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

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Introduction:

The plasma enhanced chemical vapor deposition process with a linear plasma source and the frequency up to 140 MHz enables a fabrication of the thin film silicon layers at very high deposition rates. However, an increase of the plasma frequency reduces the electromagnetic wavelength. Therefore, the electric field distribution is simulated to exam the influence of electrical properties and the deposition system geometry on the homogeneity of deposited layers. The detailed electrical model of the linear plasma source for 3D simulation is presented. Additionally, the simulation results are used to create an electrical lumped model of the structure to investigate the influence of the high excitation frequency on structure impedance.

VHF PECVD deposition system

- inline deposition system
- very high frequency range **81.36 – 140 MHz**
- linear plasma sources

Computational methods

- electromagnetic analysis using Maxwell`s equations

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

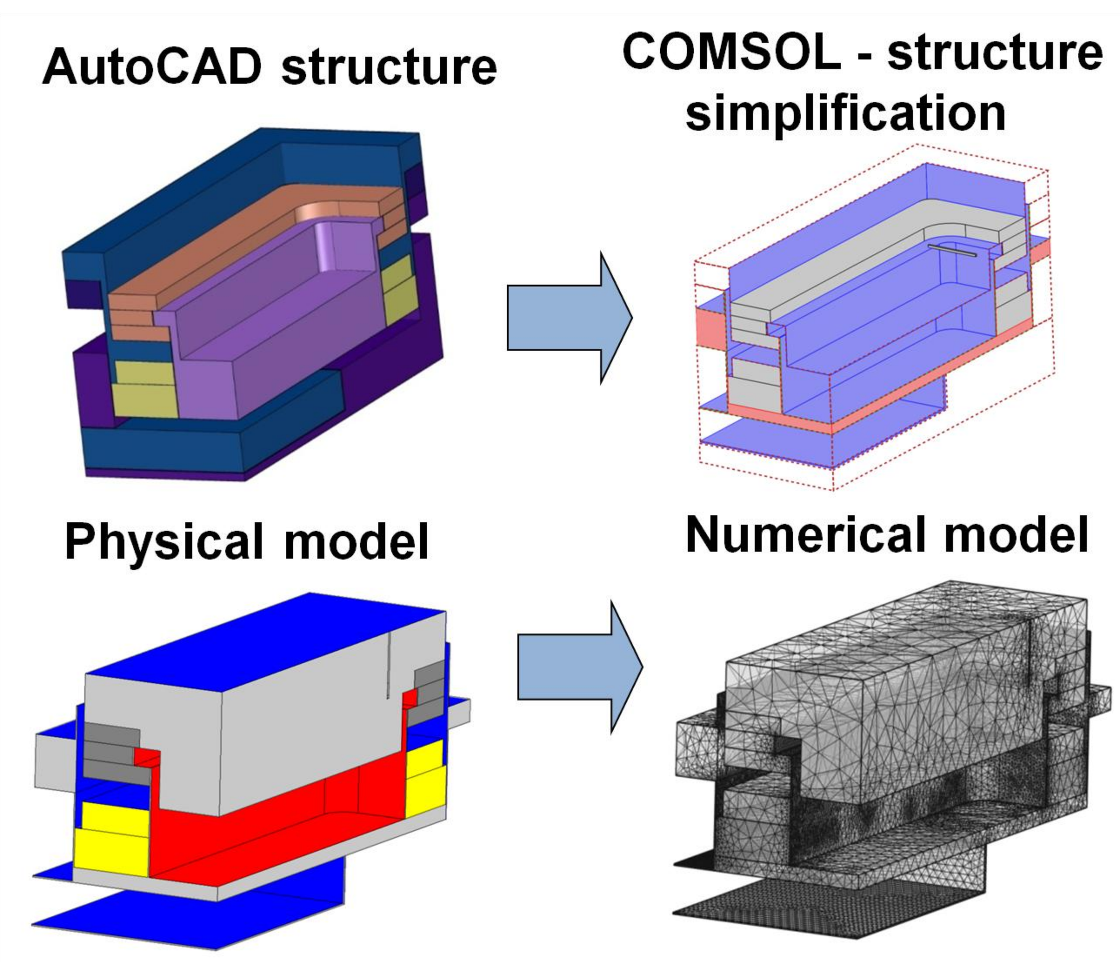
$$\nabla \times E = -\frac{\partial B}{\partial t}$$

