TECHNISCHE UNIVERSITÄT DRESDEN

IHM

FAP PLASMATECHNIK

Influence of the Excitation Frequency Increase up to 140 MHz on the VHF-PECVD Technology

Sebastian Leszczynski

Carl Gustav Carus 1789 - 1869

COMSOL CONFERENCE ROTTERDAM2013

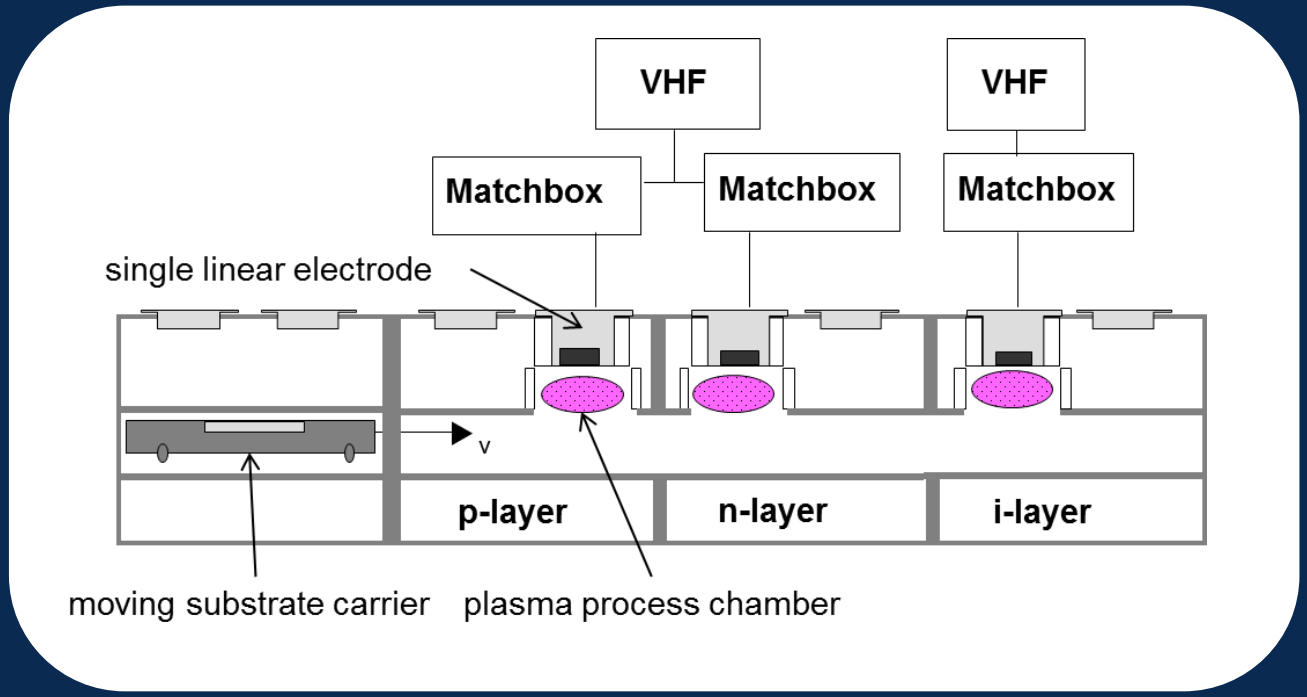
Rotterdam, 23-25.10.2013

DRESDEN concept Exzellenz aus Wissenschaft und Kultur

Outline

- VHF-inline deposition system
  - Linear Plasma Source
- Motivation
  - Modeling and Optimization of the Reactor Design
- Electrical Field Simulations
  - Deposition Rate Profiles
  - Lumped Port Model of the Linear Plasma Source
- Summary

