# Simulation of low-temperature, atmospheric-pressure plasma enhanced chemical vapor deposition reactors

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## Abstract

The simulation of low-temperature, atmospheric-pressure plasma enhanced chemical vapor deposition reactors is challenging due to the coupling of the fluid dynamics, the chemical reactions and the electric field and the stiffness of the resulting mathematical system. The model equations and the rigorous model reduction to reduce the stiffness are addressed in this paper. Considering pure nitrogen plasma, simulations with two configurations are discussed.

**Keywords:** APPECVD; Atmospheric pressure plasma; Plasma fluid model; Chemical vapor deposition

## Highlights

The industrial interest in fast and efficient surface treatments and thin films depositions on various types of substrates has drastically increased in the last decades. Low-temperature atmospheric-pressure plasma enhanced chemical vapor deposition (APPECVD) facilitates in-line treatment of a wide variety of substrates while reducing the cost by eliminating expensive vacuum devices.

Although the technology is well demonstrated at the lab-scale, scale up is challenging, mainly due to the influence of the fluid dynamics. Issues such as powder formation are observed in case of poor operation [1,2]. Rigorous modeling and simulation can contribute to an improved understanding of the various phenomena taking place in the reactor. This requires the coupled solution of the fluid dynamics, chemical reactions and electric field. Moreover, the space and time scales of the modeled phenomena necessitate a very fine spatial and temporal mesh. Because of the computational complexity, a 1D approach is usually taken[3]. Such an approach cannot be used with complex configurations.

In the present work, a plasma fluid model for the 2D or 3D simulation of low-temperature atmospheric-pressure pure nitrogen plasmas is discussed and applied to two specific configurations. A total of 9 species and 21 reactions are considered. Rigorous model reduction to deal with the mathematical stiffness is addressed.

Figure 1 shows an example of the obtained profile of metastable $N_2(A)$ species in a point-to-plane corona discharge reactor with a 6kV DC applied voltage.

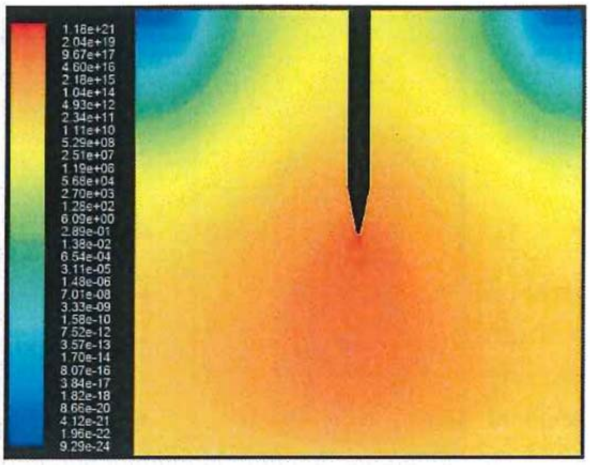


Figure 1. Density of metastable $N_2(A)$ species $[1/\mathrm{m}^3]$ in a point-to-plane corona discharge with a 6 $[\mathrm{kV}]$ applied voltage.

## References

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