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

$$\nabla \cdot B = 0$$

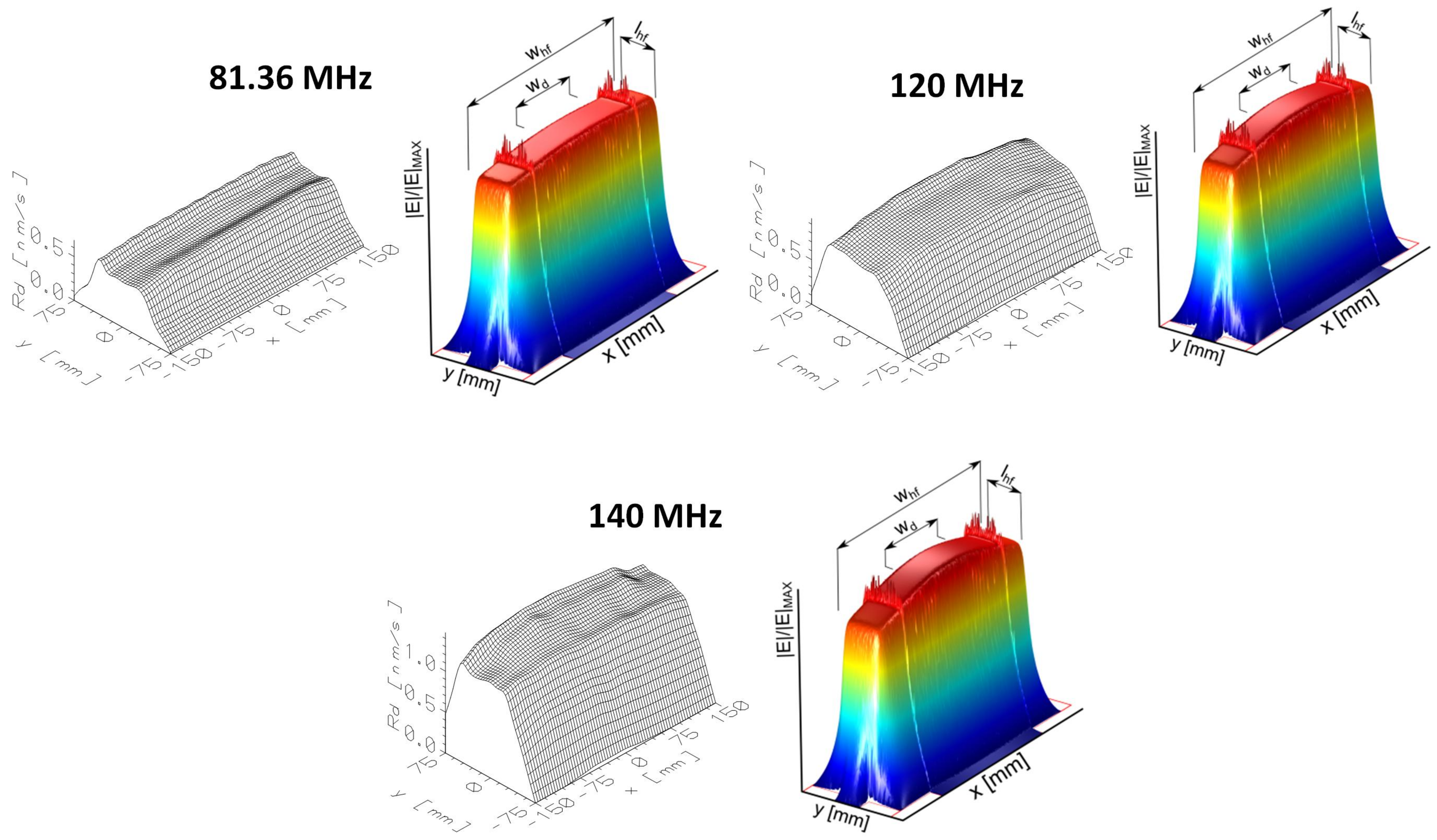
$$\nabla \cdot J = -\frac{\partial \rho}{\partial t}$$