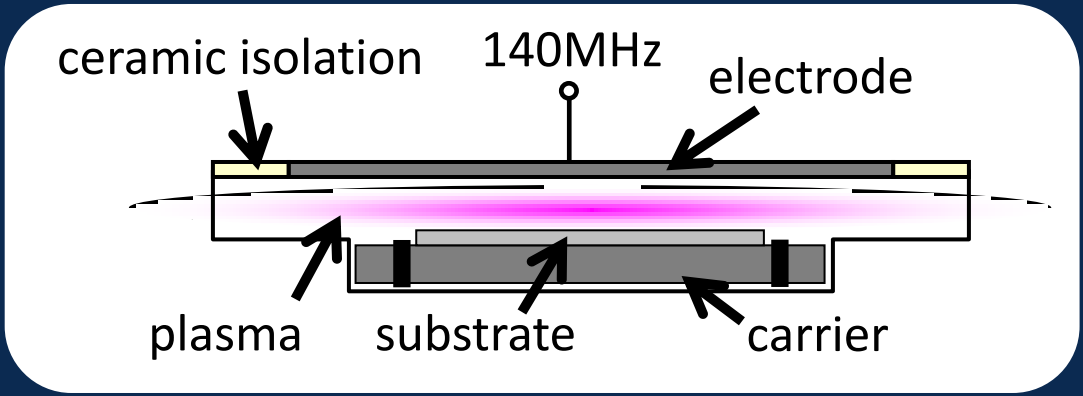
VHF-inline deposition system



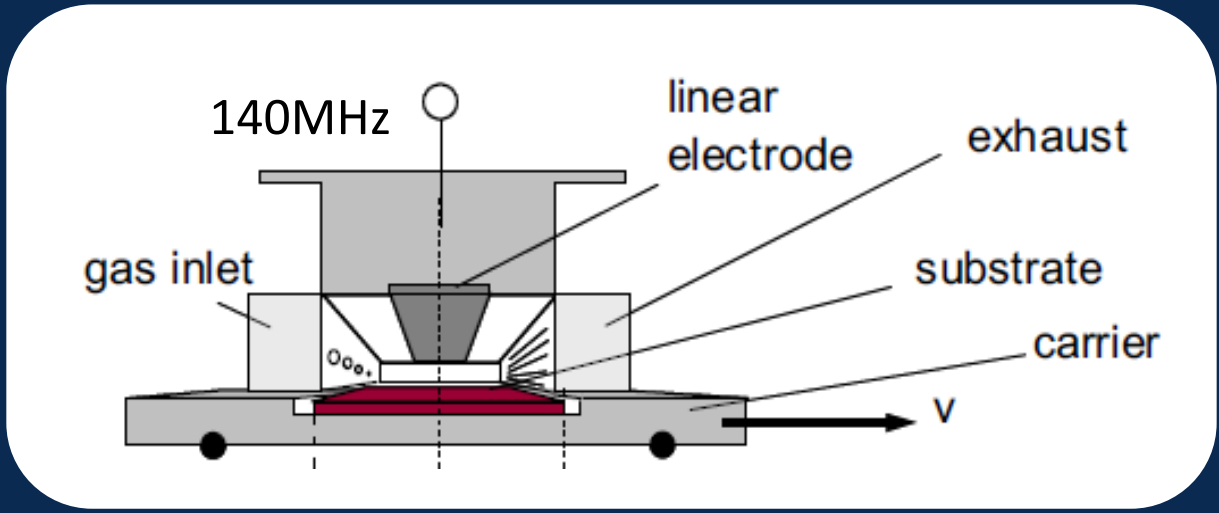
- Deposition of p-, i-, n- a-, µc-Si layers
- Excitation frequency range: 81.36 – 140 MHz
- Static and dynamic deposition

Linear Plasma Source – Principle Construction

Side view



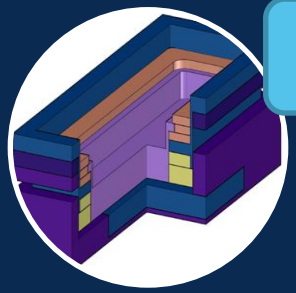
Front view



Modeling and Optimization of the Reactor Design

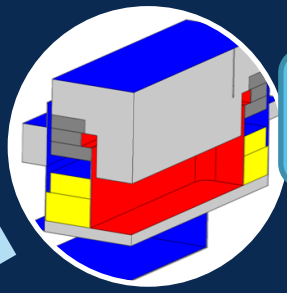
Real Objekt

CAD



Engineer Model

- Material properties
- Boundary conditions



Physical Model

System of differential equations

$$\nabla \times H = J + \frac{\partial D}{\partial t}$$

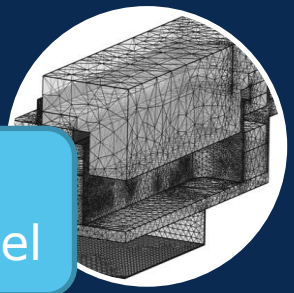
$$\nabla \times E = -\frac{\partial B}{\partial t}$$

