CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Several studies had been carried out on the simulation of the electrical discharge of the nitrogen gas laser. The most common method that had been applied is to assume that the electrical discharge can be replaced by an inductive and resistive elements (Persephonis *et al.*, 1993, 1995a, 1995b, 1998; Fitzsimmons, 1976). By solving the classical differential circuit equations together with the parameters above, the discharge behaviors of the circuit can be simulated. The results based on the time-dependent parameters such as the discharge gap voltage, the discharge current, electrons density and electrical field variation had been reported.

However, the lack of information of the plasma behavior will limit future investigations. Some of the previous studies are rather empirical in nature in assuming the inductive and resistive factors (Iwasaki and Jitsuno, 1982; Papadopoulos, 1990; Dipace, 1987). On the other hand, by assuming uniform electric field along the plasma column and assuming first order Townsend ionization effects, good results has been reported by Fitzsimmons (1976). However, these models face the limitation in assuming the uniform electrical field distribution which is not the realistic behavior of a column of plasma.

In order to capture the microscopic behavior of the gas medium and the fluid behavior of the plasma, a non-uniform electrical field model needs to be built. The first requirement of this model is to solve the fluid equations and coupled with the Poisson's equation. Spyrou *et al.* (1991, 1996) had successfully applied a high accuracy algorithm in solving these equations in order to model the discharge with non-uniform electrical field. This algorithm is called as the Flux-Corrected Transport (FCT), which was first introduced by Boris and Book (1973, 1975, 1976a, 1976b). The test results on this high accuracy codes for solving the continuity equations are reported too (Boris and Book, 1973, 1975, 1976; Morrow, 1981). Finally, the Sato's equation, which calculate the discharge current induced by the motion of the charged particles (Sato, 1980), enable the calculation of the dynamic resistance of the discharge channel with a non-uniform electrical field distribution.

This model will enable the study of the space charge effect and the cathode sheath formation. The study of secondary emission effects will also become possible too.

1.2 OBJECTIVE OF THE RESEARCH

The main objective of this study is to build a new computer model to simulate the space charge effect and the cathode sheath formation in the discharge medium of the nitrogen gas laser.

This computer model will simulate the discharge with a non-uniform electrical field and will enable the study of the fluid behavior of the plasma. Charge distributions in the medium and their motions are taken into the account. The microscopic view on the secondary emission properties at the cathode will be investigated also. The solution of the fluid equations is obtained by solving the Flux-Corrected Transport (FCT) algorithm. Its accuracies will be tested too. Comparison will be made between the new model and the earlier Fitzsimmons model. The electrical discharge characteristics will be studied and compared. The relationship between the formation of space charge effect and the electrical discharge characteristics will become one of the main objective in this study.

1.3 OUTLINE OF THE REPORT

This report consists of five chapters. The first chapter briefly outlines the background of this study and the objectives of this project. This will be followed by the literature review on the basic theory of the nitrogen laser and its previous modeling methods at the next chapter.

In Chapter 3, the present methods and the numerical solution of the model will be discussed.

In Chapter 4, the results on the electrical discharge characteristics of the nitrogen laser and the space charge effects will be discussed.

In Chapter 5, a summary of the results will be highlighted and conclusions will be made.