- detailed FEM model of the linear plasma source for 3D electrical simulations

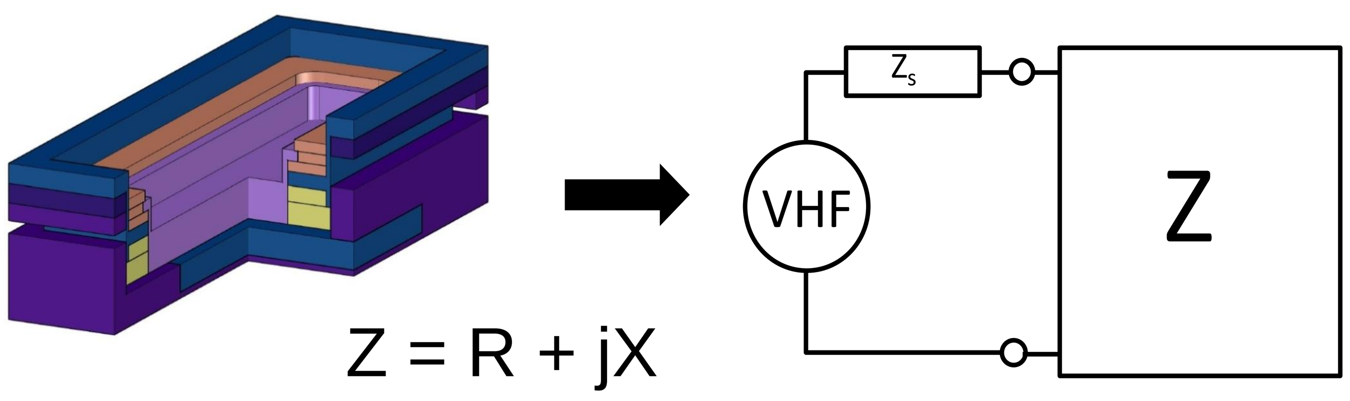


Electrical field simulation (81.36 – 140 MHz)

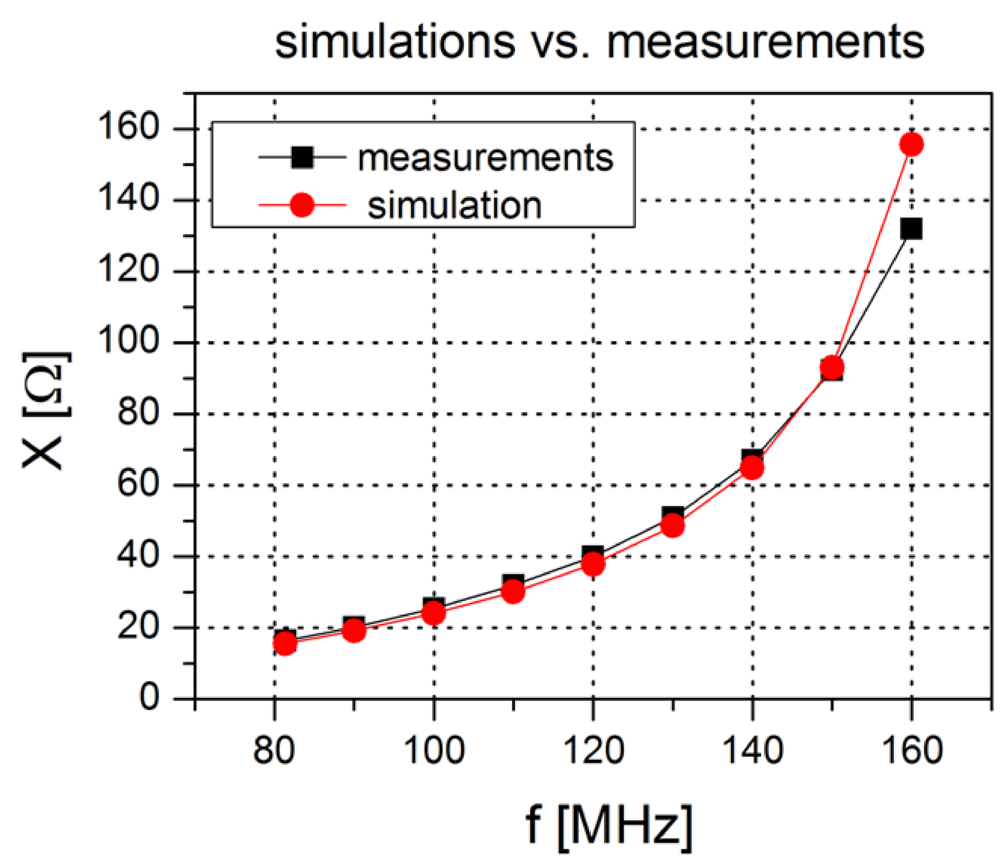
- 3D electrical field simulations compared with deposition rate profiles of amorphous silicon
- electrical field distribution shows standing waves formation at the higher frequencies
- electric field peaks correspond to powder formation during deposition