$$\nabla \cdot D = \rho$$

$$\nabla \cdot J$$

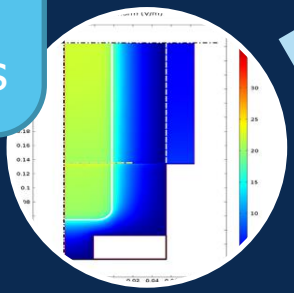
Mathematical model

Discretization



Numerical calculation model

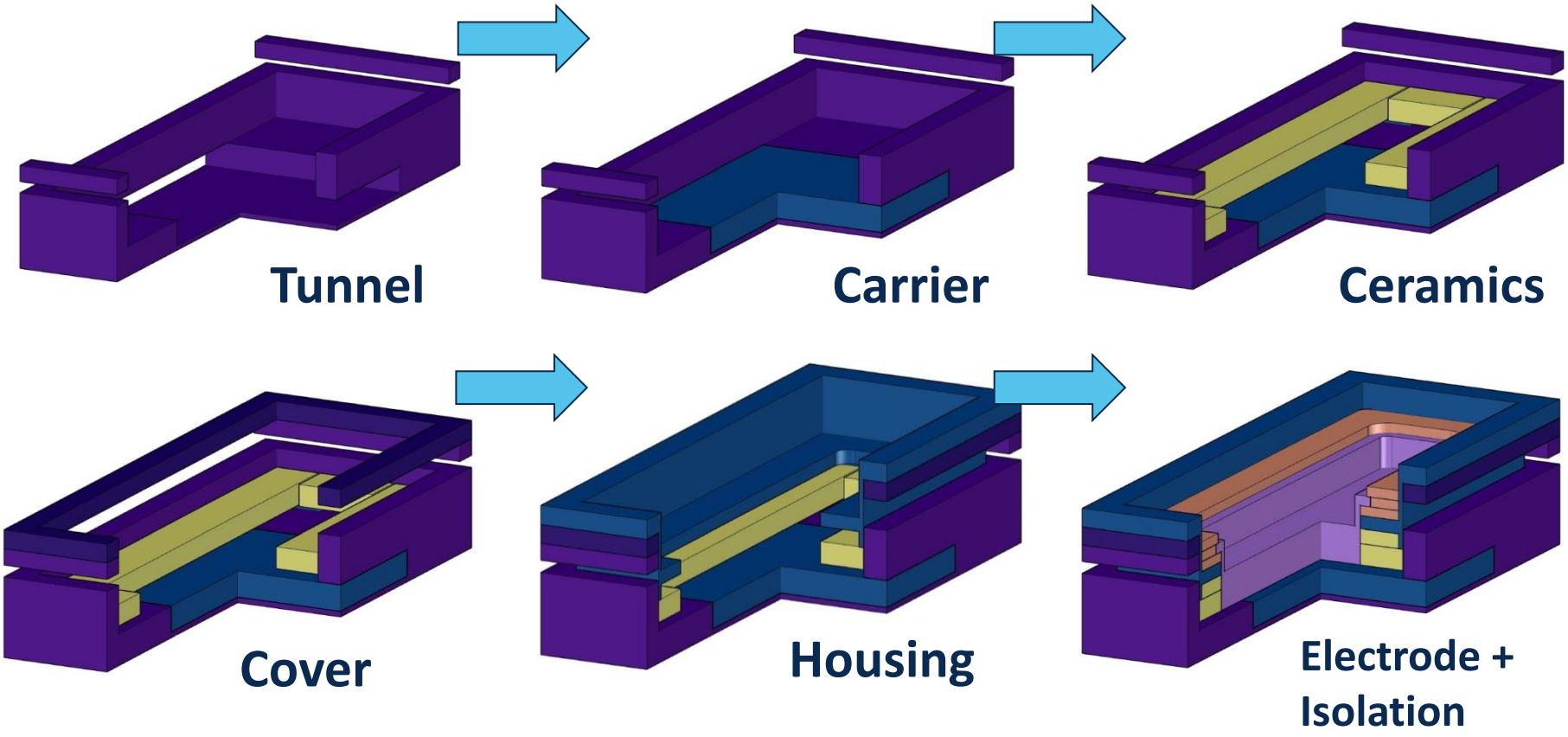
FEM +
Post processing



