Lead sulfide (PbS) quantum dots (QDs) were extensively studied for solution-processing photovoltaic (PV) devices and photodetectors. However, the trade-off between optical absorbance and energy loss from electron hopping and tunneling arose from the ultra-small quantum size of the PbS crystals. In this work, we demonstrated a general reaction model for compositional and morphological controllable synthesis of lead tin sulfide (Pb$_{1-x}$Sn$_x$S) alloy nanocrystals (NCs). The NCs with a relatively large size could absorb visible and/or NIR light and the intrinsic band gap could be tuned by adjusting the atomic ration of Pb and Sn. We fabricated optoelectronic devices by spin-coating our NCs on the ITO-coated glass, followed by depositing metal back contact. The current-voltage (I-V) measurement showed superior photoresponse of our Pb$_{1-x}$Sn$_x$S NC film to the AM 1.5 stimulated solar light indicating that our materials have promising potential applications in optoelectronic devices.