KWALITY GROUP OF INDUSTRIES

For LED lighting solutions

K.Vijaya Kumar Gupta
Director - Kwality Electricals P ltd
MD - Kwality Photonics P Ltd
Member
CSIR-NMITLI Committee for
“Development of WHITE LEDs for General Lighting Service”

Company Introduction

Since 1966, or after over more than 40 years of great determination, dedication and resilience, Kwality Electricals P Ltd. leads the SolidStateLighting manufacturing industry over a decade. Today, our products range contains LED Displays, Power LEDs, LED products , Home lights, Street lights and ultra low power portable remote area lightings Entertainment Lighting and technology luminaries.

Kwality Group of Industries,

- **Kwality Electronic Industries**
- **Kwality Photonics Pvt. Ltd.**
- **Kwality Electricals Pvt. Ltd.**
- **Ocean Park Ltd.**

The Kwality Group

- Established in 1966
- Employing more than 250 workers
- Started off with manufacture of Lamps and Lamp components etc.
- The LED & LED Displays manufacture started in 1987 after successful indigenous R&D

- India's largest producer of Light Emitting Diodes (LEDs), LED Displays & Opto Electronic Products.
- Kwality is not only the pioneer, being the first Indian Company to have successfully established LEDs production in India but also commands the highest market share in domestic sales.

LEADERSHIP IN INDUSTRY

- Technology Leader - able to deliver state of art products,
- Quality Leader - having obtained ISO 9001:2000 and consistently achieving near 100% yields, and
- Range leader - offering over 600 types of LEDs, LED Displays & Optoelectronic Products.
- Price Leader too - offering most Competitive Prices and Best Value for money.

EVERON LED LANTERNS

- JUMBO 3W LED 12V 7AH SLA 5Wp SPV
- JUNIOR 3W LED 6V 4.5AH SLA 3Wp SPV
- JUNIOR 1W LED 6V 4.5AH SLA 5Wp SPV
- GRAMJOTI 1W LED 4V 2.2AH Li 3Wp SPV

EVERON LED LANTERNS

- GRAMJOTI
  - 1W LED
  - 4V 2.2AH Li
  - 3Wp SPV

EVERON LED LANTERNS

- JUNIOR LED LANTERN
- 1W LED
- 6V 4.5AH SLA
- 3Wp SPV

EVERON LED LANTERNS

- JUMBO LED LANTERN
  - 3W LED
  - 12V 7AH SLA
  - Wp SPV

LED SOLAR HOME LIGHTING

- CCU +2LIGHTS (HL2 or HL4)
- Battery 12V 7Ah in enclosure
- Switches, fuse, Lamp sockets and indicators
- Optional Fixed Reading Lamp

