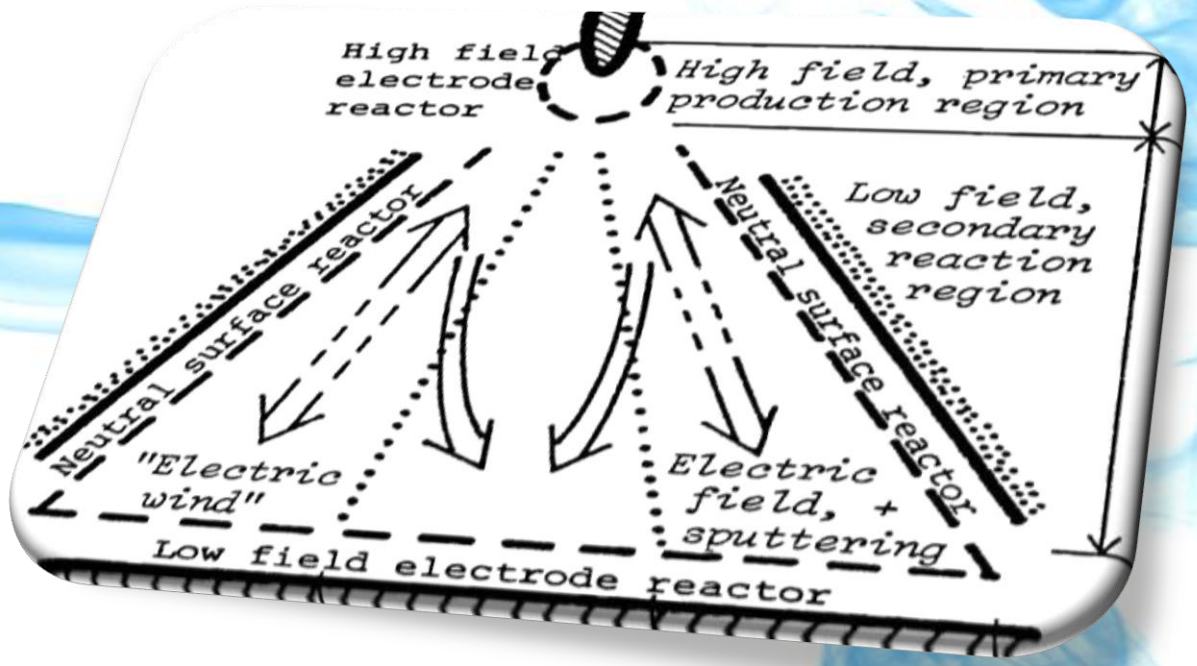
Finally Corona discharge



Warburg Distribution

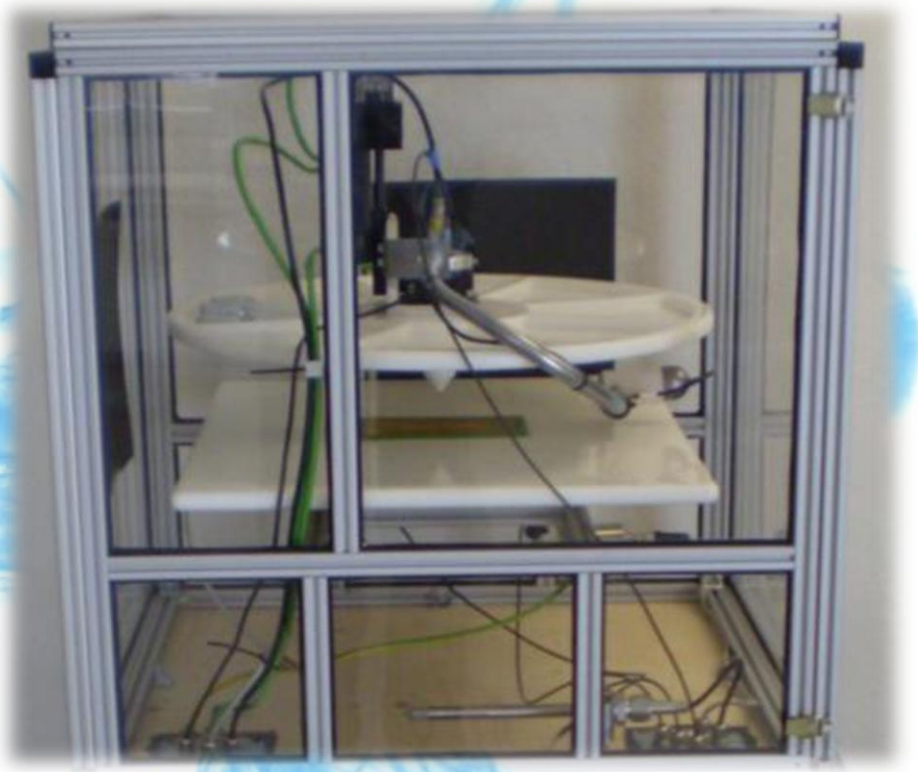


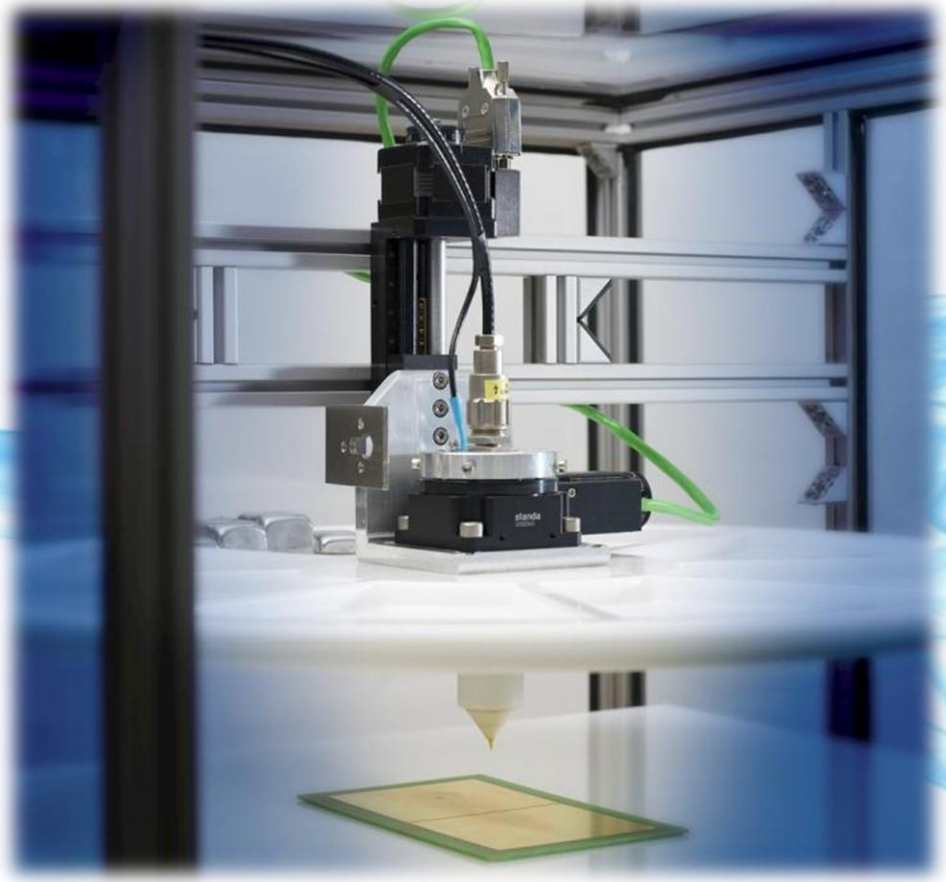
Ionic Wind


High field electrode reactor
High field, primary production region
Low field, secondary reaction region
Neutral surface reactor
Neutral surface reactor
"Electric wind"
Electric field, + sputtering
Low field electrode reactor

