Magnetic field stabilized atmospheric pressure plasma: Diagnosis of gas temperature and its effect on nitrogen fixation

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In this work a magnetic field stabilized atmospheric pressure plasma is reported. The plasma is fixed at a position when the direction of the Lorentz force and the air flow is opposite. Under such condition, a stable glow discharge can be achieved, the plasma characteristics, such as gas temperature and electric field [1], don't vary with time and can be independently adjusted by controlling the discharge current, the gas flow rate and the external magnetic field. Laser-induced Rayleigh scattering method [2] is used to measure the plasma gas temperature, which plays an important role in chemical reactions [3, 4]. The results show that the gas temperature of the inverted U-shaped plasma channel is almost the same and it decreases from 2637 K to 1474 K with the increase of the gas flow rate, which is beneficial for the production of NO_x, and the energy cost is reduced by about 15 %. In addition, the increase of the discharge current only leads to the decrease of the average electric field of plasma channel from 0.75 $kV \cdot cm^{-1}$ to 0.55 $kV \cdot cm^{-1}$, while the gas temperature varies little. The best energy cost is obtained at a discharge current of 55 mA, a gas flow rate of 6 $L \cdot min^{-1}$, and an O_2 fraction of 40 %. The lowest recorded energy cost of 2.29 $MJ \cdot mol^{-1}$ and a NO_x concentration of approximately 15925 ppm are achieved.

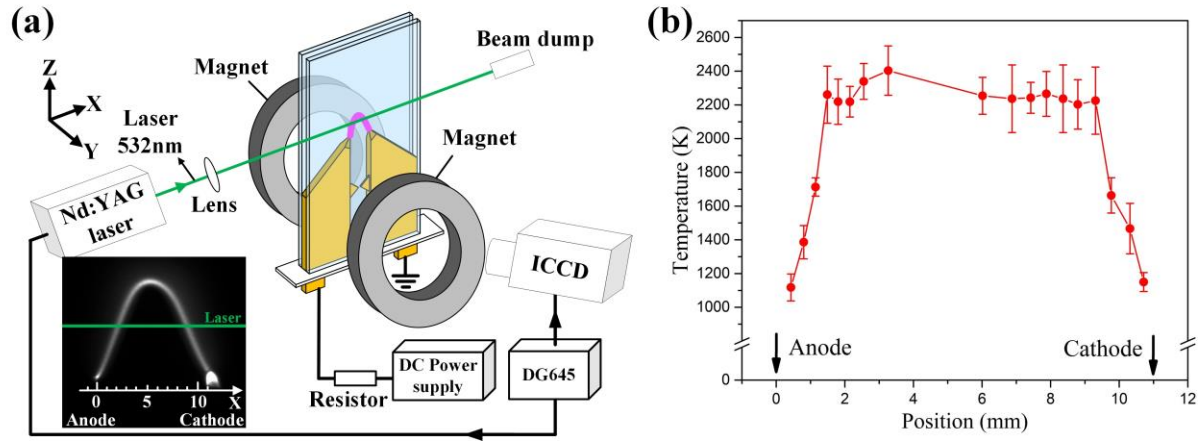

Figure 1. (a) Schematic of the plasma gas temperature measurement system. (b) Spatial distribution of gas temperature in the plasma channel.

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[3] S. Alphen, *et al.*, Sustain. Energy Fuels, **5** (2021) 1786

[4] S. Alphen, *et al.*, Chem. Eng. J. **443** (2022) 136529

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