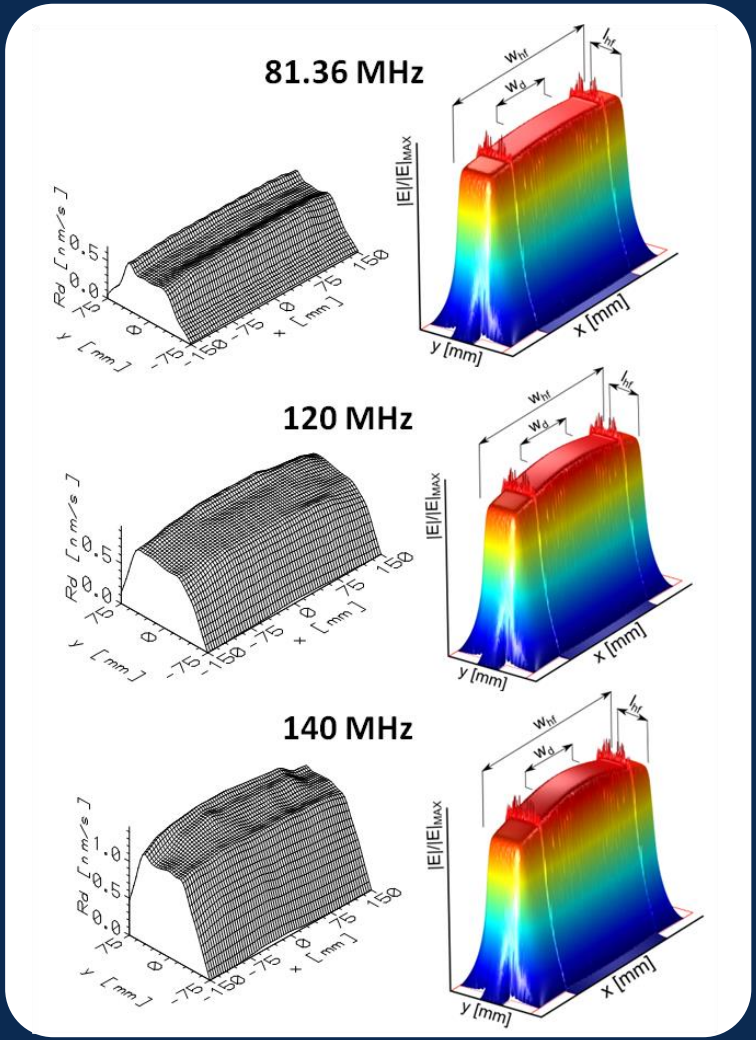
Optimization

Simulation results + Measurements

Linear Plasma Source – Model Geometry

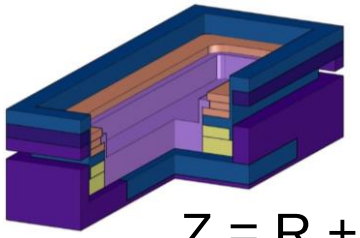


Electrical Field Simulation (81.36 – 140 MHz)

