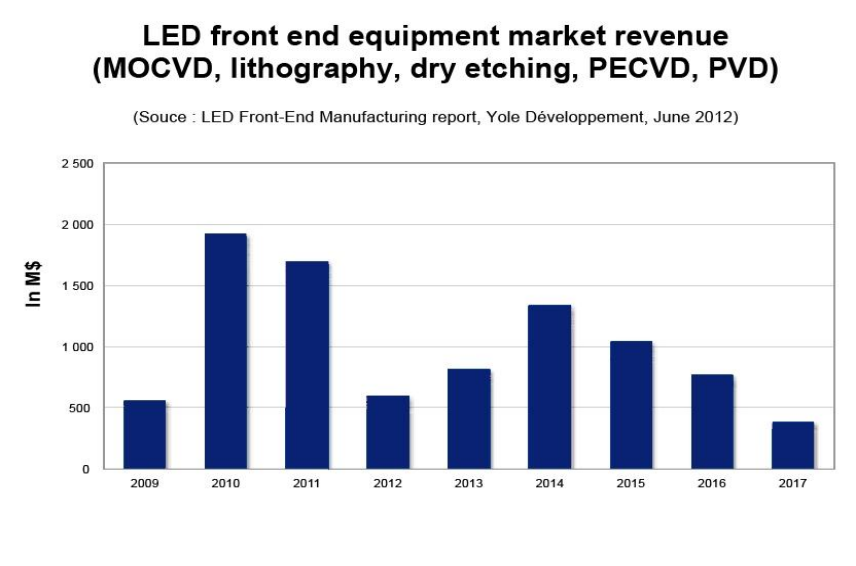
LED Front-End Manufacturing

MARKET & TECHNOLOGY REPORT – JULY 2012

MOCVD, lithography, plasma etching, PECVD & PVD tools to experience turbulent investment cycles in the coming years

GEARING UP FOR THE NEXT INVESTMENT CYCLE

The packaged LED market still presents significant opportunities for growth in the next 5 years but is expected to saturate in value by the end of the decade. Driven by MOCVD reactors, the related equipment market experienced an unprecedented investment cycle in 2010-2011. The cycle was driven by demand in LCD backlight displays, anticipation of the general lighting market and generous subsidies offered by the Chinese central and local governments in a bid to stimulate the domestic chip production and create world leading chip companies. This has resulted in a significant overcapacity situation that will take 12-18 months to absorb.



The next investment cycle driven by lighting applications will start in 2013 and will be more limited in value than the previous cycle due to improvements in equipment throughput and yields. The MOCVD equipment market represents a US$4.3 billion opportunity over the 2012-2017 period.

Together, lithography, plasma etching, PECVD and PVD tools represent a US$650 million opportunity and will essentially follow a similar trend with some exceptions. The market for dry etching tools is still growing in 2012 due to increasing adoption for PSS (Patterned Sapphire Substrate). The market for most lithography tools will however decrease as the industry transitions to larger diameter substrates and the number of wafer starts initially increases moderately but starts decreasing in 2015.

PVD equipment will also experience moderate growth during the next investment cycle. E-beam evaporators have turned into commodities, with systems available from dozens of vendors at very low cost. But opportunities exist in promoting sputtering for ITO deposition and sputtering could also gain some traction in metal deposition if the industry adopts large diameter wafers and moves from batch to single wafer processing. Sputtering equipment could then offer improved cost of ownership.

LEARNING FROM THE SEMICONDUCTOR INDUSTRY

With close to 100 companies involved in front-end LED manufacturing, the industry is too fragmented to generate significant economies of scale. We expect massive consolidation within the next 3 years (2012-2015) which should eventually speed up process and tools standardization and allow economy of scale.

LED manufacturing still uses methods that would be considered outdated in most semiconductor industries. Consolidation and emergence of LED “giants” will also facilitate and speed up adoption of manufacturing paradigms coming from the IC industry.

