CHAPTER 5

CONCLUSION AND SUGGESTIONS FOR FUTURE WORKS

5.1 Conclusion

A planar coil inductively coupled plasma system has been constructed. The system is powered by a 600 W, 13.56 MHz RF generator utilizing a matching network consisting of a transformer and variable vacuum capacitor. The system is used for nitradation of pure titanium in argon-nitrogen admixture plasma. The general behavior of the E to H mode transition characteristics of inductive discharge is studied in argon only and in argon-nitrogen admixtures.

For investigation of coil current during E to H mode transition in argon and argon-nitrogen admixture plasmas, a Rogowski coil is used. The changes of the coil current corresponding to the RF power applied exhibit hysteresis behavior. It is found that increasing the nitrogen pressure in the chamber required a higher power for E to H mode transition.

The emission intensity of the plasma is also investigated. Increasing the nitrogen pressure in the chamber has been found to reduce the Ar line intensity. It is found that a suitable balance in nitrogen atoms and Ar is essential for efficient plasma nitriding process.

The application of substrate bias is found to be beneficial in aiding the nitridation process. Nitriding at lower bias voltage (0 to –500 V), generally gives lower nitridation efficiency. The desired δ-TiN phase is formed when nitriding is done at higher bias voltage(-1000 V and –1500 V). However, nitriding at –1500 V is accompanied by a microstructural change of titanium.

Nitradation of titanium by RF plasma has been found to improve the mechanical and tribological properties of titanium. The nitrided titanium at bias voltages of -1000 V and –1500 shows more than 4 times improvement in surface hardness over the untreated titanium and the wear resistance properties of titanium has also been improved. The surface roughness of nitrided titanium has been shown to be a function of the bias voltage or ion bombardment intensity.

In conclusion, it has been proven that RF planar coil plasma with the aid of substrate bias is capable of nitriding titanium to alter its mechanical, chemical and tribological properties.

5.2 Suggestions for Future works

During the course of the project, one important aspect that has been overlooked is the substrate temperature. Knowledge of substrate temperature is important , since the formation of nitrides phases is strongly related to temperature. It is proposed that for future experiment, a thermocouple embedded directly into the substrate is used, to measure the actual substrate temperature. In this way, the relation between substrate temperature and nitride formation can be established. The aspect of nitriding time in relation to nitriding depth at different process temperature should also be investigated.

It is also proposed that the DC bias voltage is replaced by High Voltage pulsed power supply. By operating at high voltage, nitrogen can be implanted into the substrate, and this can be beneficial in promoting nitriding efficiency.

In our experiments, we have proven that argon-nitrogen pressure used is also important in the nitriding process. It is desirable to have a throttle valve placed between the chamber and the pumping station. With this, the pressure inside the chamber can be regulated by adjusting the opening of the valves while maintaining the argon-nitrogen ratio inside the chamber. Gas delivery control should be improve by means of mass flow controller to give a more precise control over the amount of gas flowing into the chamber.

Since plasma method offers great flexibility, many other diffusion processes can be attempted by using the current system. Addition of methane into argon-nitrogen atmosphere will produce a layer consisting of carbonitride compound. By using argon-methane admixture, carbides can be produced. A duplex surface treatment, consisting of the application of PVD or CVD coating over a nitrided sample should also be explored.