TiO$_x$N$_y$ films are interesting materials with particular interest for sunlight to power conversion. The oxygen substitution by nitrogen influences their remarkable optical and electronic properties. Atomic layer deposition (ALD) is a versatile tool for a controlled growth of ultra-thin films avoiding disadvantages like stress and defect formation accompanying other deposition methods, e.g., sputtering.

We compare TiO$_x$N$_y$ films prepared by plasma enhanced ALD (PEALD) using two titanium precursors: tetrakis(dimethylamino)titanium (TDMAT) and titanium(IV)isopropoxide (TTIP) and applying N$_2$- and NH$_3$-plasma, respectively. The TDMAT/N$_2$ process delivers films with higher nitrogen contents [1], higher conductivity [1] and more dominating Ti-N contributions [2] in comparison to the TTIP/NH$_3$ prepared films. In this contribution we focus on the titanium species including Ti$^{3+}$ contributions and in-gap states observed above the valence band maximum. We report how these values alter with the PEALD deposition procedure and impact the electrical properties. Laboratory- and synchrotron-based photoelectron spectroscopy data as well as current-voltage measurements will be presented.