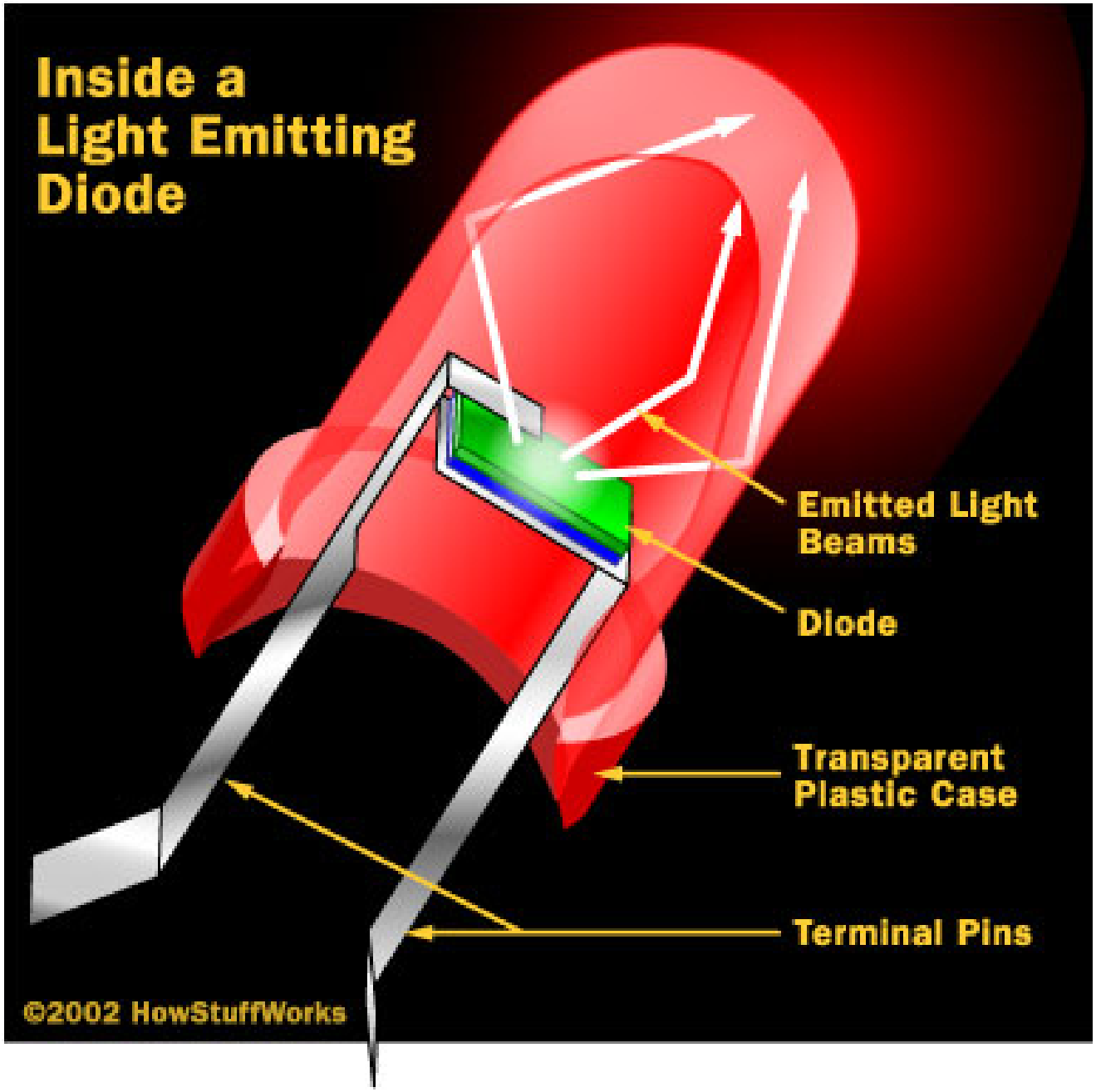
SOLID STATE LIGHTING COST REDUCTION ROADMAP & OPPORTUNITIES IN LEDs

K.VIJAYKUMAR GUPTA

MD KWALITY PHOTONICS P LTD

SOLD STATE LIGHTING OPPORTUNTIES & COST ROADMAP

- Are you part of the industry supply chain for LED-based white lighting industry supply chain either as components, luminaires or a solutions provider?
- Where are the costs heading to and what pace?
- Where are the opportunities over next 5+ years?
- Some of what I present here would be known to all, hopefully some would be new.
- As we are trying to peep into future you may agree or strongly disagree. Lets see.


Inside a
Light Emitting
Diode
Emitted Light
Beams
Diode
Transparent
Plastic Case
Terminal Pins
©2002 HowStuffWorks

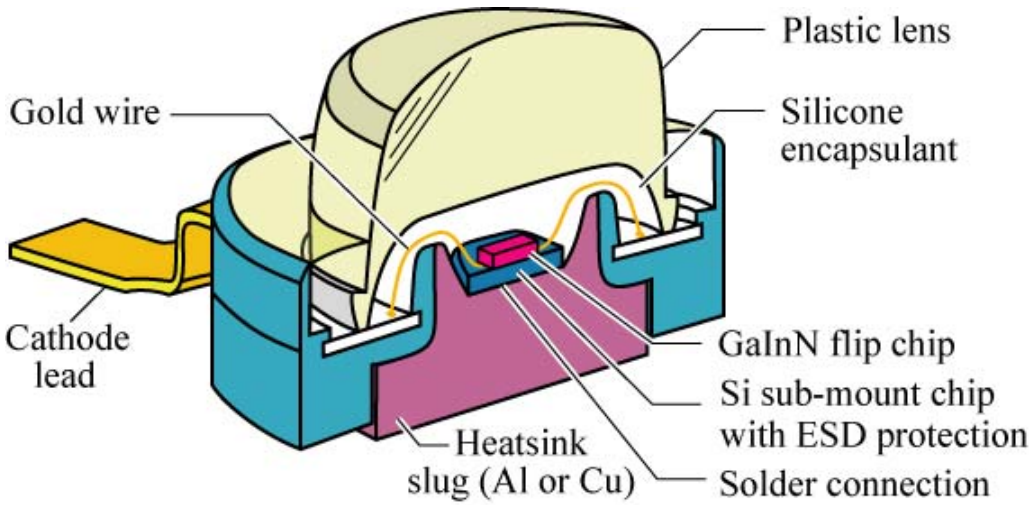


Fig. 11.2. Cross section through high-power package. The heatsink slug can be soldered to a printed circuit board for efficient heat removal. This package is called *Barracuda package* which was introduced by Lumileds Corp. (adopted from Krames, 2003).

