Effect of Polysiloxane Encapsulation Material Compositions on Emission Behaviour and Stabilities of Perylene Dyes

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Introduction

Most of the commonly used phosphors in LED applications consist of inorganic oxides doped with rare earth ions. Due to the geopolitical dependence of the supply of rare earth compounds and the high prices of those materials, alternative organic compounds are an object of recent research. Different transparent polymers were already used as encapsulation materials but polysiloxanes reveal the best combination of properties such as heat stability, high transparency, and tunable refractive indices by side group substitution. The chemical inertness of this polymer type in combination with a potential covalent incorporation of an organic fluorescence dye makes them an excellent material for improvement with regard to the dye stability. The influence of the polysiloxane structure on the fluorescence properties of a matrix incorporated dye system was not studied yet. One of the most commonly used fluorescence dyes is the commercial available, perylene-based Lumogen® F Red 305 (BASF SE). This dye can only be non-covalently embedded in the polysiloxane matrix. For stability reasons, a new Lucogen® based dye (FC546), which allows for a covalent attachment to the polymer matrix was synthesized. In our study we investigated the influence of the matrix structure on quantum yields, heat- and photostability, as well as the crosslinking behaviour of polysiloxane matrices.

Synthesis of dye incorporated polysiloxanes

- Incorporation of dyes into LRI (Shin(1)) and HRI (Dow(1)) polysiloxane matrices
- Curing of the two component polysiloxanes by platin catalyzed hydrosilylation

Quantum yield and self-absorption coefficient

- Highest QY for Dow(1) samples, independent of dye and concentration
- Dow(1)LG305 shows constant high QY > 0.95 → No dye-dye interaction due to bulky substituents
- Shin(1)LG305 shows decrease due to crystallization of LG305 (≥750 ppm).

Photostability

- High photostability for Dow(1) samples → lower oxygen permeability
- FC546 photostability > LG305 due to N-alkyl substituents
- Strongest decrease in Shin(1) → structure benefits degradation

Compatibility and solubility

- Very high solubility in phenyl containing Dow(1) matrix
- Dyes are highly soluble in hot matrix component mixture

Conclusion

The influence of a PDM Shin(1) and a PMPM Dow(1) on the properties of two different incorporated perylene dimide doped dyes was investigated. For a high performance LED focused application the heat and photostability were studied. PDMS-based materials show weak solubility for both dyes, which was increased by the curing procedure due to an increase of temperature. Crystalization of the LG305 dye in Shin(1) was observed, while no crystallization was detected for all other samples. High quantum yields ≥0.9 were detected for low concentrated samples. The Dow(1)LG305 series showed no decrease in quantum yield with an increase in concentration. A n-n stacking is blocked due to high amount of aromatic phenyl units in Dow(1). A decrease of quantum yield for the FC546 series is caused by the dye structure, which favours dye-dye interaction. The highest photostability was observed for the FC546 dye. Overall, a phenyl containing polysiloxane matrix with a low concentrated, covalently bonded perylene-based dye is a promising combination for LED application.

References, funding and cooperation


Dye incorporated polysiloxane encapsulation

450 nm blue light emitting LED chip