EUV Radiation from Hydrogen Containing Microwave Plasmas

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The development of suitable extreme ultraviolet (EUV) light sources is of great importance in many applications ranging from photochemistry to astrophysics. To this end, the EUV emission spectra radiated by microwave discharges (2.45 GHz) driven by surface waves operating in He and H_2 gas at low-pressure (0.1 – 2 mbar) is investigated.

A surface wave induced microwave plasma source is created using a waveguide surfatron based setup (Fig. 1). The microwave power is provided by a 2.45 GHz generator whose output power was varied from 80 to 300 W. The generator is connected to a waveguide (WR-340) system, which includes an isolator, directional couplers, a 3-stub tuner, and a waveguide surfatron as the field applicator [1]. The above system is terminated by a movable short-circuit, which allows the maximization of the electric field at the launcher position. The discharge takes place inside a quartz tube with internal/external radii of 1.5/2.5 mm, which is inserted perpendicularly to the waveguide wider wall. 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 has been detected by a Horiba Jobin-Yvon Plane Grating Monochromator working in the 8 to 125 nm range. The VUV spectrometer is connected to one of the tube's ends. A differential pumping system allows the pressure inside the spectrometer to remain low (10^{-4} - 10^{-5} mbar) compared with the pressure inside the tube while granting that the line-of-sight of the spectrometer is unobstructed along the axis of the discharge.

The variations of the ultraviolet (UV) spectrum in the range 10 – 120 nm with changes in pressure and microwave power delivered to the launcher have been investigated.

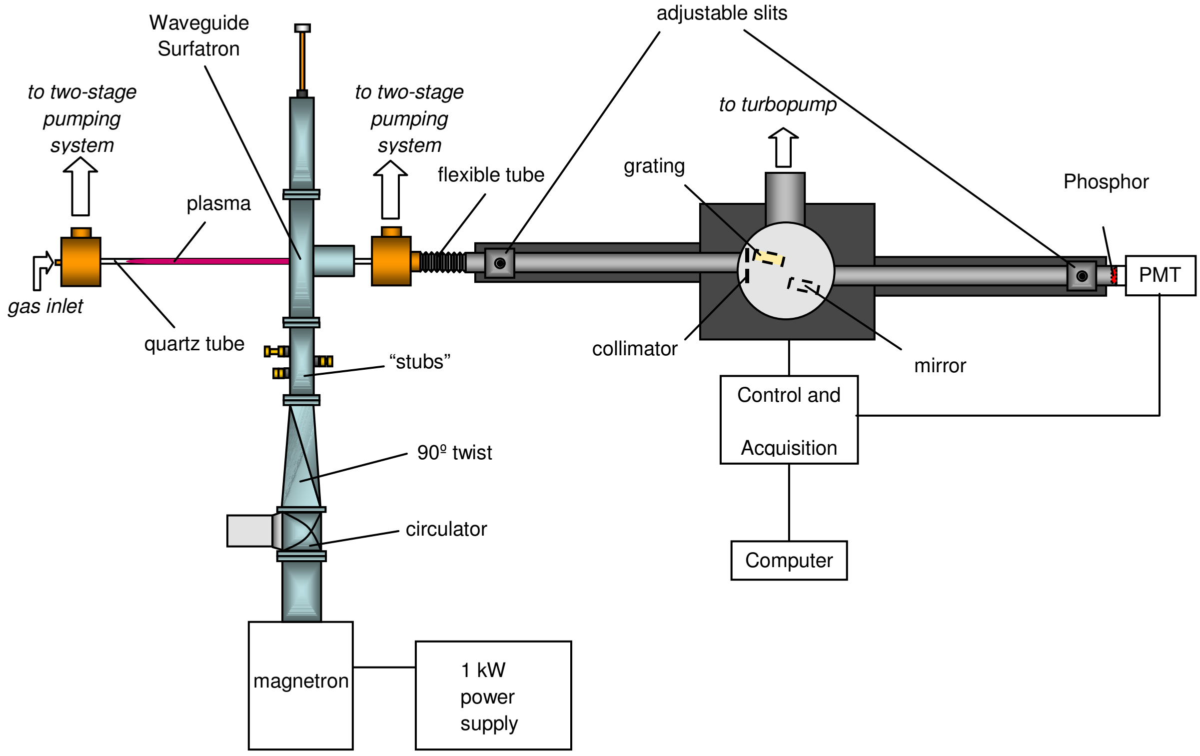

Fig. 1: Schematic representation of the experimental setup.

