Optical Diagnostics of Ne plasma with trace amount of O_2/H_2 molecules

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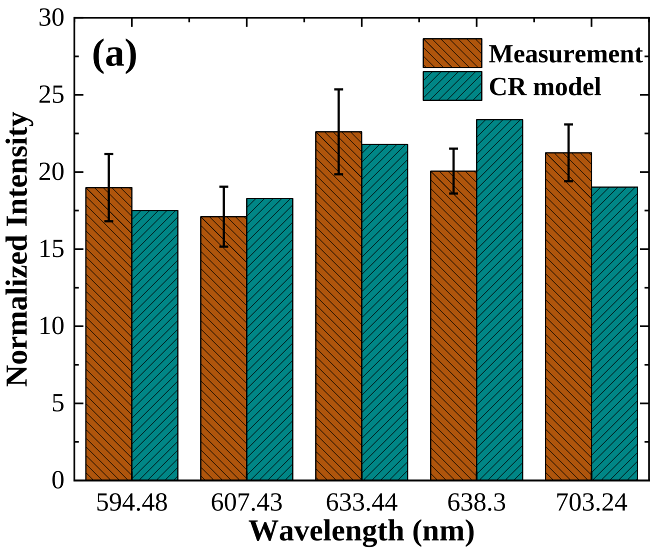
Abstract

Small amount of molecular gases (O_2, H_2, N_2 etc) are admixed with the rare gas discharges to improve the plasma characteristics and make it suitable for various applications i.e., enhanced-chemical vapour deposition, plasma etching, sterilizing bacteria, and biomedical applications [1]. Most of these applications utilizes molecular admixture with argon plasma. However, neon plasma can be more efficient than argon in some of applications [2]. Considering these applications here we produce capacitively coupled neon plasma with small admixture of O_2/H_2 molecule and perform its diagnostic using the non-invasive optical diagnostic approach [3]. In this approach, we have developed a suitable collisional radiative (CR) model and coupled it with optical emission spectroscopic (OES) measurements for different mixture concentrations of Ne-O_2 and Ne-H_2 plasma. The plasma has been generated in a 2.11 litre vacuum chamber using 13.56 MHz rf frequency capacitively coupled system. The admixture content of O_2 has been varied from 3.23% to 1.23% in Ne-O_2 discharge, whereas content of H_2 has been varied from 4.76 % to 1.84% in Ne-H_2 discharge. It has been achieved by keeping O_2 and H_2 flow rates fixed at 0.01 and 0.015 LPM. respectively, and varying neon flow rate as 0.3, 0.4, 0.5, 0.6, 0.7 and 0.8 LPM. We develop the CR model considering various collisional and radiative processes viz. electron impact excitation, de-excitation, radiative decay, self-absorption, ionization, recombination, quenching and the diffusion of metastable states. To incorporate the electron impact collisions efficiently, our self-calculated cross-section data using RDW approach has been used in the model [4]. Using developed CR model, the plasma parameters are extracted by comparing the neon line intensities as shown in Fig.(a). Electron temperature (as shown in Fig.(b)), electron density, metastable populations are extracted. The line emission intensities from oxygen and hydrogen atoms as well as self-absorption factor are also presented and discussed.

References:

1. Barreca et al. 2008 *Thin Solid Films* **516** 7393
2. Furukawa et al. 2020 *Surfaces and Interfaces* **18** 100402
3. Baghel et al. 2022, *J. Phys. D. Appl. Phys.* **55** 295201
4. Baghel et al. 2019 *Plasma Sources Sci. Technol.* **28** 115010



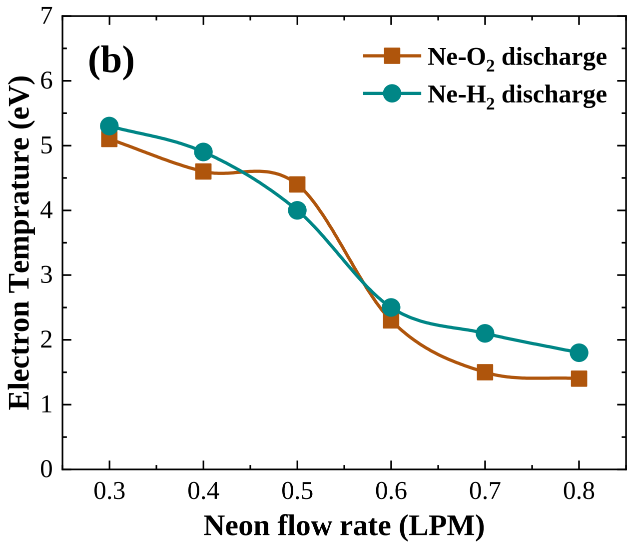


Fig. (a) Comparison of OES measured and CR model calculated intensities of selected Ne Lines in Ne-O_2 mixture plasma for Ne and O_2 flow rate as 0.7 LPM and 0.010 flow rate respectively **Fig.(b)** Variation of electron temperature with Ne flow rates in Ne-O_2 and Ne-H_2 mixture plasma where O_2 and H_2 flow rate was fixed as 0.010 LPM and 0.015 LPM respectively.