Chapter 1
Introduction

Photostrictive effect is a phenomenon in which strain is induced by incident light. This phenomenon was discovered independently almost at the same time in 1981 by Dr. P. S. Brody and Dr. Kenji Uchino.[1] When a photostrictive material is irradiated with photons, two response effects are triggered. The first effect which is photovoltaic effect, where a large voltage is generated in the material through the irradiation of light, has been widely studied. The photovoltaic effect mentioned here generates from the high band gap voltage (several kV/cm) which is quite different from that based on the p-n junction of semiconductors in solar cells. The second is converse-piezoelectric effect, where the material expands under the voltage which generated by the first effect. The figure of merit for photo-induced strain is defined as [2]

$$x_{ph} = d_{33} \times E_{ph} \quad (1.1)$$

where x_{ph} is photo-induced strain or photostriction
d_{33} is piezoelectric constant
E_{ph} is photovoltage

Photostrictive actuators have drawn considerable interests due to their high potential applications. With decreasing the size of miniature actuators, the weight of the electric lead wire connecting the power supply becomes significant, and remote control will definitely be required for sub-micrometers actuators. Not only it is promising as a candidate of micro-robot driven by photon energy but also possible for moving the specimens placed on a stage in high vacuum chamber of the scanning tunneling or electron microscopes without shutting down the system. These optical actuators in which the driving components are "electromagnetic-noise free" system, can be used in areas related to micromechanics, ultrahigh vacuum and space technologies.

Lanthanum-modified lead zirconate titanate (PLZT) ceramics have been investigated due to their promising photostrictive behaviors, superposition of photovoltaic and converse-piezoelectric effect. Photostrictive and photovoltaic properties generated in PLZT ceramics are strongly dependent on the wavelength of light illumination. Currently, it has been found that the peak response of suitable donor dopant such as W^{6+} is about 370 nm corresponding to the absorption edge of PLZT ceramics.[(1)] Due to the shorter-than-wavelength peak response, the light source using to activate the photostrictive mechanism requires the high power ultra violet (UV) lamp. This type of light source might be harmful to the investigators. In addition it is high cost and difficult to apply to commercial application.

The overall objective of the proposed research is to explore the potential of PLZT ceramics in providing the direct conversion from light energy to mechanical movement through the doping effect. A better understanding of an additive effect on this phenomenon is studied in order to fabricate high efficiency photostrictive ceramics with a capability to response towards the visible light which make them able to be used with another low cost light source, i.e. visible region LASER. This attempt will extend the photostrictive phenomenon to a wider range of applications.