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Determination of Electron Temperature in Plasma, and Influence of Plasma Chemistry by Spectroscopy

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Abstract: ***Plasma is finding interest in interest in a very large number of applications and are becoming more and a lot of exploitable in already established plasma fields like in material method. This trend in plasma science is in the main due to a bigger info of the behavior of laboratory and technological plasma. Altogether likelihood one of the foremost vital plasma parameters is delineate by the electron energy distribution operate the EEDF. The EEDF is solely depicted by one parameter, the negatron temperature (Te) when electrons assume a Maxwell-Boltzmann energy distribution. The main aim of this thesis is to study the way to deduce from the Langmuir probe measurements at .5, 0.9 and 1.55 m bar is preparing to the lepton density. This might be coherent with the electrical quasi-neutrality property of the plasma. In N2–CH4 plasma, a solid insulating film is deposited on the probe surface such the probe should be clean once every measure. Consequently, entirely many probe characteristics square measure recorded. We have a tendency to square measure aiming to show the particle density measurements obtained in associate prodigious plasma with a try of CH4 among the gas mixture, for two all utterly completely different pressures: zero.4 and 0.9 m bar. A method is depicted for determinative the electron temperature of non-aggressive plasma of the type used in physical science materials method. tiny low quantity of Associate in Nursing equal mixture of He, Ne, Ar, Kr, and Xe is any to the tactic gas (in this example Cl2) and conjointly the intensities of optical emission lines from the Easter 2p levels of the rare gases square measure recorded.***

Keywords: Plasma, Actinometry, Temperature, Pressures. Chemistry

1. Introduction

Plasma is a part of an analysis that has consumed and impressed over thirty-five years of the author's skilled activities. Throughout this era, plasma chemistry has become a quickly growing space of scientific endeavor that holds great promise for sensible applications for industrial and medical fields. Plasma has become an omnipresent component that pervades several aspects of our lives, as an example, the general public is cognizant of plasma TV, fluorescent lamps, and plasma thrusts, further as popular-culture ideas like plasma guns and plasma shields from Star Trek.

Since plasma is superb conductors, electrical potentials play a crucial role. The potential because it exists on the average within the area between charged particles, freelance of the question of however it is measured, is named the "plasma potential", or the "space potential". If an electrode is inserted into plasma, its potential can typically lie significantly below the plasma potential due to what's termed a Debye sheath.

1.1 Plasma as the fourth state of matter

Plasma is associate degree ionized gas, a definite fourth state of matter. "Ionized" means that a minimum of one electron isn't certain to associate degree atom or molecule, changing the atoms or molecules into charged ions. As temperature will increase, molecules become a lot of energetic and remodel matter within the sequence: solid, liquid, gas, and finally plasma that justify the title "fourth state of matter. Ionized gas is typically referred to as plasma when it's electrically neutral (i.e., the electron density is balanced by that of positive ions) and contains a big variety of the electrically charged particles, adequate to have an effect on its electrical properties and behavior. To be a lot of specific, most pc and cell-phone hardware is formed supported plasma technologies, not to ditch plasma TV.

We have a tendency to be attending to specialize in basic and sensible aspects of plasma applications to chemistry and connected. Additionally, to being necessary for several aspects of our daily lives, plasma IS estimated to represent over ninety-nine of the visible universe. Plasma occurs naturally, however, can also be effectively unreal in the laboratory and in business that provides Opportunities for various applications, together with atomic synthesis, natural philosophy, lasers, fluorescent lamps, and lots of others.

1.2 Applications in chemistry and related disciplines

- Temperatures of a minimum of some plasma parts and energy density can considerably exceed those in standard chemical technologies.
- Plasmas are able to manufacture terribly high concentrations of energetic and with chemicals active species (e.g., electrons, ions, atoms and radicals, excited states, and totally different wavelength photons).
- Plasma systems will primarily be aloof from physical science equilibrium, providing very high concentrations of the chemicals active species and keeping the bulk temperature as low as temperature.

These plasma options allow important intensification of ancient chemical processes, essential will increase of their potency and infrequently prosperous stimulation of chemical reactions impossible in standard chemistry. Plasma chemistry these days could be a rapidly increasing space of science and engineering, with applications widespread from micro-fabrication in physics to creating protecting coatings for aircraft, from a treatment of compound fibers and films before painting to the medical-surgical procedure for stopping blood and wound treatment, and from the production of gas to plasma TVs.

1.3 Influence of plasma chemistry on chemical element triplets

Plasma deposition, etching, associated surface modification are an integral a part of trendy technologies and cause several new challenges within the control of plasma chemistry. Particularly electronegative gas (like oxygen) plasmas attract abundant attention, in applications associated with a surface process, at air pressure, environmental studies for disposal gas improvement and lots of others. Oxygen plasma has found various applications in plasma process like reactive sputtering, dry etching of polymers, oxidation, and resist removal in a semiconductor producing. Particularly associate chemical element plasma generated with RF discharges has been found to be terribly effective for plasma etching, surface activation, cleaning, and oxidization of different materials. Oxygen plasma is physical science during a non-equilibrium gas part, excited particles tend to de-excite, usually by photon emission. Optical emission spectrographic analysis (OES) will be a strong tool for plasma medical specialty.