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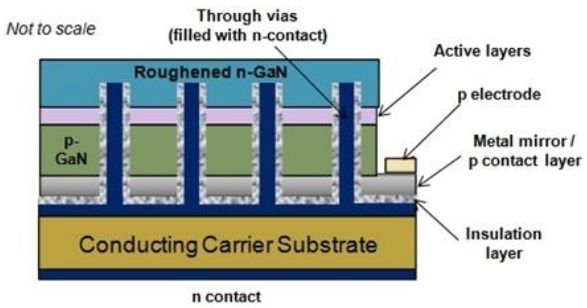
Adoption of Silicon substrates for LED manufacturing could speed up those trends by rapidly moving LED epiwafer processing into existing, highly automated and fully depreciated CMOS fabs. This would also give LED makers access to extended “process toolboxes” which could pave the way for entirely new LED structures.

Example of contact design of OSRAM ThinGaN UX:3 chip

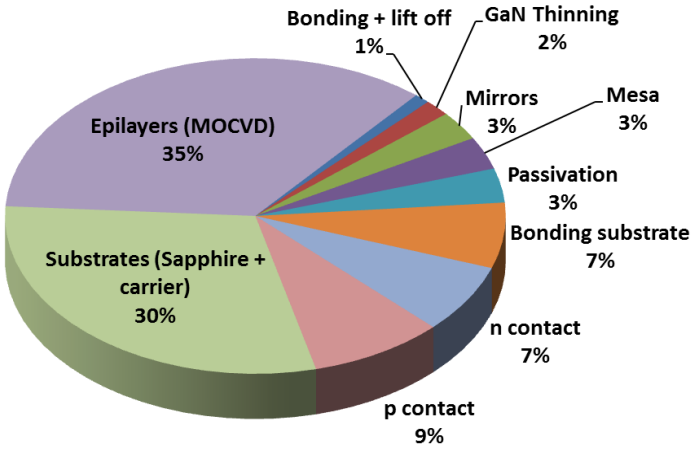


MOCVD STILL A KEY ELEMENT FOR MANUFACTURING COST REDUCTION

To enable massive adoption in general lighting applications, significant technology and manufacturing efficiency improvements are still needed to reduce the cost per lumen of packaged LED. Front-End LED manufacturing typically represents about 50% of the total cost of a packaged LED and offers significant opportunities. Continuous progress is being made in terms of LED structures and materials in order to improve performance, manufacturability or reduce cost.

MOCVD represents the single largest opportunity for front-end cost reduction. Downstream, the emergence of LED dedicated tools has already contributed significantly to cost reduction in lithography, plasma and PVD processing.

Front-End Cost Breakdown for Vertical LED



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REPORT CONTENT

This report presents a detailed analysis of front-end LED manufacturing process, equipment and LED chip design trends. The major LED die structures are presented with pro and con analyzed (standard and flip chip mesa, vertical thin film, thin film flip chip, vertical thin films with vias…). The function, manufacturing process, material and emerging trends of each of the key elements of LED die are presented, including: epitaxial layers, mirrors, pads, electrodes and contacts, passivation and insulation, texturation (patterned substrates). Trends in LED substrates are analyzed and quantified: sapphire, PSS as well as risk and opportunities for LED on Silicon. Front-end manufacturing technologies and the corresponding equipment markets are analyzed in detail, including: MOCVD, lithography, plasma etching, PECVD, PCD (e-beam, sputtering).

BIOs

Dr Eric VIREY, holds a Ph-D in Optoelectronics from the National Polytechnic Institute of Grenoble. In the last 12 years, he’s held various R&D, engineering, manufacturing and marketing position with Saint-Gobain Crystals.

Tom Pearsall & EPIC fellow: in 2003, Tom started the European Photonics Industry Consortium. Before EPIC, he works among others for Bell Laboratories, Thomson/CSF and Corning. He is a Fellow of the American Physical Society and a Fellow of the IEEE.

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