Nitrogen fixation by gliding arc plasma

Nitrogen Fixation by Gliding Arc Plasma: Better Insight by Chemical Kinetics Modelling


Dr. Weizong Wang


Bhaskar Patil


Stjin Heijkers


Prof. Dr. Volker Hessel


Prof. Dr. Annemie Bogaerts

Universiteit Antwerpen

TU/e Technische Universiteit Eindhoven University of Technology

Invited for this month's cover is the group of Prof. Dr. Annemie Bogaerts at the University of Antwerp and their collaborators at Eindhoven University of Technology in the laboratory of Prof. Dr. Volker Hessel. The cover image shows that gliding arc plasma leads to energy efficient nitrogen fixation by promoting the vibrational excitation of N_2.
The Full Paper itself is available at 10.1002/cssc.201700095.

What prompted you to investigate this topic/problem?

Considering the increasing demand of fertilizers as well as the high-energy intensity and environmental concerns triggered by industrial nitrogen fixation (i.e., the Haber–Bosch process), there is an urgent need to develop and integrate more sustainable processes of nitrogen fixation. Gliding arc plasma-based nitric oxide synthesis offers unique perspectives for this purpose, but the underlying mechanisms are clearly not yet understood. Hence, we wanted to elucidate the plasma chemistry by a combination of experiments and computations, to provide the necessary insights for gliding arc plasma-based nitrogen fixation. Our work also allows us to propose possible solutions on how to further improve the performance of gliding arc plasma technology.

What is the most significant result of this study?

Our results clearly reveal that vibrational excitation of N_2 can help to overcome the reaction energy barrier of the non-thermal Zeldovich mechanism $O + N_2(V) \rightarrow NO + N$ and can thus significantly enhance the nitric oxide synthesis in the gliding arc plasma. This provides an energy efficient pathway for nitrogen fixation using air as raw material.

What future opportunities do you see (in the light of the results presented in this paper)?

If electricity from sustainable energy sources (wind and solar) is used, the intrinsic potential of gliding arc plasma-based nitrogen fixation can provide a promising opportunity for producing nitrogenous fertilizer in remote locations by just using small-scale plants, which offer farmers a new source of revenue from their land. This helps to come up with realistic scenarios of entering a cutting-edge innovation in new business cases of plasma agriculture, in which low-temperature plasma technology might play an important role.

Acknowledgements

The authors appreciate financial supports by the European Marie Skłodowska-Curie Individual Fellowship "GlidArc" within Horizon 2020 (Grant No.657304), the FWO project (Grant G.0383.16N) and the EU project MAPSYN: Microwave, Acoustic, and Plasma assisted SYNthesis (Grant No.CP-IP 309376) under the 7th Framework Programme. The calculations were performed using the Turing HPC infrastructure at the CalcUA core facility of the Universiteit Antwerpen (UAntwerpen), a division of the Flemish Supercomputer Center VSC, funded by the Hercules Foundation, the Flemish Government (department EWI) and the UAntwerpen.