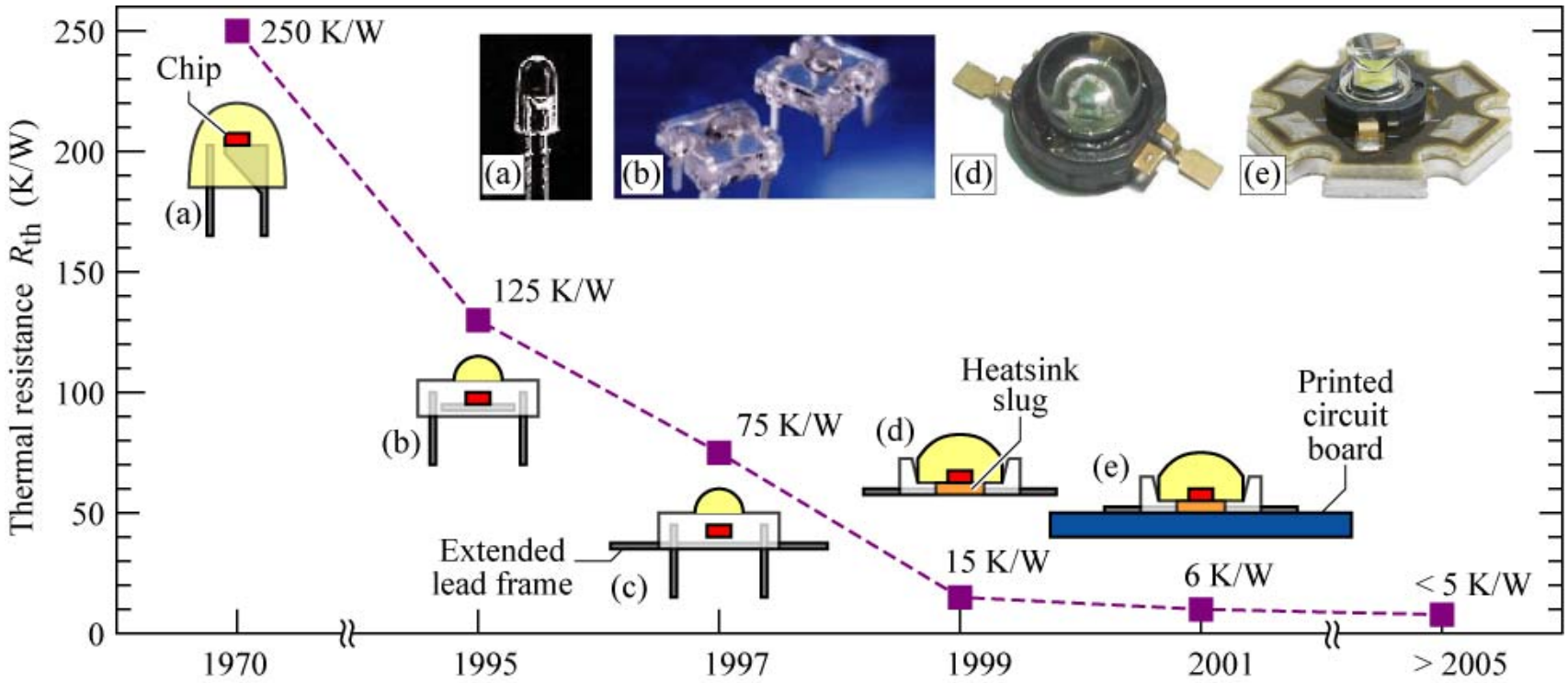
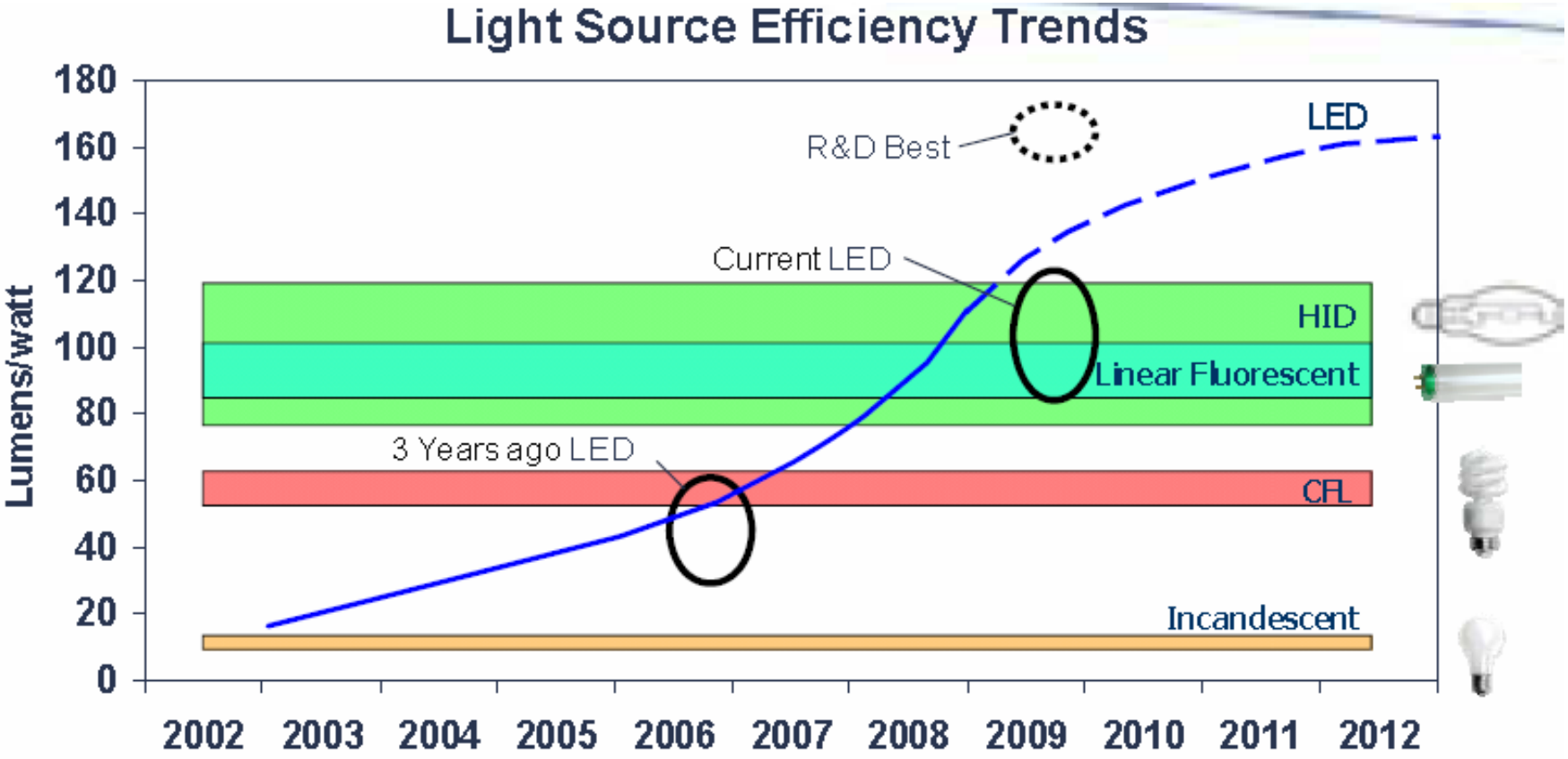


