Chapter One

Introduction

In the past 3 decades, glasses have been widely used in technology due to their many applications as monoliths, fibers, or coatings. Hence relative application is done in the field of wave-guide producing materials. There are well-known methods for producing glasses: melting, sintering, and sol-gel. The former consists of melting a mixture of inorganic compounds (oxides, carbonates, phosphates, etc) and quenching the melt, while the sintering implies the consolidation of amorphous powder to form pure glass. On the other hand, the sol-gel method consists of obtaining the sol by condensation of the precursors and gelation of this sol. The sol-gel method has some advantages with respect to melting.

The sol-gel procedure can employ inorganic salts or alkoxides as reagents. Precursor of SiO_2 is usually alkoxide due to its availability. The sol-gel process is a versatile solution process for making advanced materials, including ceramics and organic and inorganic hybrids. In general, the sol-gel process involves the transition of a solution system from a liquid "sol" (mostly colloidal dispersion) into a network of sols "gel" phase. Utilizing the sol-gel process, it is possible to fabricate advanced materials in wide variety of forms: thin film coatings, fibers, porous or dense materials and extremely porous aero-gel materials. Sol gel has produce a wide rage of compositions (mostly oxides) in various forms, including powders, fibers, coating, thin films, monoliths, composites and porous membranes.

The starting materials used in the preparation of the "sol" are usually inorganic metal salts or metal organic compounds such as metal alkoxides. In a typical sol gel-process, the precursor is subjected to a series of hydrolysis and polymerization reactions to form a colloidal suspension, or a "sol". Further processing of the "sol" makes it possible to make materials in different forms. With further drying and heat treatment, the 'gel' is converted into dense materials. The sol-gel process is a technique for making high purity glass using wet chemical reaction rather than traditional fusion mechanism. Al though heat treatment is required in sol-gel processing, the necessary temperature are far less than those required for making similar glass via fusion. Another advantage of sol-gel processing is that it avoids contamination from any type of melting container, since none in necessary.

Sol-gel processing is begins with a sol, which is colloidal suspension of solid particles less than 1 μm in size. The sol develop into a gel as the colloidal particles coalesce to form and interconnected network of polymerized solid with a continuous interstitial liquid phase. An acid or base catalyst may be added to the sol to accelerate polymerization. Use of a base catalyst generally leads to a three-dimensional monolithic gel, where as an acid catalyst normally encourages stringy two-dimensional structures suitable for thin film coatings. Sols are typically prepared using a metal alkoxide. Since metal organics are generally not soluble in water, the alkoxide is dissolved in anhydrous alcohol. Water helps the sol to allow polymerization reactions. The sol-gel polymerization process may be characterized by two main reactions: Hydrolysis and Condensation. In this project, a sol made with TEOS, the alkoxide used in this project for producing SiO_2 glasses.

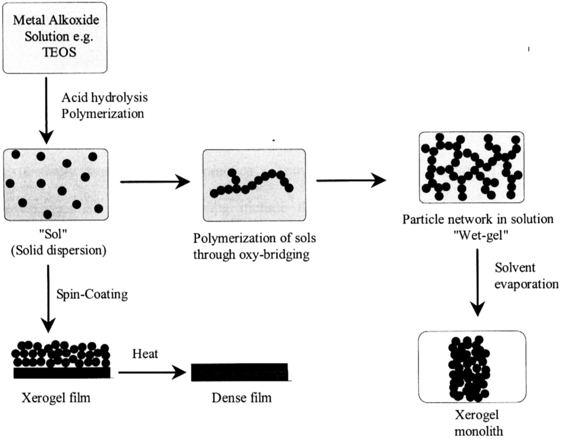

Figure 1: Process flow for the sol-gel silica thin-film fabrication