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Numerical Simulations of a Microwave Plasma Torch at Atmospheric Pressure

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Atmospheric microwave plasma devices have the advantage of being applicable without any complicated and expensive vacuum system. Using microwaves for the power supply also helps to avoid geometrical restrictions and allows one to obtain a free-standing plasma for various applications. The focus of this work is on a stepwise description and investigation of the physical processes taking place in a microwave plasma torch at atmospheric pressure. That was done by setting up various numerical models with the software COMSOL Multiphysics®.
In a first model the cold gas flow through the torch without any plasma was described. This lead to an optimisation of the geometry and the development of a tangentially arranged gas supply which later helps to envelop the hot plasma and to keep it away from the quartz tube which contains it.
A first simulation of the plasma was carried out by using the Drude theory. For that purpose parameters like the electron density and the collision frequency were implemented into the model and the frequency dependent conductivity and permittivity of the plasma were taken into account. The results showed how the electron density affects the distribution of the electric field in the resonator of the microwave plasma torch.
In a further step the plasma was modelled using a fluid approach which contains drift diffusion equations and a set of reaction mechanisms for an argon plasma. It could be shown how the behaviour of the plasma changes considerably when simulated at atmospheric pressure and at low pressure respectively.
In a final step the single models could partly be coupled in order to get a better insight into the complex interactions and to describe and predict the plasma processes.
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