Characterization of Plasma Conditions for Reactive Pulsed DC Magnetron Sputtering System

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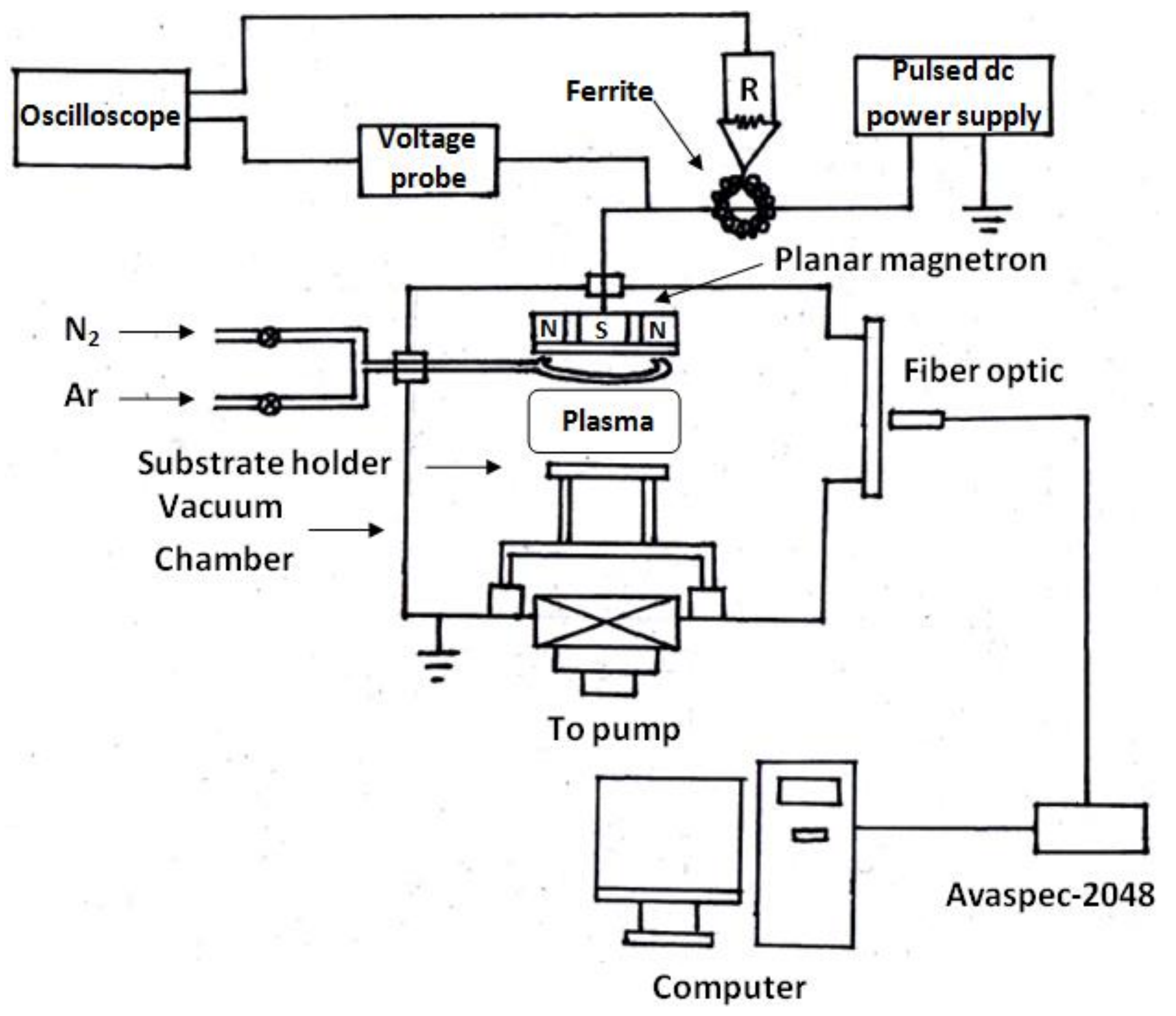
Abstract

Reactive pulsed dc magnetron sputtering technique is highly effective in thin film deposition, particularly thin film of dielectric materials. In this work, we design and set up reactive pulsed dc magnetron sputtering system for deposition of Titanium Nitride (TiN) and Titanium Nitride-Hydroxyapatite (TiN-HA). Proper plasma conditions for deposition are analyzed using the optical emission spectroscopy. In this experiment, the pulsing parameters (frequency and duty cycle) and glow discharge parameters (voltage and pressure) are varied.