Fig. 11.5. Thermal resistance of LED packages: (a) 5mm (b) low-profile (c) low-profile with extended lead frame (d) heatsink slug (e) heatsink slug mounted on printed circuit board (PCB). Trade names for these packages are "Piranha" (b and c, Hewlett Packard Corp.), "Barracuda" (d and e, Lumileds Corp.), and "Dragon" (d and e, Osram Opto Semiconductors Corp.) (adopted from Arik *et al*., 2002).

TRENDS-LED SOURCE EFFICIENCY



LED Costs-Role of Equipment and Process Technology

- SSL can reach cost and performance parity with current lighting technologies, dramatically reducing global energy usage.
- The semiconductor industry's experience in achieving remarkable cost and performance improvements is directly applicable to the SSL industry through
  - support by industry standards,
  - technology roadmaps and
  - collaborative partnerships between equipment suppliers and Chip manufacturers

Past Trends in Cost Of Solid State Lighting

- During the past decade, the cost of LED devices has decreased by 10x, primarily due to enhancements in LED device efficiency and increases in drive current. As devices become more efficient, the cost per lumen scales. In the past decade, LED efficiency has improved approximately 20-fold and this has led to the 10-fold decrease in cost per lumen (Haitz's Law).

SMICONDUCTOR LED FORECAST

- The US DOE goal for 2015 requires an additional 10 to 20-fold decrease in costs while the theoretical maximum additional efficiency improvement is less than 2x. Additional cost savings must come from yield improvements, materials innovation, automation, and other manufacturing efficiencies.

