Detection of energetic hydrogen atoms in a pulse glow discharge

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Time resolved spectroscopy of Balmer alpha line is used to investigate the occurrence of energetic hydrogen atoms in a pulse glow discharge. It was found that excessive Doppler broadening and corresponding energetic atoms are present in the period of high current and also after the termination of discharge current.

Hydrogen Balmer lines that are excessively Doppler broadened have been detected in various types of discharges during the last two decades (see Ref. [1] and references therein). This phenomenon is also found in plasma fusion experiments. Namely, widely broadened profiles have shown the presence of hydrogen atoms with high kinetic energies, up to several hundreds of electronvolts. The origin of this effect is usually explained using the collision model (CM) or field acceleration model (FAM) [1-5]. Hydrogen ions (H^+, H_2^+, H_3^+) are accelerated in the electric field and undergo charge exchange reactions thereby generating energetic H atoms. Also, ions are backscattered from the cathode as fast hydrogen atoms after undergoing neutralization and fragmentation. Energetic atoms reach high energy and are efficiently exited in collisions with the bulk gas [5]. The results of multibeam model calculation were compared to experimental results [1]. Recently, we have examined the influence of cathode with low atom reflection [6] and influence of discharge conditions [7] on energetic H atoms in an abnormal glow discharge.

We present here the preliminary experimental results of Hα line measurements from a pulse glow discharge, to investigate the excitation and properties of fast H atoms. The used glow discharge source is of the Grimm type described in detail elsewhere [8]. The discharge image was projected by achromatic lens to the entrance slit of Echelle type monochromator equipped width a two-dimensional ICCD (PI-MAX2, Princeton Instruments) with 1024×1024 pixels. Details of the experimental setup are the same as for the DC case in Ref. [7]. The spectrum was recorded in direction of observation along the cathode surface normal (end-on). The discharge is driven by a laboratory made pulse voltage power supply at

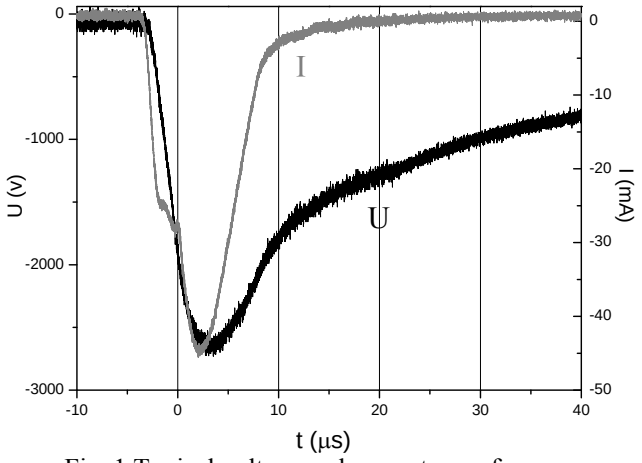

Fig. 1 Typical voltage and current waveforms of pulse glow discharge at 2 mbar pressure.

frequency of 630 Hz. Discharge voltage is measured via P6015A Tektronics voltage probe while current is monitored by measuring the voltage across a non-inductive resistor connected in series with the discharge. Discharge voltage and current were monitored using Tektronics TDS 3032 oscilloscope.

Typical waveforms for current and voltage at 2mbar pressure are given in Fig. 1. The current increases with voltage but stalls after the initial rise. After a short period of almost constant value, current continues to increase following the voltage increase. The discharge exhibits abnormal voltage-current characteristics with values expected for the Grimm discharge. Balmer alpha emission was measured at different time instances of discharge development so that the time resolved line profiles are obtained. Three characteristic line profiles obtained at the raise of the current, maximum current and after the current extinguishes are given in Fig. 2. Temporal development of Hα radiation coincides with current time development reaching maximum at the moment of the maximum current 2.5 μs at Fig. 1. As can be seen in Fig. 2, the wings of the profile coming from collisional excitation of energetic atoms are present in the early phases of discharge development. It is interesting to note that line profile is excessively broadened even in the afterglow - after the current termination. This is probably the consequence of applied voltage still being present in the time where current signal drops to negligible values. As described in [7] energy distribution of excited fast H atoms may be obtained from the red wing of broadened line profile, representing atoms approaching the cathode. Thus obtained distributions for the mentioned three time instances are given in Fig. 3. Distributions in the period of high current exhibit almost the same shape and maximal energy, while energies of H atoms are somewhat reduced in the period of zero current, as may be expected from the voltage values.

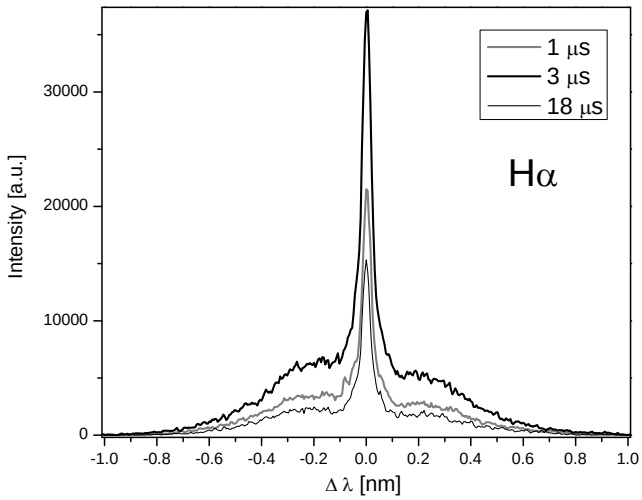

Fig. 2 Balmer alpha profiles at different times of discharge pulse at 2mbar.

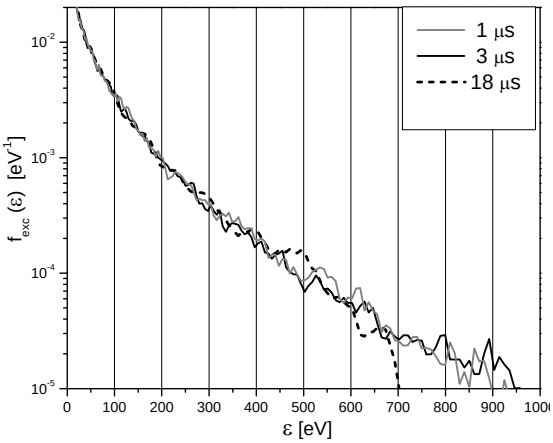

Fig. 3 Energy distributions of fast H atoms obtained from the red wing of Hα profiles.

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