Lithium phosphorus oxy-nitride thin films (LiPON) are widely studied and used thin film electrolyte for lithium ion battery applications. There were many studies on processing and characterization of LiPON films that includes radio-frequency sputter deposition, e-beam evaporation, plasma-assisted ion implantation, etc. These studies includes, improvement in the ionic conductivity, improvement in the deposition rate and the extended studies on characterization. LiPON films processed by RF sputter deposition have very low deposition rate, however it is more reliable and controllable processing method. In typical research facilities at Universities, sputter deposition is a general technique for conducting research. This dissertation study includes the methodologies used in sputter deposition and materials characterization. The LiPON thin films were RF sputter deposited under varying conditions of process gas, substrate bias, and deposition temperature. To understand the variations in ionic conductivity observed, the films were extensively characterized to examine structural and compositional differences, including examination by x-ray photoelectron spectroscopy (XPS), inductively coupled plasma optical emission spectroscopy (ICP/OES), and spectroscopic ellipsometry. The characterization methods that were developed include improved sample digestion procedure for ICP/OES, in-house set up of XPS depth profiling experiments and penetration depth/optical bandgap calculations from spectroscopic ellipsometry. In addition, film density, intrinsic stress of the deposited films was also studied. The highest ionic conductivity of 9.8 x 10^{-6} \, \text{S/cm} was obtained at elevated deposition temperature and is correlated to a reduced density of defects, as indicated from the optical characterization.