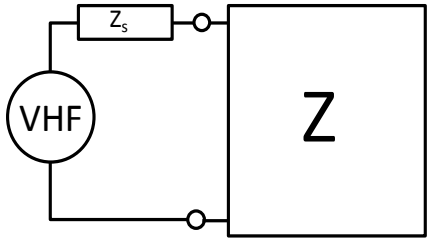


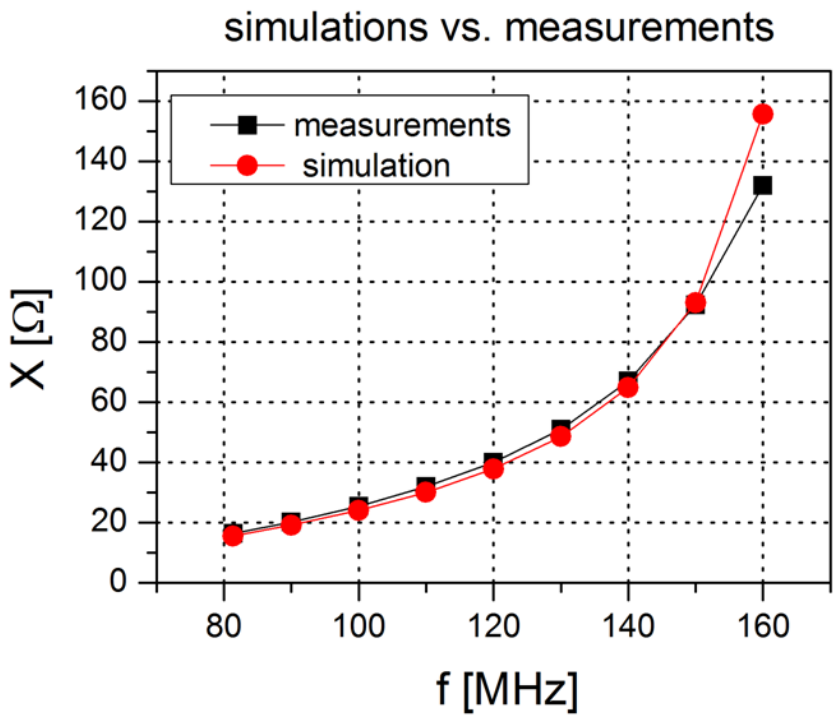
- 3D electrical field simulations in the presence of Vacuum (right) compared with deposition rate profiles (left) of amorphous silicon
- electrical field distribution shows standing waves formation at the higher frequencies
- electric field peaks correspond to powder formation during deposition

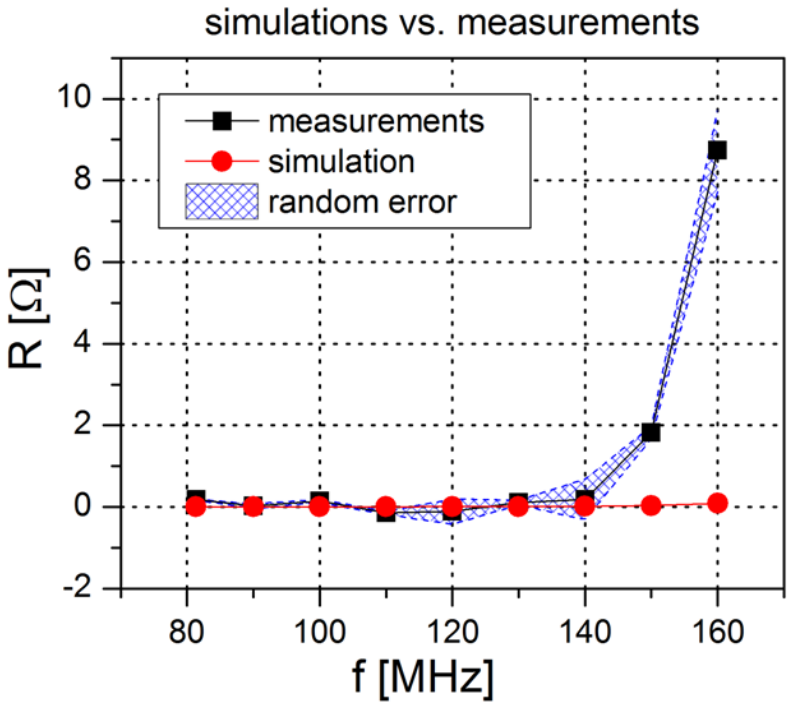
Lumped Model of the Linear Plasma Source



$Z = R + jX$







Summary

- The whole 3D electric model of the linear plasma source was developed
- Standing wave formation inside the deposition chamber was observed and compared with the measured deposition rates of amorphous silicon
- It has been showed that detailed electrical models can give important information about homogeneity of deposited layers in a complex deposition system without modeling of the complicated plasma physics
- The lumped model of the structure was used to validate the simulation process

TECHNISCHE UNIVERSITÄT DRESDEN

IHM

FAP PLASMATECHNIK

Thank you for your attention

This work is financed from funds provided by the European Union and Freistaat Sachsen.