The emitted radiation intensity depends on the character of the excited states. Radiation from metastable states, as an example, is typically not ascertained, whereas the strongest emission is commonly observed from atomic transitions, chemical element atoms are shaped in chemical element plasma primarily by 2 competitive processes; negatron impact dissociation and divisible attachment. The density of excited atoms depends on the assembly and loss rates. Whereas the assembly rate depends solely on the negatron temperature and density, the loss rate depends on various parameters, together with the pressure, the characteristics of the discharge chamber, and also the material properties of the plasma boundary.

1.4 Electron temperature determination by OES

Optical emission spectroscopic analysis (OES) is that the most popular technique to research gas discharge (plasma).Since it's a straightforward technique which it produces no perturbation within the plasma. There are three models of plasma based on the mechanism of electronic interaction.

- The fixed crown model, the time-based crown model.
- The local thermal equilibrium model (LTE)
- The collision radiation model.

Three strategies are available for electron temperature measuring, these are:

1) The magnitude relation of two lines' intensity.
2) The magnitude relation of a line to time intensity.
3) The magnitude relation of two components of time intensities.

The simplest and most direct technique of exploitation spectral line intensities to work out the temperature of plasma is to use the relations existing between the strengths of the lines, when atomic state densities are in equilibrium, so as to work out the electronic by exploitation the relative between two spectral lines, it's essential to contemplate plasma within the thermodynamic (LTE).

LTE primarily strains the ionization processes and excitation are created solely by electron impression. The temperature and electronic plasma density to be (ne ≥ 1014 m -3 and Te < 1 ev), see Fig (1)

In these work circumstances were "cold" electrons. The electron temperature is calculable by using the strength quantitative relation of some emission lines labeled 1 and 2 in flowing equation:

$$\frac{I_1}{I_2} = \frac{A_1 g_1 \lambda_2}{A_2 g_2 \lambda_1} exp\left(-\frac{E_1 - E_2}{kT_e}\right) \quad (1)$$

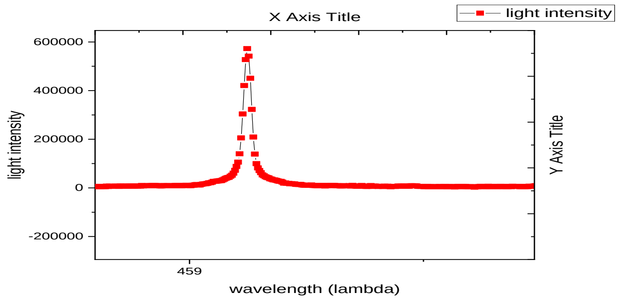

Figure 1: The electronic plasma density and temperature to be ne ≥ 1014 m $^{-3}$

where I1, I2 are the intensities of two spectral lines, A1, A2 are the transition probability of two spectral lines, see in Fig (1), Fig (2) λ1, λ2 are the wavelength of two emission lines, $g1$, $g2$ are the statistical weights of two spectral lines, E1, E2 are the upper level energies of the transitions of the producing two spectral lines and k is the Boltzmann constant. Extracting Te from Eq.:

$$kT_e = \frac{E_1 - E_2}{Ln\left(\frac{I_2}{I_1}\right) - Ln\left(\frac{A_2 g_2 \lambda_1}{A_1 g_1 \lambda_2}\right)} \quad (2)$$

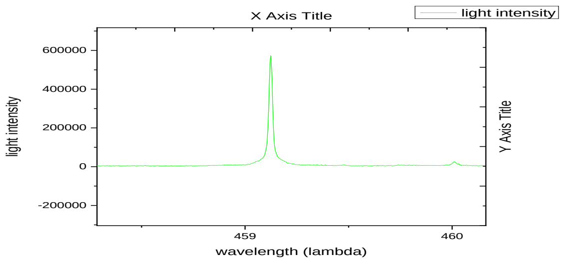

Figure 2: λ1, is the wavelength of two emission lines

2. Results and Discussion

In a pure N2 plasma, the particle density, deduced from the chemist probe measurements at .5, 0.9 and 1.55 mbar is with reference to the electron density, this may be coherent with the electrical quasi-neutrality property of the plasma. In N2–CH4 plasmas, a solid insulating film is deposited on the probe surface such the probe should be clean when every mensuration. Consequently, completely many probe characteristics square measure recorded. Figure one shows the particle density measurements obtained in a particularly plasma with an attempt of CH4 among the gas mixture, for two altogether fully completely different pressures: zero .4 and 0.9 mbar. Here again, the chemist probe provides a value of positive particle density nearly up to the lepton density.

