Methane decomposition in low-pressure, large area glow discharge

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Abstract: This work presents the investigation results of a normal glow discharge conducted in Ar-CH_4 gas mixtures. The discharge is performed in gas at a pressure of P=0.4-1 Torr and is characterized by a lack of a positive column. This study focused on measuring products of methane decomposition, such as C_2, CH, and H using a planar laser-induced fluorescence approach.

1. Introduction

In this work we investigate and study a low-pressure normal glow discharge, characterized by large area, homogenous plasma in the cathode glow region. In the current setup the homogenous plasma covers an area up to 12.56 cm^2 (~2 squared inch), adjacent to the cathode.
Uniformly spread carbonaceous deposit is formed on the cathode surface. Products of decomposition of methane were measured, focusing on H, C_2 and CH.

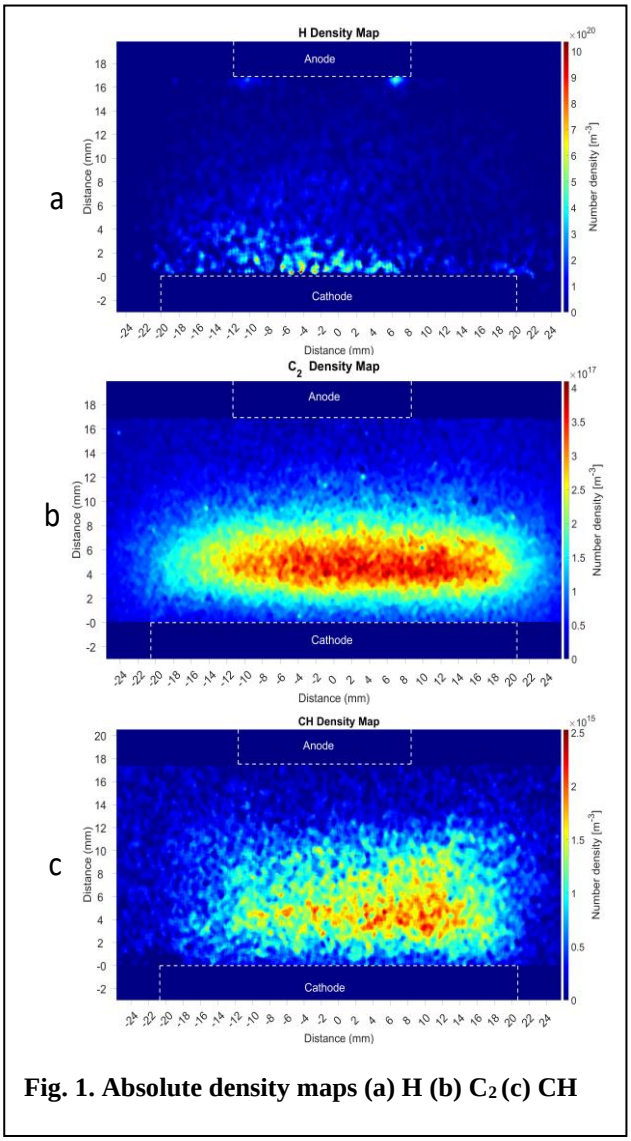

Fig. 1. Absolute density maps (a) H (b) C_2 (c) CH

2. Methods

The discharge is produced by applying a DC voltage of 1000 V to the brass anode and copper cathode with diameters of 20 and 40 mm respectively. The pressure in kept at 0.4 Torr and gas composition is 85% Ar and 15% CH_4, and the measured current is 0.736 mA. The measurement of the produced species is done by planar laser-induced fluorescence (LIF) approach, where a nanosecond laser pulse is provided by a wavelength tunable laser system[1]. 2D temperature map was also obtained by CH-LIF approach, utilizing Boltzmann plot approach for different rotational levels of CH (A-X).

3. Results and Discussion

Absolute densities of key byproducts of methane decomposition were measured by means of planar laser-induced fluorescence. Atomic hydrogen density peak n_H~$5x10^{20}$ m^{-3} is located adjacent to the cathode, in the negative glow region, decreasing towards the anode direction. C2 and CH molecules are well localized between the cathode glow and negative glow regions (cathode dark space), with peak densities of ~$4x10^{17}$ m^{-3} and ~$2x10^{15}$ m^{-3} , respectively. Spatial temperature map shows rather uniform temperature ~500 K in the region occupied by CH molecules. Planar LIF approach was demonstrated for temperature measurement and ns two-photon LIF (TALIF) for hydrogen atom measurement.

4. Conclusion

The distribution of the C_2 and CH molecules is shown to be homogenous in radial direction and localized to the cathode dark space. Spatial extent of the H atom is limited to area projected by the anode geometry.
High density of atomic hydrogen indicates methane decomposition of up to 20%.

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References

[1] T. Nikhar et al 2024 J. Phys. D: Appl. Phys. 57 475205