ULTRASONIC CHARACTERISATION OF SUPERIONIC AND OPTOELECTRONIC GLASSES

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Introduction

Fast ionic conduction (superionic) and optoelectronic glasses have drawn substantial interest in recent years because of their possible use as solid electrolyte and in optical data transmission and laser technology. Several studies have focused on phosphate and borate glass system combined with a metal halide due to their high ionic conductivities, thermal and mechanical stabilities and relative resistance to attack by moisture. Other phosphate glasses containing rare earth ions are potential glass laser materials. In addition, fluoride glasses particularly those doped with rare earth ions are promising candidates for the production of eye-safe microchip lasers for use as transmitters and detector amplifiers in laser radar systems and as transmitters in ultrahigh data rate communication system. At present, the characteristics of these glasses are still not very well understood. Further work needs to be carried out in order to obtain a better characterisation and understanding of the properties of these glasses.

Materials and Methods

Appropriate quantities of various AR/industrial grade chemicals are weighed and put inside a lided alumina crucible. The chemicals are mixed and heated at various high temperatures (up to 1000°C). The melts are then quenched by pouring them into metallic moulds to give cylindrical samples. These samples are then cut into appropriate sizes for various experimental measurements (Chow et al. 1996). The elastic properties of the samples can be studied by measuring the ultrasonic velocity of longitudinal and shear waves propagating through the samples using a pulse-echo overlap technique. The physical properties such as elastic constants, Young's modulus, bulk modulus and poisson ratio can then be evaluated (Sidek et al. 1998). As part of a comprehensive plan to study these glasses in more details, the electrical (ionic) properties of these glasses were also be investigated.

Results and Discussion

Several series of binary and ternary phosphate and borate glass systems have been synthesised and their elastic properties and ionic conductivity determined and compared. The densities of both and binary and ternary silver phosphate glasses increase linearly with the mole fraction. The density increment for the binary series is higher than the ternary series. The longitudinal and shear wave (ultrasonic) velocities for both the two series of glasses decrease with increasing contents of Ag_2O and AgI. All the elastic moduli (Young's modulus, bulk modulus and shear modulus) increase with the mole fraction of Ag_2O and AgI (Chow et al. 1998). Similar behaviours of velocity measurement are also observed for zinc chloride phosphate, lead chlorophosphate and lead zinc phosphate glasses (Sidek et al 1996; 1998), where the ultrasonic velocities decrease with the mole fraction of the modifiers or doping salts. The elastic constants of these glasses, on the other hand, are found to decrease also with the mole fractions. The a.c. conductivities of the binary and ternary silver phosphate glasses have been measured over a range of frequency, composition and temperature. Conductivity as high as 10^{-5} Scm^{-1} and activation energy in the range of 0.28-0.77 eV have been observed depending on the composition and the operating conditions. The conductivity at room temperature for both the binary and ternary phosphate glass system increases generally with frequency. The increases are very gradual initially at low frequencies. However a rapid rise at frequency above 10 kHz generally is observed. As a function of composition, the conductivity increases almost linearly with the mole fraction of Ag_2O and AgI. As a function of temperature, the conductivity increases too with temperature while the activation energy decreases with increasing content of Ag_2O and AgI. The conductivity is found to increase when the activation energy decreases. For the ternary silver borate glasses, the ionic conductivity is found to increase with the mole fraction of AgI and also with frequency, just like the ternary phosphate glasses. However, these glasses exhibit much higher conductivity at room temperature than the ternary phosphate glasses (Low et al. 1998). As a function of temperature, the conductivity of the borate glasses shows an anomalous result; the ionic conductivity measured at higher temperature tends to have lower values than those measured at lower temperature. Further investigations are required to study this anomalous behaviour of the ternary borate glasses.

Conclusions

Several series of superionic and optoelectronic glasses have been successfully prepared in the laboratory . These include, among others, the binary and ternary silver phosphate and borate glasses, zinc chloride phosphate glasses, binary lead phosphate and ternary lead chlorophosphate glasses and also lead zinc phosphate glasses. The ultrasonic /elastic properties and ionic conductivity of these glasses have been determined and compared wherever possible.

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