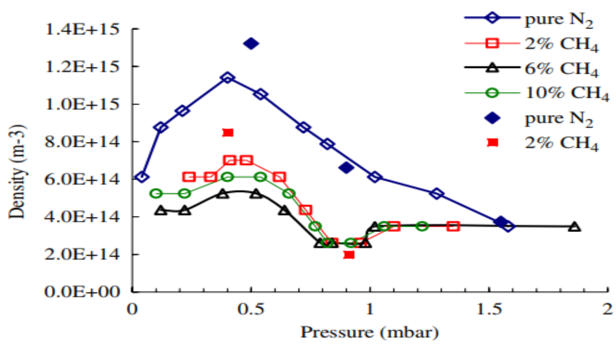

Figure 3. Electron and ion densities as a function of pressure in pure N2 and in N2–CH4 plasmas.

The electron temperature is set from the slope of Boltzmann's plot that uses the intensity of many spectral lines versus their corresponding excitation energies. it's ascertained that electron temperature is higher once optical emission is recorded in axial direction as compared with radial direction .The electron temperature was measured by victimization spectrographic analysis. We tend to elite 2 spectrum (696.54nm and 772.37 nm), these spectrum were clearly distinguished. We tend to calculate the electron temperature to be 0.66 ev by victimization the Ludwig Boltzmann technique.

Optical measure

An inert tracer gas of identified concentration nongovernmental organization may be supplemental to the feedstock to produce quantitative info on the unconventional density Na (Coburn and subgenus Chen, 1980). We select an excited state of the tracer T that has nearly an equivalent excitation threshold energy, the emission wavelength is:

$$\lambda = \frac{2\pi c}{\omega}$$

$$\text{where} \quad \hbar\,\omega = e(\mathcal{E}_{A^*} - \mathcal{E}_f).$$

$$\frac{\Delta\lambda}{\lambda} = \frac{v_{thi}}{c}$$

Let nA be the concentration of the atom A and let (in watts) be the optical emission intensity, integrated over the line width. The mission due to excitation from the bottom state A will be written as:

$$I_\lambda = \alpha_{\lambda A} n_A$$

Where

$$\alpha_{\lambda A} = k_D(\lambda) \int_0^\infty 4\pi v^2 dv\, Q_{A^*}(p, n_e)\sigma_{\lambda A}(v) v f_e(v)$$

The two cross sections are related by.

$$\sigma_{\lambda A} = b_\lambda \sigma_{A^*}$$

Also shown, with the overlap shown as the shaded area. For the tracer gas,

$$I_{\lambda'} = \alpha_{\lambda' T} n_T$$

With

$$\alpha_{\lambda' T} = k_D(\lambda') \int_0^\infty 4\pi v^2 dv\, Q_{T^*}(p, n_e)\sigma_{\lambda' T}(v) v f_e(v)$$

We then take the ratio to obtain

$$n_A = C_{AT}\, n_T \frac{I_\lambda}{I_{\lambda'}}$$

3. Summary

We believe that the little variations in intensities that seem between the numerically generated spectra and measured spectra are due to the modification in spin orbit constant as J will increase and therefore the manifolds modification their character, a wonderful reproduction of the measured spectra is obtained for all three bands the arrogance level being higher than ninety fifth. Examples of measured vibrational band spectra and therefore the corresponding fits. Another interesting initial result is that the gas temperature is higher in the inductively coupled regime than capacitive coupled regime. This observation is most likely explained by improved efficiency in coupling the power into the discharge in the H mode compared to the E mode.

The gas temperature measure technique delineated employs fits to careful qualitative analysis measurements of the 0-0, 1-0, and 2-0 emission bands of the primary positive system of N2. Initial tests of the technique obtained nearly identical results once any of the three bands of the primary positive system were used in the analysis. A technique is pictured for determinative the electron temperature of a non-aggressive plasma of the kind used in natural philosophy materials method. little ow amount of Associate in Nursing equal mixture of He, Ne, Ar, Kr, and atomic number 54 is any to the manoeuvre gas (in this instance Cl_2) and collectively the intensities of optical emission lines from the Easter 2p levels of the rare gases area unit recorded. Whereas the truth of the tactic is foretold to be high, the accuracy of *Te* determined from optical emission would probably be improved with further correct cross section data implications or actinometry determination of species concentrations in plasma is in addition mentioned, a correct determination of gas temperature victimization this analysis technique requires:

1) A measure of the spectrum of one or additional of the 3 bands.
2) Determination of the parameters p and w for the prism spectroscope by employing a temperature lamp to record a spectral line within the relevant spectral vary that's then work with equivalent weight.
3) Use of a regular intensity standardization lamp to correct for the optical system wavelength sensitivity.

While the exactitude of the method is predicted to be high, the accuracy of *Te* determined from optical emission would doubtless be improved with additional correct cross section information implications for actinometry determination of species concentrations in plasma is additionally mentioned.

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