Experimental Setup

- Plexi glas Box
- Box filled with air
- **Temperature 21.5-23 °C**
- **Pressure ~ 967-998 mbar**
- **Moisture 41-45 %**





One Step Motor to move tip Up and Down

Two Teflon Plates

Metall tip on 8-10kV

Etched conductor board

Distance of metal plates ~ 1mm

Distance of tip to metal plate is held constant at 27 mm

Modeling with Comsol Multiphysics

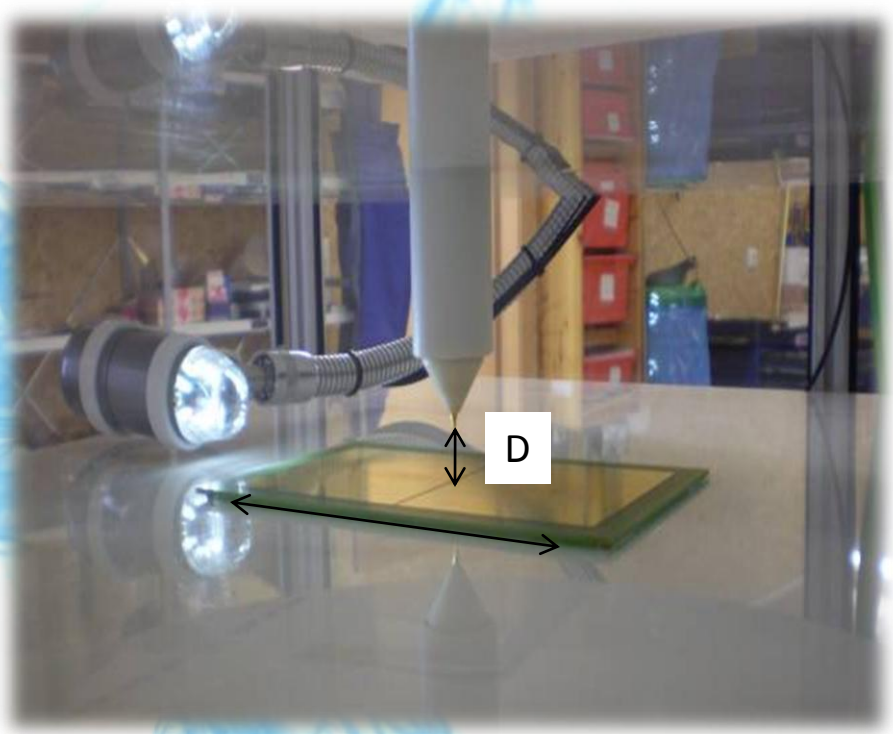
- **First Experiment:**

  D is constant

  Voltage increases 0…10kV

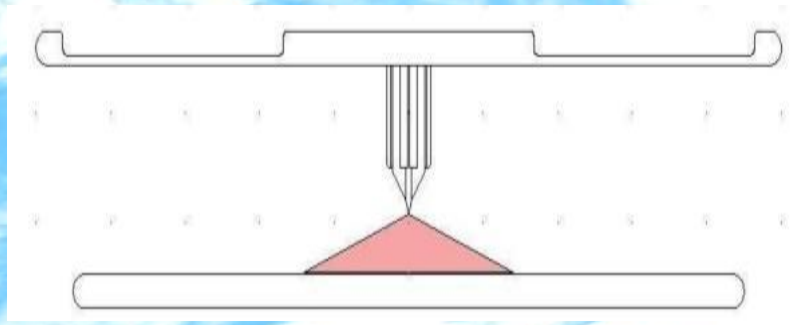
- **Second Experiment:**

  Scan the Metall plate from left to right, keep Voltage konstant.



