ACHIEVING AFFORDABLE OLED LIGHTING PANELS

JOHN HAMER
6/5/2013
OLEDWorks has (in partnership with others):

- Designed, built, installed, started, and debugged an OLED lighting panel production line.
  - Located in Rochester, NY
- Currently transitioning our product formulations from research to the production lines.
  - For white tandem hybrid we have matched performance and lifetime.
- Sales from mass production will start this year

The facility has attracted the interest many companies:

- Interested in obtaining US-supplied OLED lighting panels
- Interested in collaborating in developing technology
  - Equipment, process technology
  - Organic materials, formulations
  - Substrates/light extraction
  - Encapsulation
CURRENT STATE OF OLED LIGHTING PRODUCTS

Sehwan Son, LG Chem, International LED and Green Lighting Seminar, June 2012

- **LG Chem is the leader in OLED lighting product performance**
  - Current production – 60 lm/W
  - Rumored selling price range - $100-$70 /panel
    - $10,000-$7,000/m2 – expected range based on prices in industry
  - Introducing in 2013 - 80 lm/W (triple stack) with 30,000 hour T70 @ 3k nits
  - Working on 100 lm/W
  - Introducing in 2013 47 lm/W flexible light (50mmx80mm)
**CRITICAL ELEMENTS FOR SUCCESS IN GENERAL LIGHTING**

- **4 Key cost elements of Direct Costs**
  - 1) Integrated substrate ($60/m²)
  - 2) Organic Materials ($40/m²)
  - 3) Encapsulation ($35/m²)
  - 4) Depreciation ($110/m²)

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2012 DOE SSL Mfg Roadmap
Table 3.3 Direct costs $/m²
CURRENT STATE OF OLED LIGHTING PRODUCTION

LG Chem is the leader in OLED lighting production
- G2 line installed in Korea – capacity 6,000 G2 sheets/month (6 min TAC)
- Capacity of 36,000 4” panels/mo at 50% yield
- At 80% yield and full capacity (55,000 panels/mo), for $30M line cost, depreciation is $615/m² (7 year, based on area of panels, 80% yield)
- If they can achieve 1 min TAC, (330k panels/mo) depreciation will be $106/m²

- Other companies with ~G2 production lines
  - Philips – Germany
  - Osram – Germany
  - Blackbody - France
  - Lumiotec - Japan
  - First O-Lite – China
  - Panasonic Idemitsu - Japan
  - Konica Minolta – Japan
  - Kaneka – Japan
  - Fraunhofer – Germany
  - Moser Baer (soon) – USA
  - And others
**Critical Elements for Success in General Lighting**

- **Depreciation Estimates:**
  - $615/m² for G2 at 55k panels/mo
  - + $30M capital
  - $105/m² for G2 at 300k panels/mo
  - + 1 min TAC

- **A big gap. A new approach is needed.**

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Table 3.3 Direct costs $/m²
Sunic is leader in production equipment for OLED lighting

- G5 with 1 min TAC, 60% material usage efficiency
- SID comment “approx 10x cost of G2”
- LG Chem – 3 Million 4” panels per month

- Analysis of LG Display announcement of production equipment for White OLED displays (like lighting)
- $650 M for OLED equipment for 26,000 G8 sheets/month
- Can be accomplished with 4 G 5.5 lines at 70 sec TAC, 70% uptime (half-cut)
- $160M per G5.5 line.
- With 80% yield, and 80% glass pattern efficiency, 7 year depreciation = $85/m2.
CRITICAL ELEMENTS FOR SUCCESS IN GENERAL LIGHTING

- **Depreciation Estimates:**
  - $615/m² for G2 at 55k panels/mo
    - + $30M capital
  - $85/m² for G5 at 3M panels/mo
    - + $160M capital

- A big gap. A new approach is needed.

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Table 3.3 Direct costs $/m²
CRITICAL ELEMENTS FOR SUCCESS IN GENERAL LIGHTING

- 2013 estimates are based on low volume prices but high yields
- Expect price to fall when negotiating larger volumes.
- Expect prices to fall as OLED TV production increases industry volumes.
- Expect cost of organic materials to go down as usage efficiency goes up with larger machine.
- Expect price may go up for new higher-performing solutions.
- A big gap. A new approach is needed.

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Table 3.3 Direct costs $/m²

* Very rough estimates based on industry numbers
We see many announcements and presentations on improving the performance of OLED lighting.

However, it is the high cost of panels that is slowing OLED lighting market development.

- Panels are available with adequate performance, yet there are very few luminaires available.
- We are stuck – a chicken and egg problem
  - Prices will stay high until volumes increase.
    - Capacity of 300k panels/mo from G2 at 80% yield, 1 min TAC
    - Additional investment for large-scale equipment won’t occur until volumes increase.
  - $160M investment required

WE NEED CREATIVE SOLUTIONS
1. **Cost effective substrates with light extraction**
   + Extracting 70% of light generated
   + Anode sheet resistance < 30 ohms/sq
   + Meet cost targets of $60, $44, $28 per m$^2$ of good product\(^1\) in 2015, 2017, and 2020.

2. **Cost effective encapsulation solutions**
   + 20 year shelf life without dark spots > 100 um
   + Meet cost targets of $35, $24, $17 per m$^2$ of good product\(^1\) in 2015, 2017, and 2020.

3. **Equipment for whole line with ratio of**
   + Capital: Throughput of good product\(^1\) < 100:1 \$/m$^2$/year
   + With > 60% material usage efficiency

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\(^1\) After 80% yield, 80% glass pattern usage, and 80% machine uptime
SUPPORT AND COLLABORATION REQUIRED

- Give strong support to OLED lighting manufacturing
  - This is technology where US can have mfg advantage (adv mfg)
  - We must all share the burden of getting started – manufacturers, materials suppliers, equipment suppliers, luminaire makers, governments.

- OLEDWorks is the first, but we don’t want to be the only US panel manufacturer.
  - We need suppliers, technology, equipment, experts, .. “a commons”.

- To strengthen the commons, we support the idea of US Pilot OLED Line
  - To help accelerate OLED technology development, in order to accelerate the US OLED lighting industry.
    - This idea must be executed quickly to have impact in the industry
    - Cooperative models (with gov’t support) work well in other countries and regions.
  - By sharing our resources, we are more than the sum of the parts.
MESSAGE OF ENCOURAGEMENT

- When faced with this challenge, our team and our partners have generated creative winning solutions to these problems
  + Don’t follow the OLED display route – think faster, cheaper, different.
  + Focus on cost in every aspect of the business
    - Product design
    - Process design
    - Equipment design and construction
    - Operation
- We have a strong advantage being suppliers in the US
  + Customers want partners – responsive, fast, flexible.
  + Lighting is based on design. The OLED is a visible part of the luminaire design.
- Having locally produced OLED panels will help US luminaire makers grow the US OLED lighting market
  + This will accelerate the adoption of SSL, and US energy savings.