3-Dimensional Simulation of InGaN/GaN Micro-Ring Light-Emitting Diodes

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Background: research on extraction efficiency of LEDs

- Optimizing of epitaxy and processing
- Improving current spreading
- Designing of resonant cavity structures
- ................

Here: geometrical design

They have higher extraction efficiency than micro-disk and broad-area (BA) LEDs.
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Simulator: **APSYS** by crosslight
About APSYS

- Quantum drift-diffusion model for current flow/spreading (included).
- MQW quantum well gain/spontaneous emission model with effective mass approximation (included).
- 3D ray-tracing model (included).
- K.p model for MQW (optional).
- Self-heating model (optional).
- Polarization surface charge/self-consistent model (optional).
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BA LED

micro-disk LED (1/4)

micro-ring LED (1/4)

**Simulator:** APSYS

Schematic structure
Narrower conduction path

Higher ohmic resistance

Fig. 2. I-V curves of different structures.
Out power: simulation > experiment

Reasons: 1, substrate absorption
2, package absence
3, reabsorbed by neighbors
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3D ray-tracing technique in APSYS applied to detect angular dependence of emitted power
<50degree agree with experiment
>50degree disagree

Reason: 1, reabsorbed before detected
2, sidewall of micro-ring is not vertical to substrate in experiment
Smaller active region ➔ more current crowding ➔ more overflow loss ➔ IQE decreased
Current in micro-ring device is more crowded than those in micro-disk/BA devices.
Next:
1: multi-ring simulation to research inter-device reaction
2: relationship between IQE and diameter of micro-ring LED
3: relationship between extraction efficiency and diameter of micro-ring LED
That's all, thank you very much!