- **transport equation** included in the CM chemical engineering toolbox:

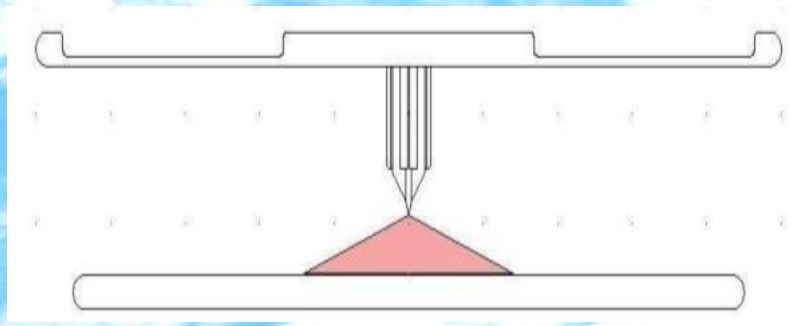
$$\nabla(cu - zK\nabla V - D\nabla c) = 0$$



- Concentration of ions c
- Speed of Air u ~ 1…6m/s
- Diffusion D = 5.686e-6m²/s
- Ion mobility K = 2.2e-4 m²/Vs

- **Poisson equation** included in the ACDC Modul :

$$\nabla((\sigma + \frac{\varepsilon\varepsilon_0}{T})\nabla V - J^e) = \frac{\rho_0}{T}$$

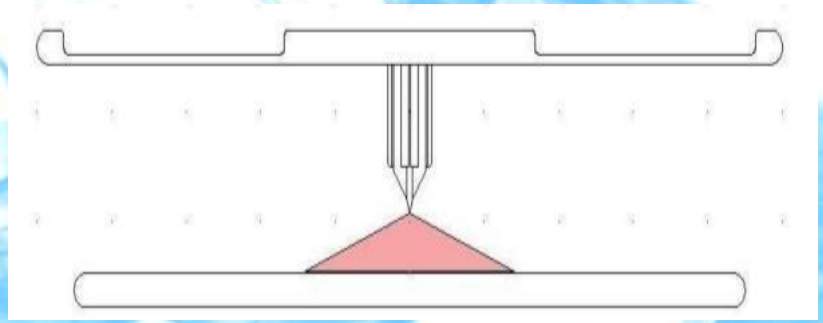


- Relative permittivity ε ~ 1.0003
- Permittivity of vaccuum, ε0
- Conductivty σ

$$\nabla(cu - zKc\nabla V - D\nabla c) = 0$$

Transport equation

$$\rho_0 = F \cdot c$$



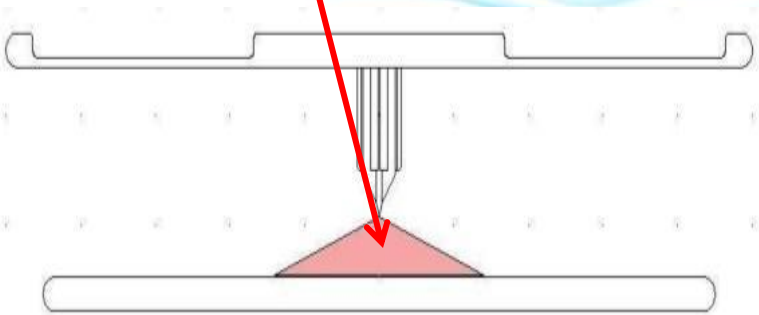
$$\nabla((\sigma + \frac{\varepsilon\varepsilon_0}{T})\nabla V - J^e) = \frac{\rho_0}{T}$$