LED COSTS- RELATED TO SUPPLY CHAIN ROAD MAP

- ***Significant reductions could be achieved in the cost of producing LEDs if the supply chain can collaborate on an industry-wide roadmap,***
- It should be possible to achieve about a 70% reduction in production costs for LED lighting by 2015. This was one conclusion reached by attendees at two US Department of Energy (DOE) workshops that looked at ways to improve solid-state lighting (SSL) manufacturing. A big part of that potential decline is projected to come from a reduction of about 85% in the cost of the packaged LED, which now accounts for some 40% of the cost of the luminaire.

DOE- WORKSHOP FORECASTS

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LED COSTS- PROCESS RELATED

- The LED manufacturing process today is very similar to the semiconductor manufacturing processes in the mid-1970s.
- LED wafer sizes are 2–3 inch,
- process equipment tends to be custom made (internally modified by manufacturers),
- deposition processes are poorly controlled and linewidths are only a few microns.
- LED throughput is typically less than 50 wafers per hour with low yields.
- Since 1975, the semiconductor industry has made enormous strides in cost reduction, mostly through scaling, but also through manufacturing efficiencies that can be directly applied to LED manufacturing.

PACKAGING FORECASTS

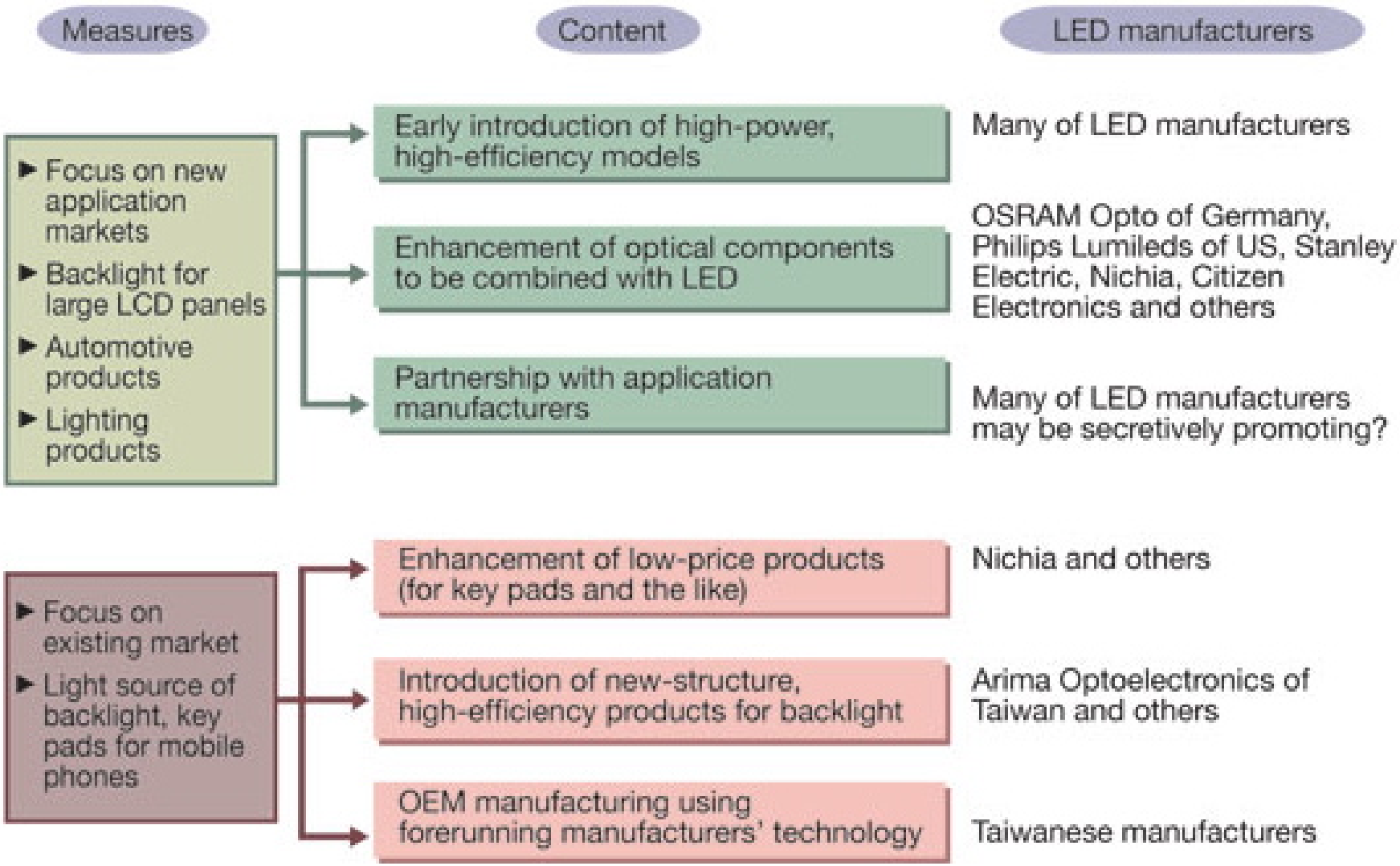
- LED package cost, especially of power LEDs has been influenced by thermal aspects ,
- At Chip Level-Needing costly processes of removal of sapphire substrate and thinning of wafer, post fabrication.
- At package Level-Needing costly interventions like insertion of Copper slugs, Ceramics, flip chip bonding on Silicon add on substrate.
- The small foot print, spot molded Packages we see today are well evolved from viewpoint of scale of manufacturing,
- Though the large Luxeon type packages will remain popular for small scale production of LED lights.