Figures 1. A schematic diagram of the reactive pulsed dc magnetron sputtering system with the optical spectroscopy (OES) system.

Materials and Methods

To characterize the proper plasma conditions, plasma spectra from the OES technique was investigated by considering the relationship between the chemical composition of plasma and the electron temperature (Te) to sputtering pressure, discharge voltage, duty cycle, frequency and the content of nitrogen gas.

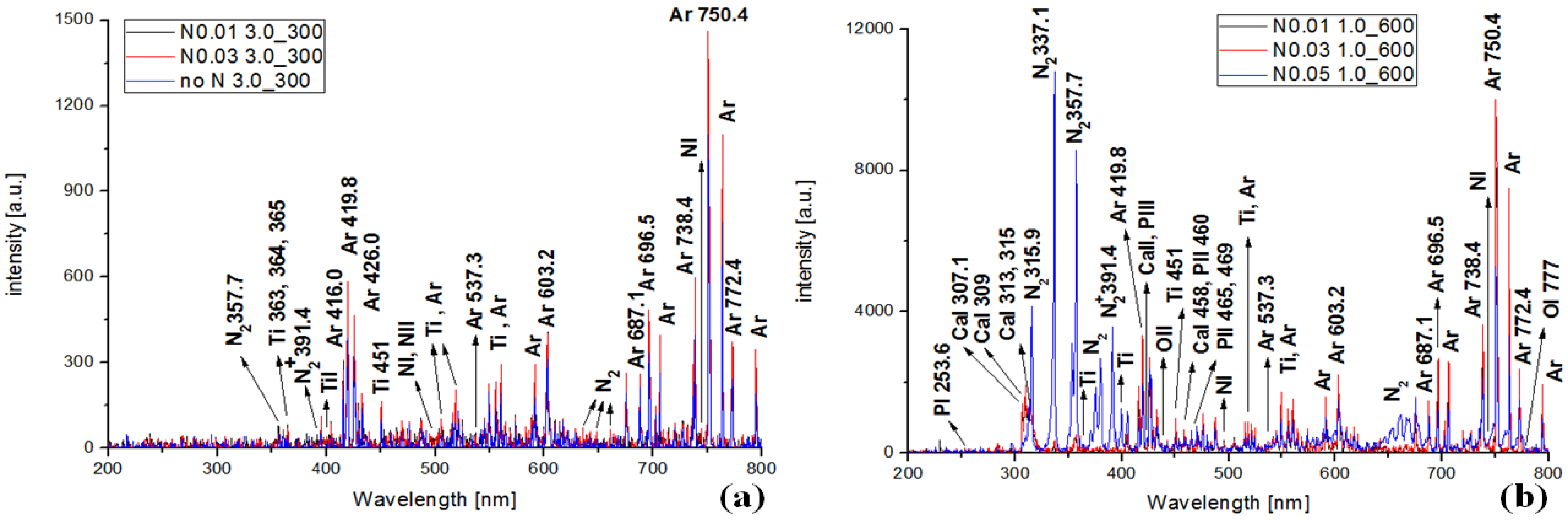
So, the pulsing parameters (frequency and duty cycle) and glow discharge parameters (voltage and pressure) are varied.