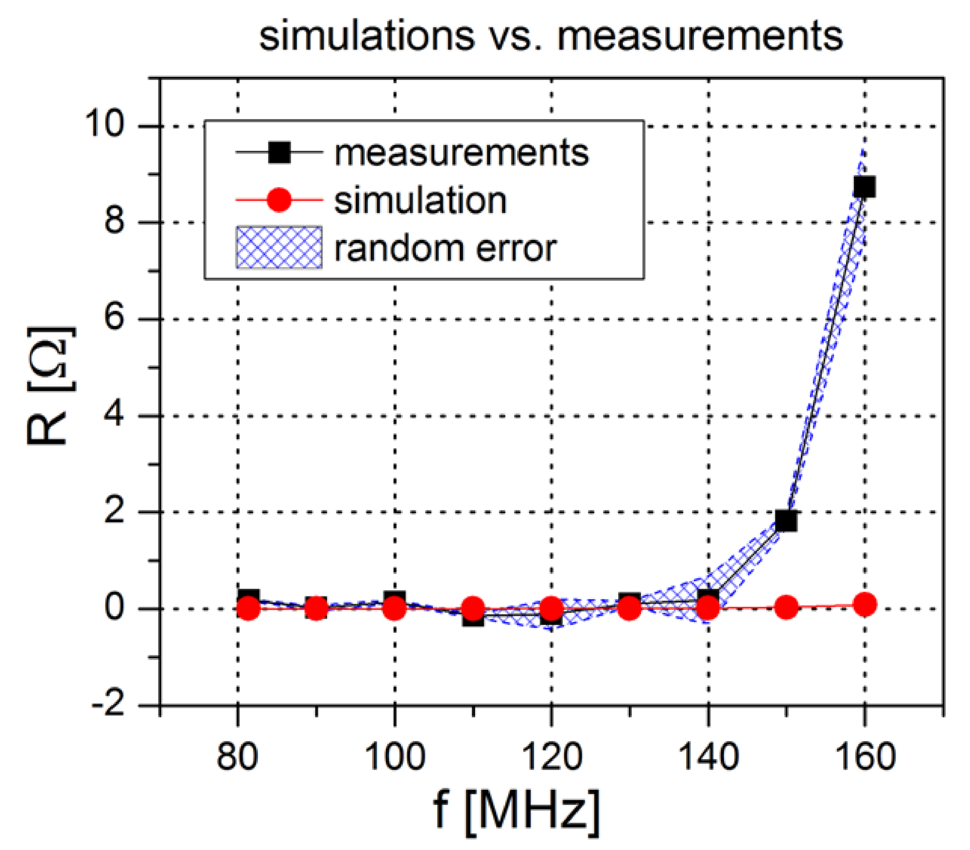


Electrical lumped model of the linear plasma source



- impedance of the electrical lumped model compared with measurements
- simulation results show 5% deviation from measured values
- above 140 MHz the impedance values were obtained at the upper detection limit





Conclusions

This study shows that detailed electrical models give important information about homogeneity of deposited layers in a complex deposition system. Furthermore, the lumped model of the structure can be used to validate the simulation process as well as to improve the electrical matching of the system.

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