Rigorous optical analysis of curvature effects on cylindrically bent flexible light-emitting diodes (FOLEDs)

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INTRODUCTION

• Unique mechanical properties of organic materials offer novel exciting applications in the form of flexible electro-optic devices[1].
• Only little research has been conducted on FOLEDs to date; published work mainly deals with mechanical aspects of the flexible devices[2].
• We present a rigorous electromagnetic model for the optical emission of cylindrically curved FOLEDs, developed to analytical closed-form expressions, indicating that bending above a critical radius gives rise to unique phenomena due to large-angle emission enhancement[3].
• This emission enhancement can improve device outcoupling efficiency, which is the main barrier for boosting OLED performance[1].

FORMULATION

Plane-Parallel OLED (PPOLED)[4]

Flexible OLED (FOLED)[5]

RESULTS

Viewing Angle Expansion

Critical dimensions (interplay):

\[ d \rightarrow R \]

Substrate thickness

Radius of curvature

Light escape enhancement

Viewing Angle Expansion

Back-illumination

Optimal Expansion

\[ R/d_i = 2 \]

\[ R/d_i = 1/2 \]

CONCLUSIONS

• Curvature effects are significant when radius of curvature is comparable with substrate thickness.
• Bending reduces angle of incidence at substrate/air interface \[ \Rightarrow \] decreased total internal reflection (TIR) losses and increased viewing angle (even back-illumination).
• Optimal radius and maximal possible viewing angle can be obtained analytically, as well as estimation of the light escape enhancement.
• Reduced TIR losses can be utilized to overcome outcoupling efficiency challenge for OLEDs.

REFERENCES


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