

Goal: Become an Expert in LED Technology (with R&D focus)

This roadmap is based on what **professional R&D engineers** in top LED companies (like Seoul Semiconductor, OSRAM, Lumileds, Nichia) follow.

Phase 1: Solidify Fundamentals (0–3 months)

Topics:

- **Semiconductor physics** – Bandgap, electron-hole recombination, radiative/non-radiative processes
- **LED chip structures** – Lateral, vertical, flip-chip
- **PN junction & epitaxy** – GaN, InGaN, AlGaNp

Resources:

- *Light-Emitting Diodes* – E. Fred Schubert
- *MIT OpenCourseWare* – Solid-State Devices
- *YouTube channels* like AllAboutCircuits, EngineerGuy

Outcome:

- Understand how light is generated, and how chip design affects performance.
-

Phase 2: Learn LED Packaging Technologies (3–6 months)

Topics:

- **Packaging types:** SMD, COB, Flip-Chip, CSP, WICOP
- **Materials:** Phosphors, encapsulants, lead frames, ceramic/EMC substrates
- **Thermal management:** Heat flow, TIM (thermal interface materials)
- **Optical design:** Lenses, reflectors, light guides

Books:

- *LED Packaging for Lighting Applications* – Sheng Liu
- *Thermal Management for LED Applications* – Clemens Lasance

- Seoul Semiconductor whitepapers (search "WICOP", "Acrich")

Tools to Explore:

- **Zemax/LightTools** – Optical simulation
- **ANSYS ICEPAK** – Thermal modeling
- **COMSOL Multiphysics** – If you deal with stress, heat, optics together

Outcome:

- Know how packaging impacts brightness, color, heat, and lifetime
-

Phase 3: Hands-On Process & Manufacturing (6–12 months)

Topics:

- **Mounting & Bonding:** Die attach, wire bonding, flip-chip bonding
- **Phosphor deposition:** PiP (phosphor in package) vs. PiY (phosphor in YAG glass)
- **Encapsulation & lens molding**
- **SMD process / Reflow profile / MSL handling**
- **Testing:** LM-80, TM-21, JEDEC thermal cycling

Suggested Actions:

- Visit production line (if possible)
- Work with reliability & quality teams
- Join debug or yield improvement taskforces

Outcome:

- You can analyze defects, propose design-for-manufacturing (DFM) solutions
-

Phase 4: Advanced Topics & Specialization (1–2 years)

Choose Your Track:

| Specialization | Focus Area |
|-------------------------|---|
| Optical R&D | Lens shaping, color mixing, ray tracing, color rendering (CRI, CCT) |
| Thermal R&D | TIMs, PCB substrates, multi-chip modules, lifetime vs. heat stress |
| Material R&D | Encapsulant aging, phosphor conversion, blue light absorption |
| Mini/Micro-LED | Wafer-level packaging, mass transfer, drive IC integration |

Key Skills:

- Data analysis (Excel, Python, JMP, MATLAB)
 - Experimental design (DoE, Taguchi method)
 - FA (failure analysis): X-ray, SEM, cross-section
-

Phase 5: Industry & Innovation Engagement (Parallel, continuous)

- Attend **conferences**: SPIE Photonics West, LED Expo, SEMICON Korea
 - Read **journals**: IEEE Photonics, Optical Express, Elsevier Solid-State Electronics
 - Follow **companies**: Seoul Semiconductor, Cree, Lumileds, Nichia, Samsung LED
-

Final Goal: You're able to...

- ✓ Design LED packages with optimal heat/light balance
- ✓ Evaluate and improve lifetime, efficiency, and reliability
- ✓ Propose new packaging concepts (e.g., WICOP, CSP-COB hybrid)
- ✓ File patents or publish papers
- ✓ Lead or mentor R&D teams in next-gen LED tech