Abstract

Thin-film solar cells including both organic (OSC) and perovskites (PSC) devices have emerged as an excellent alternative to the traditional silicon wafer technology in the field of photovoltaic technologies. The basic materials used in these devices provides the solar cells with unique properties such as low weight, semi-transparency, mechanical flexibility and potentially low cost, which in turn opens up for completely new application areas. OSC has recently achieved Power Conversion Efficiencies (PCE) of more than 13%, and PSC has shown an outstanding PCE of more than 22%, whereas in both cases, their stability still lacks significant improvements.

This work is dedicated to research on improving the performance, including device stability, of organic and perovskite solar cells, using novel metal-oxide based interlayers. The thesis will initial focus on the fabrication and optimization of DBP/C_{70} organic cells, where new developments towards integration of OSC for usage in low-consuming electronics will be shown. Specifically it is shown how efficient OSC reaching very high output voltage above 6V can be developed by multi-stacked devices, applying efficient interfaces between each sub-cell, and by optimized the thickness in the individual sub-cells. Integration of novel reactive sputtered Molybdenum oxide (MoO_x) layers will be demonstrated as a new method to improve the stability of these organic solar cells, while maintain a high device performance, compared to cells made thermal evaporation of MoO_x hole transport layer. This is obtained by development of crystalline films with high work functions, which in the end lead to the improved device stability.

Based on the analysis on OSC devices, new metal-oxide based interlayers for PSC devices are also investigated. Especially adaptation of NiO:Cu hole-transport layers are investigated alongside solvent engineering approaches for developing high performing PSC devices. At the end, it is show that copper in combination with specific electron transport layers leads to PSC with high performance and improved device stability.

Resume

Tyndfilms solceller inklusiv bade organiske (OSC) og perovskite (PSC) devices er blevet til lovende alternativer til den traditionelle silicium wafer teknologi inden fotovoltaiske enheder. De basale materialer der anvendes i disse devices giver solcellerne unikke egenskaber såsom lav vægt, gennemsigtighed, mekanisk fleksibilitet og potential billig pris, hvilket giver anledning til helt nye applikationsområder. OSC har for nyligt opnået effektiviteter på mere end 13% of PSC har vist fremragende effektiviteter på mere end 22%, I begge teknologier halter stabiliteten dog stadig efter.

Dette arbejde er rettet mod forskning omkring forbedring af ydeevne, inklusiv stabilitet, af organiske og perovskite solceller ved brug af nye metal-oxid baserede interfacelag. Denne afhandling vil I begyndelsen have fokus på fabrikation og optimering af DBP/C_{70} organiske solceller, hvor ny udvikling indenfor integration af organiske solceller til forsyning lav effekt elektronik vil blive vist. Specifikt vises det hvordan effektive OSC der opnår meget høje output spændinger omkring 6V kan blive udviklet vha. tandem devices, ved anvendelse af effektive interfacelag, og optimering af tykkelsen af de enkelte sub-celler. Integration af nye reaktiv sputteret Molybdæn oxid (MoO_x) lag demonstreres som en ny metode til at forbedre stabiliteten af disse organiske solceller, imens der opnås høje effektiviteter sammenlignet med celler der er fremstillet ved termisk pådampning af MoO_x hul transport lag. Dette opnås ved at udvikle krystallinske film med meget højt løsrivelsesarbejde, hvilket i sidste ende resulterer I den forbedrede device stabilitet.

Baseret på OSC device analysen undersøges nye metal-oxid baserede interfacelag til PSC devices ligeledes. Specielt adaptionen af NiO:Cu hul transport lag undersøges sammen med optimering af opløsningsmidler til udvikling af højeffektive PSC devices. Til slut vises det hvordan kobber sammen med specifikke elektron transport lag fører til PSC med høj effektivitet og forbedret stabilitet.