Recent progress on solution processable polymeric photovoltaic (PV) cells has drawn a lot of attention. Over 8% cell efficiency has been demonstrated. Compared with inorganic semiconductors, polymer semiconductors have relatively low carrier mobility and therefore carrier transport plays an important role in determining the performance of polymer solar cells. In addition to carrier mobility, carrier lifetime in the polymer-fullerene blends is another important parameter determining the cell efficiency. We have extensively studied the carrier transport and recombination of several donor-acceptor conjugated polymer systems. We found that while low mobilities in polymers lead to strong charge imbalance resulting in low power conversion efficiencies, high mobilities in some polymers do not always lead to high power conversion efficiencies. In this presentation, we will present our device results based on dioctyldithienosilole (DTS) polymers with a wide-absorption band and excellent transport properties. Even though DTS polymers have a high hole mobility, the power conversion efficiency is limited by its fill factor. In order to study the loss mechanism of the photo-current, we carried out transient photo-voltage (TPV) measurements to probe the bimolecular recombination of photo-carriers under open circuit condition. Based on our photo-CELIV (carrier extraction by linearly increasing voltage) data, we will present a model to explain the loss mechanism in polymer solar cells based on these donor-acceptor polymers. Finally, we will report on our recent progress of high efficiency polymer solar cells based on a low band-gap polymer having an alternating dithienogermele-thienopyrrololedione repeat unit (PDTG-TPD). By controlling the interface recombination, a power conversion efficiency exceeding 8% has been achieved with inverted solar cells using this material.