Colossal photo-conductive gain in low temperature processed TiO$_2$ films and their application in quantum dot solar cells

Debranjan Mandal and Arup Rath

Email: d.mandal@ncl.res.in

Colloidal quantum dot (QD) solar cells have seen remarkable progress in recent past to reach the certified efficiency of 10.6%. Anatase titanium oxide (TiO$_2$) is a widely studied n-type widow layer for the collection of photogenerated electrons in QD solar cells. Requirement of high temperature ($\sim$500 °C) processing steps proved to be disadvantageous for its applications in flexible solar cells and roll to roll processing, and it also has adverse commercial implications. Here, we report that solar light exposure to low temperature processed (80 °C–150 °C) TiO$_2$ and niobium doped TiO$_2$ films leads to unprecedented enhancement in their electron densities and electron mobilities, which enables them to be used as efficient n-type layers in quantum dot solar cells. Such photoinduced high conducting states in these films show gradual decay over hours after the light bias is taken off and can be retrieved under solar illumination. On the contrary, TiO$_2$ films processed at 500 °C show marginal photo induced enhancements in their characteristics. In bilayer configuration with PbS Qds, photovoltaic devices based on low temperature processed TiO$_2$ films show improved performance over high temperature processed TiO$_2$ films. The stability of photovoltaic devices also improved in low temperature processed TiO$_2$ films under ambient working conditions.