

# Chapter 5

## Conclusion

The conduction characteristics of ZnO are primarily dominated by electrons generated from  $O^{2-}$  vacancies and Zn interstitial atoms. The electrical conductivity in ZnO:Al (AZO) films is higher than that in pure ZnO films due to the contribution from  $Al^{3+}$  ions on substitutional sites of  $Zn^{2+}$  ions. The substitutional doping of  $Al^{3+}$  at the  $Zn^{2+}$  site creates one extra free carrier in the process. As the doping level is increased, more dopant atoms occupy lattice sites of zinc atoms resulting in more charge carriers. However, after a certain level of doping, zinc sites can not be occupied by the dopant atoms. Al atoms which can not be substituted to zinc sites do not behave as effective donors. Higher levels of Al incorporation lead to interstitial incorporation of Al in the form of  $Al_2O_3$  giving rise to greater electron scattering. The aluminum atoms may also segregate to the grain boundaries in the form of  $Al_2O_3$  which enhances the grain boundary barrier. Thus, the doping concentration reaches a maximum when the substitutional doping of the zinc oxide by aluminum is at a maximum whereas the mobility will continue to fall as more scattering effect occurs [22].

Therefore, it is necessary to optimize the  $Al_2O_3$  content in the target for Al doping. In order to get highly conducting AZO films by RF magnetron sputtering, other deposition parameters such as substrate temperature, working pressure, and RF power also need to be

optimized. The optimal results have been discussed and shown in this text. We obtain the high quality transparent conducting films by using these optimum parameters. Even the R.T. grown AZO film itself is of good quality TCO (2wt% AZO film with low resistivity =  $4.92 \times 10^{-4}$   $\Omega$ -cm and high visible region transmittance  $\approx 85\%$  at room temperature). Because the good quality TCOs can be fabricated at room temperature, there is a good compatibility with low-temperature process. This feature or advantage will be more and more important in the future applications. Low-temperature process makes AZO thin films attractive for flexible electronics on plastic or flexible substrate.