Field equation

Subdomain Conditions, Boundary Conditions, Initial Conditions

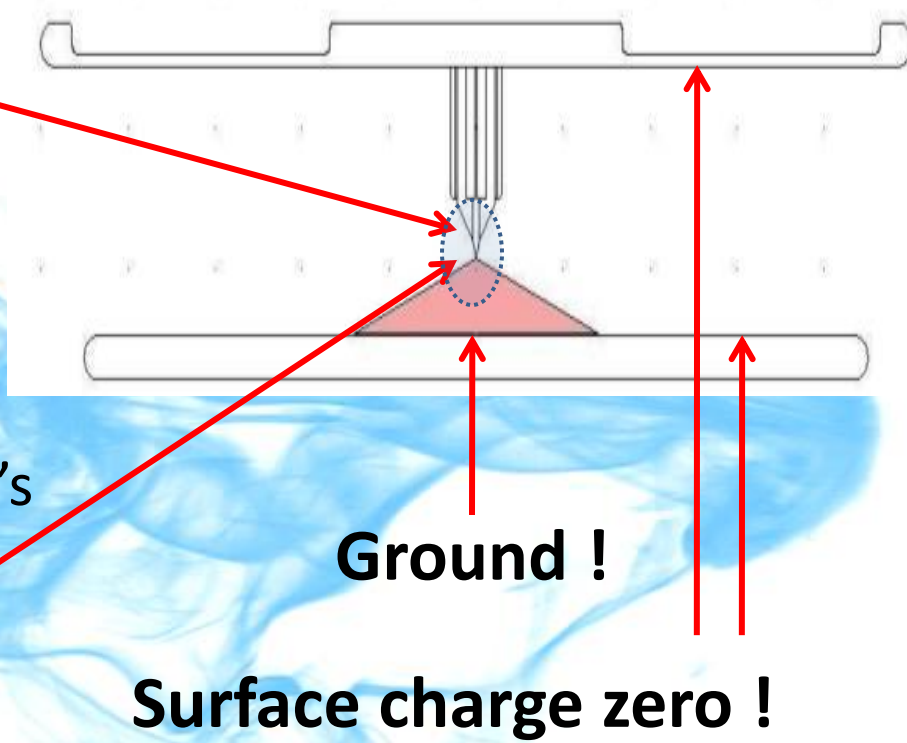
$$\sigma := \frac{1.890 \cdot 10^{-13}}{d^{3+f}} \cdot \left(\frac{V - 3800}{1000} \cdot 0.000245 - 0.0005 \right)$$

Experimental function for conductivity in the air



Material	σ	ε
Copper	$5.99e10^{7}$	∞
Iron/steal	$1.50e10^{6}$	∞
Teflon	- ∞	2.1

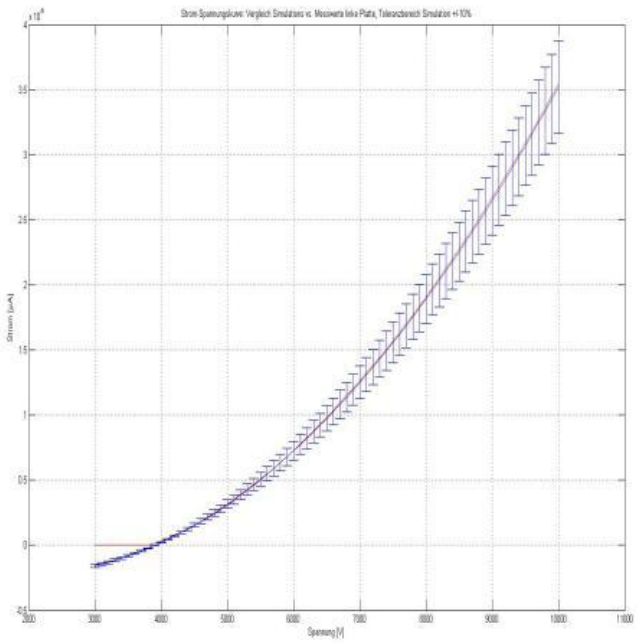
- Air speed u ~ 1…6 m/s
- initial concentration of ions c ~N_L*10-9
- N_L = 2.6871025 1/m^3 Loschmidt's number.
- Voltage V = 0….10kV



