Solid ionic conductors have become a great concern for researchers in the field of materials physics in recent years. The solid ionic conductors have an important role in the development of electronic components. High ionic conductivity in solid materials becomes a dream to realize all-solid-state ionic devices. The ionic crystals usually have low conductivity at room temperature. The high ionic conductivity in ionic crystals will be obtained at high temperatures near their melting points. The transportation of the ionic charges relates to the atomic vibration and ionic bonding in the molecules of the solids. In crystals, the ionic charge transport is the result of the existence of defects caused by static and/or thermal disorders. The disorder arrangement that is caused by thermal disorder and/or static disorder in the structure of ionic materials is known as the most possible reason for high ionic conductivity. The studies on the structure, disorder, and thermal vibration become very important to understand the mechanism of charge movement in solids. A new technique of analysis, namely diffuse scattering intensity analysis, as well as Rietveld analysis, were used to study the structure and disorder in solid materials. On the other hand, the synthesis and characterization of superionic conductors based on glasses were presented to study the crystal structures, thermal properties, and conductivities. The challenge to find new materials with high ionic conductivity given by recent technology and the study of ionic conduction processes motivates to carry out this research topic. This new technique of X-ray and neutron diffuse scattering intensity analysis was applied in the analysis of Ag₂O, Cu₂O, and Al. It is capable of finding the correlation effects among thermal displacements, short-range order parameters, and interatomic force constants.

Neutron and X-ray diffraction intensities usually consist of Bragg peaks and background intensities. The background intensities result from coherent and incoherent scattering. The oscillatory background scattering known as diffuse scattering intensities are affected by the thermal vibration of atoms in crystal and any imperfections of crystal structure arrangements from perfectly...
ordered structure. The measurement of the diffuse scattering intensity is important to realize the static and
dynamic disorder in crystals. Investigations in lattice constants and crystal structure of Ag$_2$O and Cu$_2$O
have been carried out at two different temperatures with conventional double-axis diffractometer setup
and triple-axis mode with analyzer crystal adjusted to the incident wavelength. Ag$_2$O and Cu$_2$O have
same crystal structure with space group of $Pn\bar{3}m$ and show negative thermal expansion but different
lattice constant. The diffuse scattering intensity of Ag$_2$O at low temperature has noticeable oscillation in
contrast to Cu$_2$O. This indicates that correlation effects and thermal parameters of Ag$_2$O are larger than
those of Cu$_2$O. Those results are also shown in MEM (Maximum Entropy Method) analysis. The spread
of nuclear density distributions of Ag and O atoms in Ag$_2$O is very large even at low temperature. The
measurement in elastic mode of Ag$_2$O shows small diffuse contribution at low temperature but no visible
diffuse components at high temperature. It probably relates to static disorder in the system or phonon
softening and increasing of soft phonons density at low temperature. Investigation in lattice constant and
crystal structure of Al has been conducted at temperature 290 K by neutron diffraction measurement of
HRPD beam line installed at JRR-3. The crystal structure of Al belongs to fcc structure with the space
group $Fm\bar{3}m$. The correlation effects among first, second and third nearest neighboring atoms in Al were
obtained from diffuse scattering analysis. The values of correlation effects at temperature 290 K are
almost same as those in ionic crystals and semiconductors near room temperature. Those values decrease
rapidly with the increase of interatomic distance. The force constants among first, second and third
nearest neighboring atoms are calculated using a new equation transform from correlation effects among
thermal displacements of atoms to force constants. In Extended X-ray Absorption Fine Structure
(EXAFS) analysis the force constant among first nearest neighboring atoms can be obtained but it has
serious problem for the second and third nearest neighboring. The force constants and the crystal structure
of Al are used to estimate the phonon dispersion relations, phonon density of state and specific heat by
computer simulation. The calculated results of phonon dispersion relations and specific heat by computer
simulation are compared to those by inelastic neutron scattering and specific heat measurement of Al. The
results could qualitatively explain the observed result by inelastic neutron scattering and specific heat
measurement.

Characterization and synthesis of (AgI)$_{0.33}$(LiI)$_{0.33}$(LiPO$_3$)$_{0.34}$ and (AgI)$_{0.44}$(LiI)$_{0.22}$(AgPO$_3$)$_{0.34}$ are based to the preliminary study on the (AgI)$_x$(LiI)$_y$(LiPO$_3$)$_{1-x-y}$ and (AgI)$_x$(LiI)$_y$(AgPO$_3$)$_{1-x-y}$ with $x = 0.22, 0.33, 0.44$ and $y = 0.44, 0.33, 0.22$. The results showed that both compositions have better conductivities. Syntheses of (AgI)$_{0.33}$(LiI)$_{0.33}$(LiPO$_3$)$_{0.34}$ and (AgI)$_{0.44}$(LiI)$_{0.22}$(AgPO$_3$)$_{0.34}$ have been carried out by melt quenching method. The characterization of both compounds is conducted to analyze the crystal structures, thermal properties and conductivities. The both compounds have almost same characteristics each other. The crystal structure of both shows the mixture of amorphous background and small of crystalline form with several Bragg peaks correspond to AgI. These indicate that a number of AgI are not dissolved in those mixtures. Those results are also confirmed by the thermal properties measurement. An endothermic peak appears at temperature of $\beta$ to $\alpha$ AgI phase transition. The
conductivities of both compounds are relatively high even at room temperature and higher than those of the most well known of AgI-LiPO₃ and LiI-LiPO₃. The activation energies of both compounds are slightly different but almost same to the activation energy of AgI. Conclusively it is indicated that the conduction mechanisms are mainly to silver ions.