UV Emission from Microwave Plasmas

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Radiation emitted by a surface wave plasma source is investigated by means of Extreme UV Spectroscopy in the 8 - 125 nm range. Molecular Lyman and Werner bands are identified and the dependence of their emission intensity on the input microwave power is measured. The same is done for detected atomic Lyman lines. A theoretical self-consistent model is developed for interpretation and validation of the results.

Introduction

Ultraviolet (UV) and Extreme ultraviolet (EUV) light sources are of great importance in applications ranging from photochemistry to astrophysics. In this work, UV emissions from He, Ar, H_2 and Ar-H_2 surface wave microwave plasmas operating at low-pressures (0.1 – 2 mbar) are investigated.

Experimental conditions

The surface wave induced plasma source is created using a waveguide surfatron-based setup. The power is provided by a 2.45 GHz generator, coupled to a waveguide (WR-340) system, which includes an isolator, directional couplers, a 3-stub tuner, and a waveguide surfatron as the field applicator. The discharge takes place inside a quartz tube with internal/external radii of 3/5mm inserted perpendicularly to the waveguide's wider side. The background gas is injected into the discharge tube at flow rates from 20 to 100 sccm under laminar flow conditions. The EUV end-on emission is detected by a Horiba Jobin-Yvon Plane Grating Monochromator (PGM) operating in the 8 -125 nm (155 - 9.9 eV) spectral range. The VUV PGM is connected to one of the tube's ends.

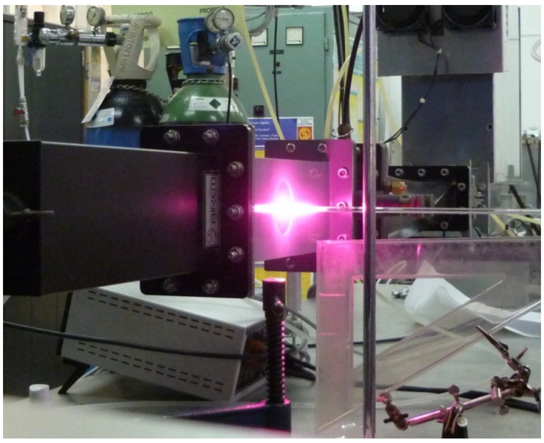

Fig. 1: Microwave hydrogen discharge.

Results and Discussion

Ultraviolet spectra in the range 10 – 120 nm, particularly the atomic emissions of the well-known 30.4 nm line of He II [transition H^{2+} (^2S - $^2P^0$)] and the Lyman α and β lines of atomic hydrogen at 121.6 nm and 102.6 nm (L_α and L_β) were detected for different settings of pressure and microwave power delivered to the launcher. Molecular emissions of the H_2 ($C^1\Pi_u \rightarrow X^1\Sigma_g^+$) Werner and H_2 ($B^1\Sigma_u^+ \rightarrow X^1\Sigma_g^+$) Lyman bands in the range 100 – 120 nm were also detected. The dependence of the integral intensity on the power was determined for both the molecular and atomic emissions. The experimental results are compared with theoretical results of a self-consistent theoretical model which was developed. This model is based on a set of equations including the electron Boltzmann equation, the thermal balance equation, the local surface wave dispersion as derived from Maxwell's equations and the rate balance equations for vibrationally excited molecules, H_2 ($X^1\Sigma g^+$, v), electronic excited states of H_2 and H (n = 2–8), ground-state neutrals (H_2, H) and ions (H^+, H_2^+, H_3^+, H^-).

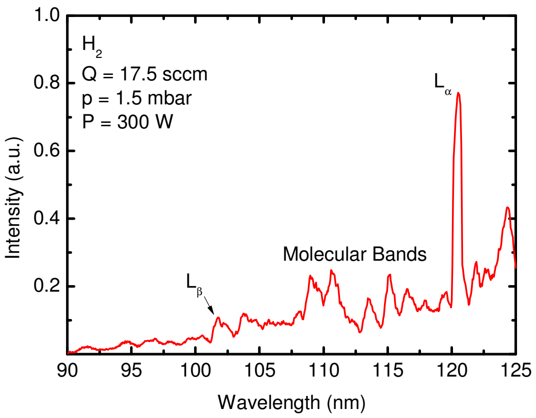

Fig. 2: UV spectrum emitted by microwave hydrogen plasma

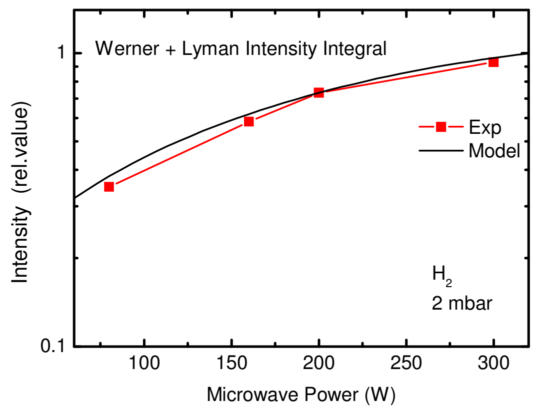

Fig. 3: Intensity dependence on microwave power

Conclusions

The microwave discharge driven by surface waves investigated in this work has been shown to be an attractive source of ultraviolet radiation for potential use in many applications.

Acknowledgements

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