Ferroelectric photovoltaics: progress and prospects

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Ferroelectric materials possess switchable spontaneous electric polarization that is exploited in ferroelectric-based non-volatile memories and logic devices. Further, the strong coupling between polarization and elastic strain makes the ferroelectrics very good piezoelectrics, which make these materials suitable as sensors, transducers, micro-electro-mechanical systems or highly precise actuators. Besides, ferroelectrics possess interesting optical properties, such as birefringence and non-linear optical characteristics. However, interaction of ferroelectric materials with light to control the charge transport phenomena has not got its due attention until recently. Only in the last decade the coupling of polarization with optical properties has received surge in research interest which has been triggered notably by low-band gap ferroelectrics suitable for sunlight spectrum absorption and photovoltaic effects. Since the first report in 2009, the field of ferroelectric photovoltaics has been thriving, achieving quickly an unprecedented power conversion efficiency (PCE) of 8.1%. It has been predicted that an extremely high photovoltaic efficiency up to 19.5% can be achieved from ferroelectric thin films with thickness ~1.2 nm. However, the theoretical upper limit of PCE of ferroelectrics is still an open question, notwithstanding that thermodynamic considerations set the theoretical upper limit of PCE in any single band gap absorber to 44%. In addition to bulk photovoltaic effects in ferreoelectrics, an anomalous photovoltaic effect has been demonstrated in ferroelectric thin films where an above band gap photovoltage (V_{oc} ~16 V) was reported for $BiFeO_3$ (E_g ~ 2.5 eV). Such discoveries have made photoferroelectrics as potential alternatives to conventional photovoltaics based on semiconductor p-n junctions. This tutorial shall provide a consolidated overview of the rapidly progressing field of ferroelectric photovoltaics and address other technologically appealing emerging fields such as photostriction and photocatalytic properties of ferroelectric materials.