A schematic diagram of the experimental setup with the optical spectroscopy (OES) system is shown in **Fig. 1.**

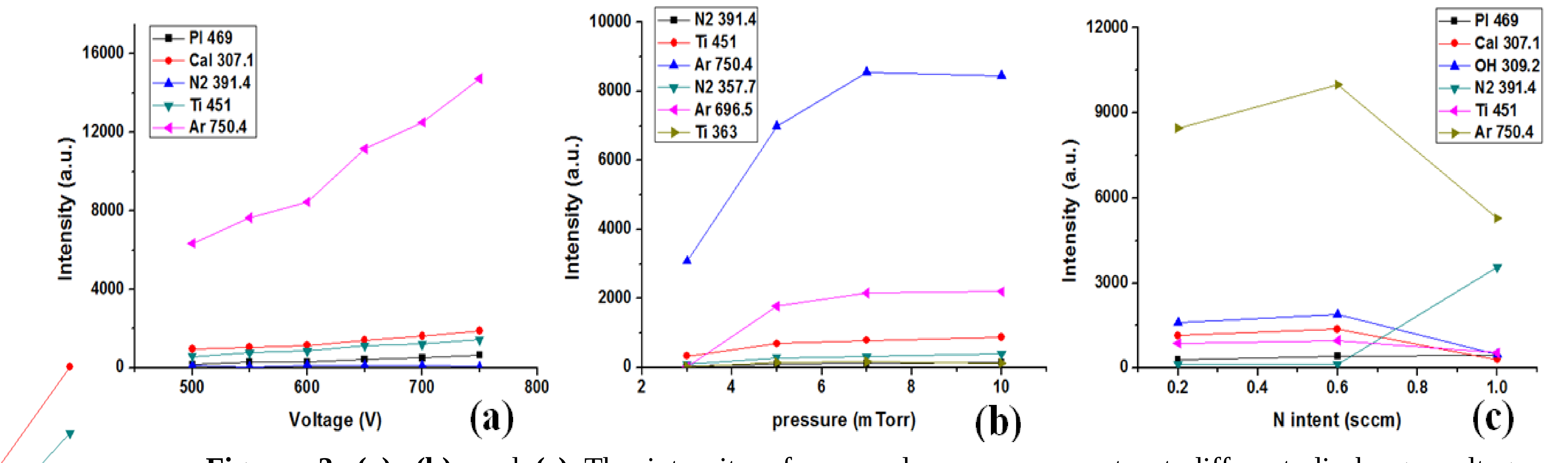
Introduction

For high quality thin films, the plasma parameters during the deposition in the magnetron sputtering system are important to investigate the relations between the characteristics of deposited films and the plasma process properties. The optical emission spectroscopy (OES) technique based on recording light emitted (photon energy) from the excited particles in the plasma chamber. The energy is a characteristic of the particle species then the analysis of photon energy can show the plasma composition. Furthermore, the OES measurement can analyze the electron temperature in order to study the effects of the control parameters on the plasma processes.