PACKAGING FORECASTS

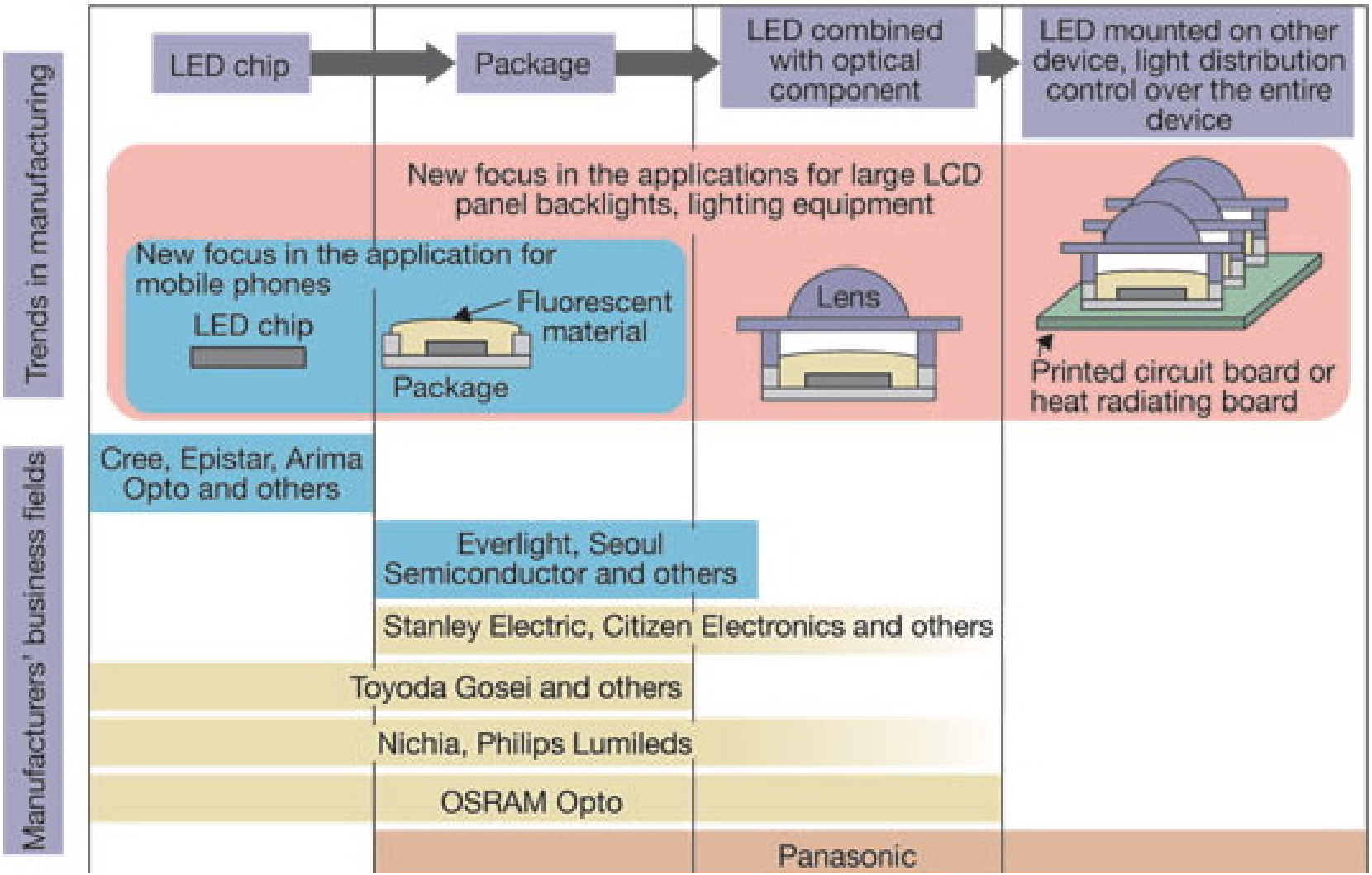
- Wafer level packaging is going to be the next wave of cost reduction.
- WLP is complex but scalable.
- Integration of Si- LED chip issues involve IP.
- MEMs technologies opened doors WLP LEDs
- 12” wafer saves 9 out of 10 production cylces employed hitherto.
- High scalability carries the promise of cost reduction of 70% in LED packages within next two years.

