Below, a summary is presented of the work performed during a internship at Philips research, from 19-11-2012 to 19-05-2013, by Daan Verwijmeren, for his masters programme "Nanomaterials: Chemistry and Physics". The actual report is confidential, and will therefore not be public, as imposed by Philips and confirmed here by the project supervisor, Marcel Böhmer by his signature.

30-05-2013

Marcel Böhmer

Project supervisor

Summary of the project

LED technology is becoming more and more important for application in everyday lighting. This is due to a large energy efficiency and lifetime. However, it is still hard to efficiently produce pleasant white light. Normally, a blue LED is a starting point. Inorganic yellow phosphors can be used to convert a part of the blue light. This produces an unpleasant, pale white light. A small amount of red light is needed for the emission of pleasant white light. However, classical inorganic red phosphors have a broad emission. This is unfavourable, since the human eye sensitivity decays very fast in the red light domain. Ideally, a small band emitter is necessary which produces red light in the flank of the eye sensitivity curve.

Quantum dots display properties which are of good use in LED-technology. They are typically narrow emitters, with tunable optical properties and a high quantum efficiency. However, to apply them in a usable layer a matrix is needed. Certain polymer materials are viable for lighting applications, as long as the polymers have a good chemical and thermal stability, and high optical transparency.

However, upon dispersing quantum dots in a polymer-system, depletion interaction comes into play, possibly destabilizing the particles. These interactions are disadvantageous, since flocculation of quantum dots can promote the degradation quantum dots, diminishing their optical properties. In the typical concentrations of polymer used for producing applicable layers, this driving force exceeds [kT]. It is known that the properties of the quantum dots ligands can influence the behaviour of particles in presence of a depletant. In the specific case that the ligand length is higher or similar to the length of free polymers, wetting of the ligand layer occurs. In this case, the depletant so to speak disappears in the ligand layer. This prevents the flocculation normally induced by the depletant.

In this thesis, we report the successful synthesis of core/multishell CdSe/CdS/ZnS quantum dots using a facile, one-pot, hot injection synthesis. Afterwards, a successful exchange with customized ligand was performed. Afterwards, the increased stability in polymer solutions and melts are confirmed. For higher molar weight polymer systems, mixed samples (high molar weight polymer in a solvent/low molar weight polymer) were used in an attempt to increase stability. Indeed, stable working frames varying from 2 h up to 2 weeks were reported for several mixed systems. It is expected that the mixed systems can be translated to applicable systems when using crosslinkable polymers. For the solvent based mixtures, shrinking behaviour might be expected. For the low molar weight/high molar weigh mixtures these effects might be reduced to a great extent. However, further research is necessary to confirm the exact behaviour of crosslinkable mixtures before, upon and after crosslinking. Furthermore, a computational approach can be used to translate all relevant quantities in usable phase diagrams.