Ultrafast diagnostics of electric discharges in plasmas

Nanosecond precise optical emission spectroscopy is used as an important tool to determine and monitor the behavior of plasmas and discharges.

Plasmas and electric discharges have a wide range of applications from material processing, cleaning and disinfection, to treatment of cells and tissues. Modeling the discharge processes in plasmas can be extensive and requires a lot of computational resources if all interactions and physical details are considered. However, in many situations, when justified by the experimental conditions, simplified models can be used to save time and increase efficiency.

Researchers around Mohammed Yousfi from Toulouse demonstrate the application of such models by performing measurements on plasma discharges created by pulsed electron beams in air. According to the researchers using an electron beam has advantages over electric field induced plasmas that make the results of their studies applicable to a wider range of experimental situations.

In addition to microwave absorption, optical emission spectroscopy is used in the experiments to characterize the physical properties of the discharge. The optical signal is picked up by a fiber with 400 µm core diameter and detected by an IsoPlane 320 spectrograph using a PI-MAX 4 emICCD. Using the ultrafast measuring capabilities of the intensified camera, the optical spectra specifically are used to investigate the relaxation of the plasma after the electron beam passes through. Spectra are taken using a 50 ns exposure time, which is positioned at 4 different points in time within 150 ns after the pulse passes.

Using a 2400g/mm grating the experiment achieves an optical resolution of 0.065 nm and the optical spectra of discharge in air show the rotational and vibrational structure of nitrogen molecules.

Using this data Prof. Yousfi and his team are able to determine the vibrational and rotational temperature of the molecules discharge and confirm that the vibrational excitations become the dominant process for energy dissipation.

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Researcher: M. Ribiere, O. Eichwald, M. Yousfi

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