Next we will discuss the
OPPORTUNITIES FOR ENTERPRISES
WITH REFERENCE TO
LED or SOLID STATE LIGHTING
along total LED supply chain

LED Segment Road Map



Vertical Span of LED Business



Going up the Value Chain
LED Application Markets

- Growing Markets are LCD backlights, Automotive and Lighting
- Technology needed to expand business
  - Combining Chips with Optical components
  - Mount Chips on other devices
  - Control Light Distribution over the entire device.

Opportunities in SUBSTRATES and EPIWAFERS

- The innovation in the high brightness LED market has its origin in compound semiconductor technology based on combinations of gallium, indium, aluminium on one side and arsenic, phosphorus and nitrogen on other side popularly known "the III-Vs"
- One starts with host substrate of sapphire or silicon-carbide (Silicone and Galliumnitride arefuture bets).
- Placed in a high-tech epitaxial reactor where you inject vaporized metal combinations to cover the wafers with "epitaxial layers" in combinations that produce the red-orange-yellow-green-blue spectrum. Those "epi-wafers" in somewhat in spectral order, include gallium arsenide, indium gallium aluminum phosphide, gallium indium nitride and gallium nitride

Opportunities in SUBSTRATES and EPIWAFERS

- **Opportunities are few new players.**
- **Existing players will have big boom .**
  - Huge capital and IP investments were created and need to be generated both for the material and equipment supply chain. There isn't much room for really fresh entries.
  - The metal organic chemical vapor deposition or MOCVD "reactors" (the amazing million dollar ovens), supplied by companies like Aixtron, Veeco & Oxford, are pretty much closed group yet with sufficient Competition.
  - There is some near term action in the sapphire substrate market where solid state lighting and Backlighting demand has overtaken the supply of current sapphire capacity. The demand for largerr than 2”substrates, current standard, required fresh investments and and R&D espcially in crystal puller.
  - There is opportunity for Development of lower cost bulk GaN.
  - For existing supplier there is temporary excess profits that both fund the existing sapphire folks capital expansion, as well as opens the door to some new entries.

Opportunities in CHIPS and PACKAGED LEDs

- ***The pace of innovation has been breath taking since*** Nakamura's break through blue GaN LED chips to commercialization in 2003 to present days 100LPW LED packages.
- Many levels innovation contributed to this. All this IP was quickly dovetailed with all the existing HB-LED production know-how that was built up with the red, yellow and green technology.
- The Big 5 Chip makers have themselves moved to package their "best and brightest" chips.
- At the chip level many startup from Taiwan entered and bought up huge number of MOCVD reactors. After some consolidation occurred, few stars have emerged like Epistar, Teckore, ForeEpi, Huga, SemiLEDs etc. Korea also has atleast one significant player today.

Opportunities in CHIPS and PACKAGED LEDs

- **The Opportunities available are few here-**
  - **There are some challenges in store for mid-tier players as the big brands enjoy the price and profit benefits of the increasing economies of scale.**
  - Even if a company has some real breakthrough IP that avoids stepping on one of the existing player's turf, the capital requirements to be a competitive chip producer are massive, especially when you bear in mind that companies such as Epistar were able to scoop up massive amounts of equipment by acquiring smaller competitors at the equivalent of discount prices. Best way for new IP holder would be to prove it and sell it to one of the other players.
  - At the packaged LED level, there is still less room for innovation, and without controlling your die, your cost model is driven by someone else's innovation, which makes it challenging against industry leaders who own the end to end technology of materials, chips and packaging

Opportunities in DRIVERS ,OPTICS and other Components

- **Optical Components are inevetable part of Lighting.**
- This is the real innovation zone where competitive through IP creation & entrepreneurial talents will have ample space for play.
- Lenses, Reflector Cones and Diffusers- Bending light is the name of the game. There is dearth appropriate solutions to meet the geometric variations in innumerable combinations of package structures with differing Chip locations, combination of deferring array counts and pitches, and differing profiles dictated by aesthetics and deployment constraints.
- Can you direct it better, with better materials or a manufacturing innovation ? Go ahead and reap the rewards.
- Other wise it’s more of a marketing battle, both prove your technology and gain the mind share that gets the phone to ring.