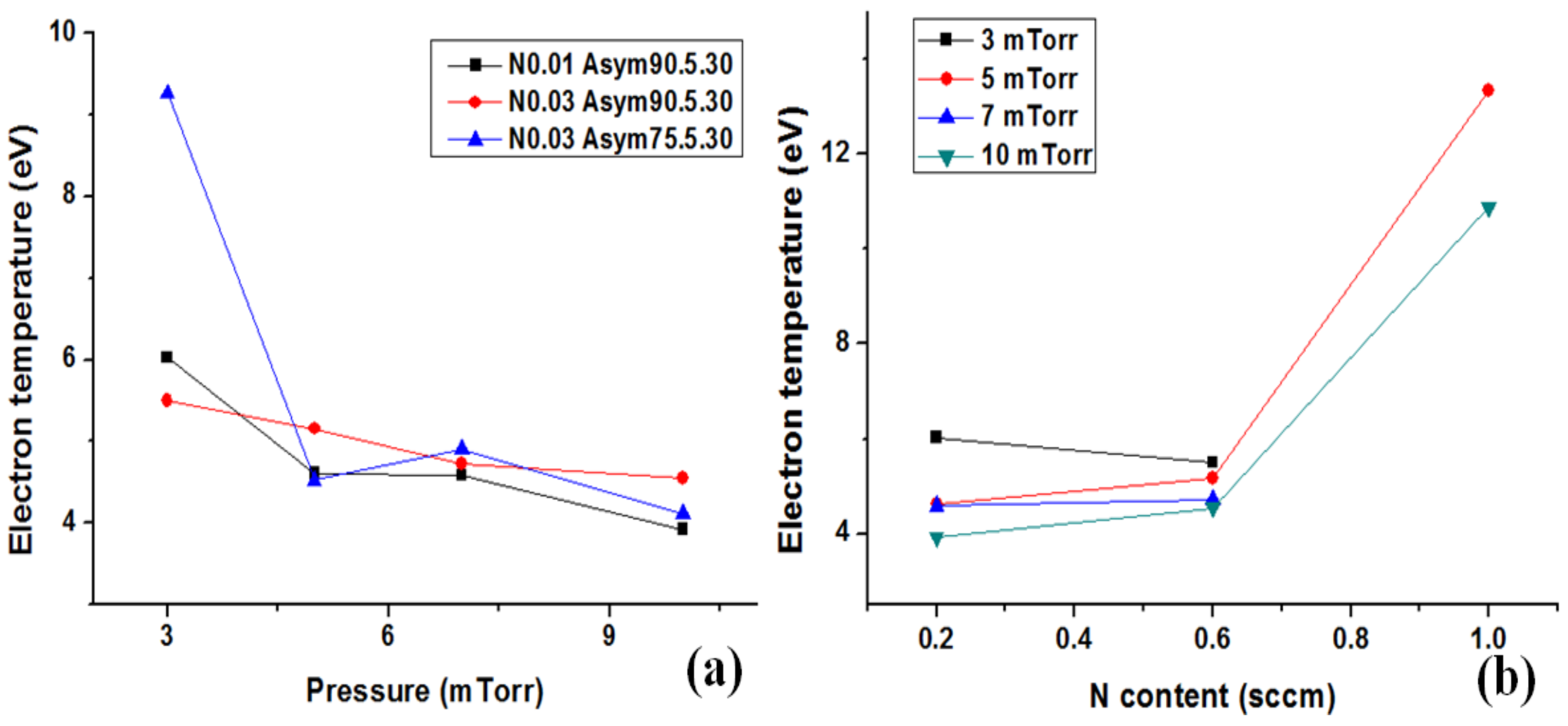
Result and Conclusions



Figures 2. (a) The spectra of Ar-N_2-Ti at p=3 mTorr, V=300 V and varies N_2 content (no N_2 add, 0.2 and 0.6 sccm), **(b)** The spectra of Ar-N_2-Ti-HA at p=10 mTorr, V=600 V and varies N_2 content (0.2, 0.6 and 1.0 sccm).
* N0.01, N0.03 and N0.05 are the N_2 content 0.2, 0.6 and 1.0 sccm respectively.



Figures 3. (a), (b), and **(c)** The intensity of some plasma components at different discharge voltage, sputtering pressure, and N_2 content respectively.



Figures 4. (a), (b) The electron temperature at different sputtering pressure and different duty cycle, and at different N_2 content respectively.

The relation of intensity of plasma components increase with duty cycle, frequency, discharge voltage and N_2 content increases but decrease with raise the N_2 content to 1.0 sccm unless the intensity of nitrogen increase (**Fig. 2** and **3**). In the part of electron temperature increases with N_2 content increased and decrease with the sputtering pressure and the frequency increased. In addition, the electron temperature was highest at the sputtering pressure equal to 3.0 mTorr of all plasma conditions (**Fig. 4**). And the intensity of all components in the plasma raise maximum at 0.6 sccm of N_2 content.

So, we can estimate range to the deposition conditions for the high deposition rate as follows:

For TiN films, range of discharge voltage is 300 – 400 V. The sputtering pressure and duty cycle are 3 mTorr and 80% or more respectively. The frequency is 30 – 50 kHz and the N_2 content less than 1.0 sccm.

For TiN-HA films, range of discharge voltage is 500 – 700 V for the sputtering pressure at 3 - 7 mTorr and if the pressure more than 7 mTorr that can use the voltage below 500 V. The duty cycle is 80% or more. The frequency is 30 – 50 kHz and the N_2 content less than 1.0 sccm.

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