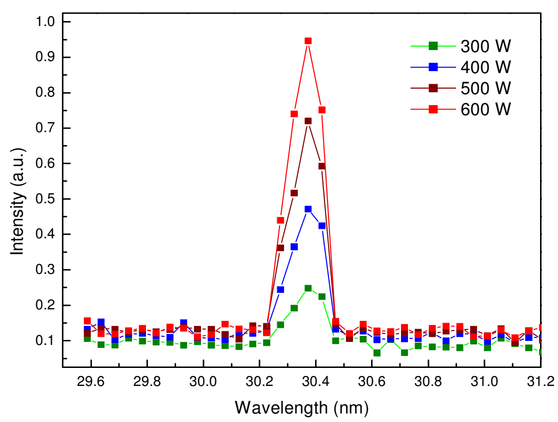

Fig.2: 30.4 nm line of HeII for different values of applied power.

Measurements of the EUV radiation from pure He plasma have been performed in order to optimize the measuring setup. As seen in Figure 2 the intensity of the well-known 30.4 nm line of HeII [transition $H^{2+}(^2S - ^2P°)$] strongly increases when the microwave power delivered to the launcher increases.

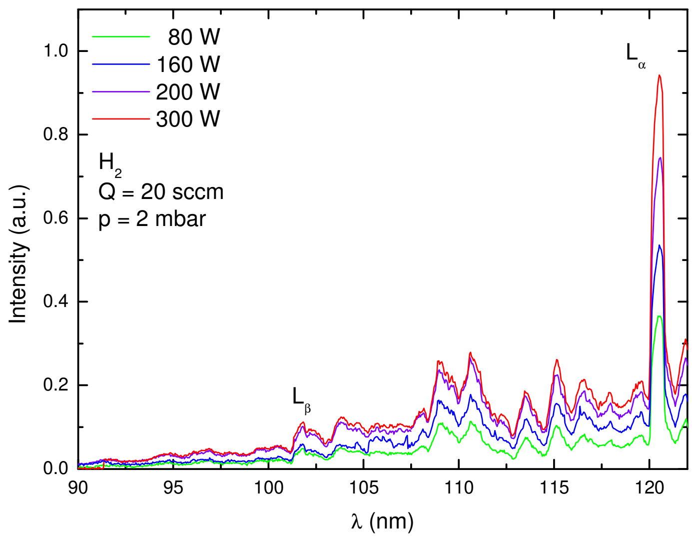

Fig. 3: UV emissions of H_2 plasma at different microwave powers.

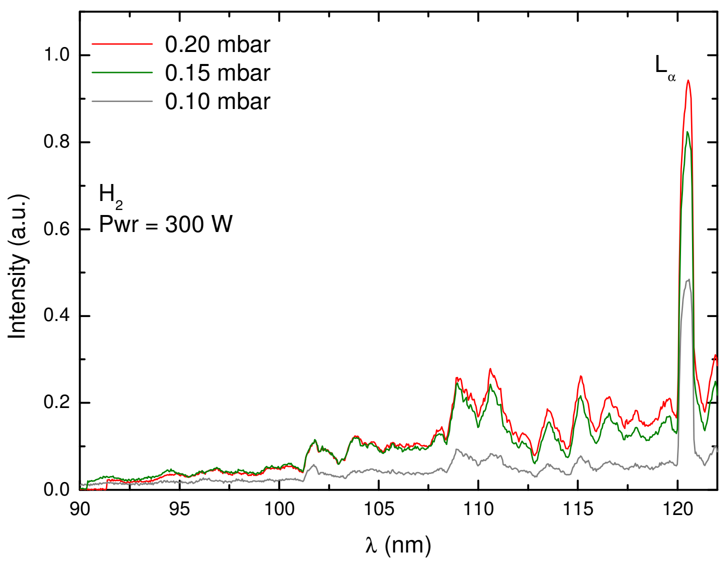

Fig. 4: UV emissions of H_2 plasma at different pressures.

The detected ultraviolet emission spectra of pure hydrogen plasmas at constant pressure and microwave power ranging from 80 to 300 W are shown in Fig. 3. The Lyman α and β lines of atomic hydrogen at 121.6 nm and 102.6 nm due to the transitions from n = 2 and n = 3 to n = 1, respectively, can easily be seen in the detected spectra (they are marked with L_α and L_β).

The L_α intensity increases nearly three times as the microwave power increases from 80 to 300 W. Strong emission of $H_2(C^1\Pi_u \rightarrow X^1\Sigma_g^+)$ Werner and $H_2(B^1\Sigma_u^+ \rightarrow X^1\Sigma_g^+)$ Lyman molecular bands in the range 100 – 120 nm also appear in the spectra of pure H_2 plasma. The integral intensity of these molecular bands also increases with microwave power as seen in Fig. 3.

The radiated spectra at constant microwave power and different pressures are shown in Fig. 4. A twofold increase in L_α intensity is observed when the pressure increases from 0.1 to 0.2 mbar. The same increase in Werner and Lyman molecular band intensity can be noted.

Simultaneous measurements of Balmer series lines corresponding to the transitions H (n=11) $\rightarrow$ H(n=2) show that the emission of H_α H_β, H_γ, H_δ, H_ε, H_ζ , H_η and H_θ lines strongly increases with microwave power.

Acknowledgements

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References

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