Opportunities in DRIVERS ,OPTICS and other Components

- **LED drivers**
- There is a lot of room for improvement in the **technology** and **variety** of drivers and power systems.
  - For the IC designers – Challenge of how to design chips that convert the 110/220/440V AC that we use in our homes, offices and roadways, into more friendly voltages (3-5V) that get fed into individual LEDs.
  - You also have to provide it in controlled constant levels of current and not at constant voltages as we do for all applications known hitherto.
  - At such current levels that will help that maintain the LED at the target, and healthy, brightness level.
  - The power supply/driver combination can range from "big" to feed a 50-100W LED street light, to very small, as might fit into the base of Small MR16 bulb. And yet withstand the heat from the LED. It also needs to last as long as the LEDs do, or at least long enough to meet the 35,000+ hours that some studies tout as a key element in LED lighting providing its payback

Opportunities in DRIVERS ,OPTICS and other Components

- **For LED driver Industry the opportunities are Good.**
  - There's room for innovation, but you probably need a broad line or other products in other markets to amortize the overhead.
  - More intelligence is being asked of the driver
  - more efficiency is always needed
  - The design tools are readily available bothe for IC design as well as complex magnetics +Microprocessor baord level design.
  - The IC design/fab outsourcing is a cost effective choice affordable to Powersupply makers companies.

Opportunities in LED Luminaires/Fixtures

- ***LED luminaires/fixtures***
- There's plenty of room for innovation. Real opportunity exists for Companies that can produce a reliable product,
- There are some IP walls being built for replacement for the fluorescent tube, Domestic"Edison" bulb etc.
- Most heard technical challenge is "managing the heat", and it is as a really big issue. As far as todays LEDs are concerned, but not for ever !
- When the real LED lighting revolution happens, non-branded participants will watch or simply wonder what happened. There is need to hurry as many players are already in. Then there is need to build the brand quickly.

Opportunities in *LED Luminaires/fixtures.*

- LED innovation that has taken us in just 2-3 years from standard efficiencies of 50 lumens per watt (lm/w) to now over 100 lm/w and lab versions are showing close to 200 lm/w now.
- Those efficiency jumps have two big effects.
  - One is that more lumens can be packed into a smaller space. We can make street lights without worrying about the wind gale resistance.
  - Second is simplification of fixture design from Heat management angle, giving back the freedom to use sheet metal if not all plastic.

Opportunities in *LED Luminaires/fixtures.*

- **The Reducing role of Heat management in LED Fixtures**
- Consider a 2000Lumen LED in a fixture.
- In the present 100 LPW LED, 30% (2000L) goes to creating light, and 70% (14W) of it goes to creating heat.
- In the 150 lm/w, only 50% (10W) goes into the heat. And 50% (3000L) as light..
- Since we need just 2000L, we can reduce the LED power. And have
  - No of LED chips reduced by 1/3
  - input power reduced to 14W !
  - Heat generated reduced to 7W - the heat problem Is amazingly halved .
- At 200 lm/w, you're down to 3.5W of heat! Heat is no longer a problem !
- So what is your IP and USP today , looses its value tomorrow, even before the expiry of your patent! What matters then is the Brand and market share.
- **Conclusion- Massive Opportunities, but create your brand and gun for the market share.**

LED Costs-Role of Equipment and Process Technology

- SSL can reach cost and performance parity with current lighting technologies, dramatically reducing global energy usage.
- The semiconductor industry's experience in achieving remarkable cost and performance improvements is directly applicable to the SSL industry through
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LED costs- Supply Chain road map

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- Since 1975, the semiconductor industry has made enormous strides in cost reduction, mostly through scaling, but also through manufacturing efficiencies that can be directly applied to LED manufacturing.

LED COSTS- FACTORS

- LED efficiencies are approaching their theoretical limits and will lead to a further reduction in manufacturing costs by about 2x,
- LED current density (droop minimisation) increases (while maintaining high efficiencies) probably will contribute factor of about 2x
- A 5x cost reductions will come through additional manufacturing cost reductions from a combination of larger wafers and more productive tools.
- The semiconductor supply chain helped deliver consistent and significant cost reductions in the FPD & SPV with techniques such as use of industry standards to reduce costs and spur innovation, and pre-competitive supply chain collaboration on technology roadmaps, technology targets and efficiency goals.

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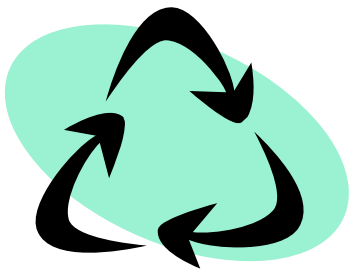
Questions



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