Results Experiment I

Raising up Voltage measuring current

Experiment and Simulation
Data fit within Error tolerance 10%



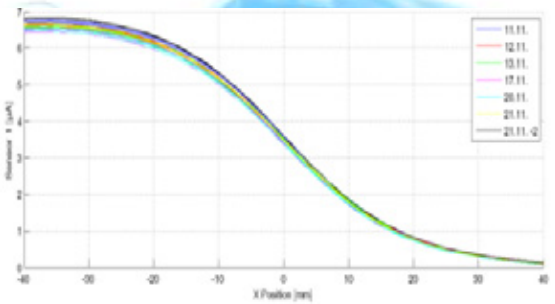
Results Experiment II

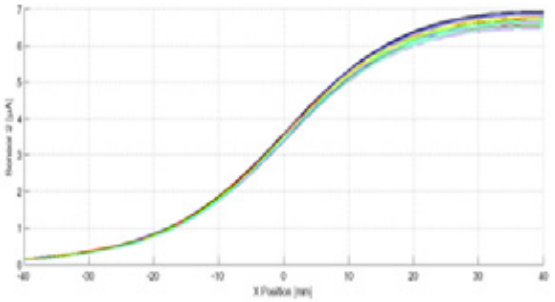
Measuring the Warburg Current scanning the surface with tip at 10kV

Experiment was rerun seven times during a day at different daytimes

Experimental result an simulation agree with experiment within tolerance of 10%

Warburg Current on left plate





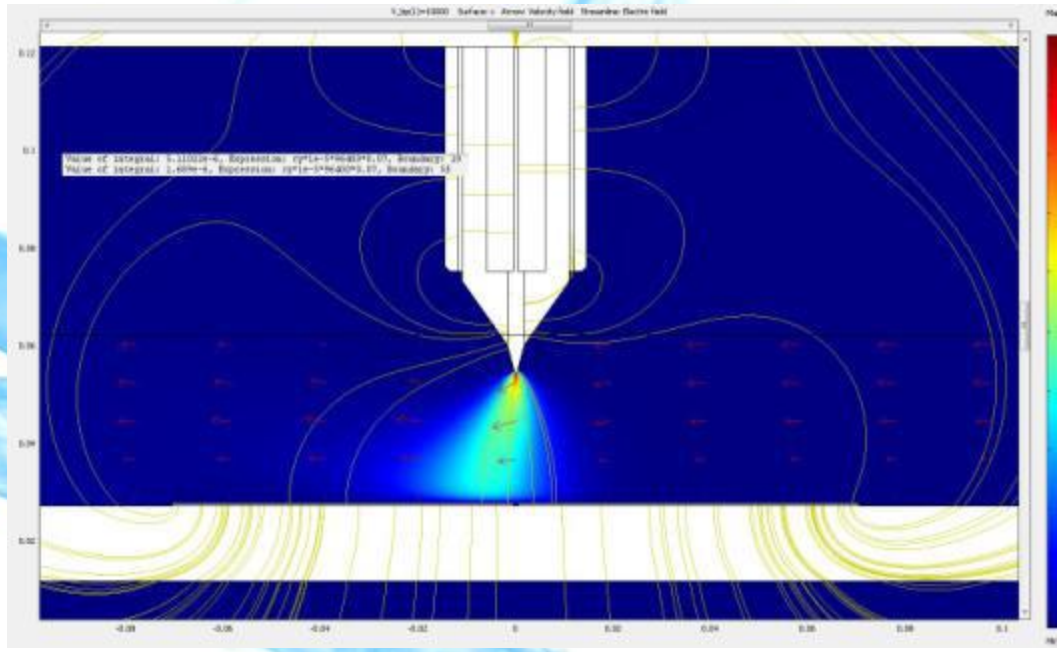
Warburg current on right plate

Hypothesis Test

Experiment and Simulation give the same result
Side Wind
5.11 µA on left plate
1.70 µA on right plate

Without Wind
3.5 µA on both side

Simulation and Experiment agree again very well



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Thank you for your attention

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