ABSTRACT

In view of the growing importance of Micro-LED and its application in the down-stream lightening industry, many LED makers have had heavy R&D investment in meeting the micro-LED market characterized by fast-growing demand yet stringent in requirements of Quality Control. This paper based its empirical study upon big data analytics and SIPA (Simultaneous Importance and Performance Analysis) method, has successfully consulted clients how to cope with the technical trends and market development of micro-LED [1]. Focus will be on the following four areas:

1. Niche application of micro-LED (especially under P1=1mm)
2. Dominant players and their technology policy
3. Data analytics for technical and quality service
4. Consultative technical and service strategy

KEYWORDS

Micro-LED, Mass Transfer, Big Data

INTRODUCTION

Micro LED has been the innovative and emerging display technology after the LCD, OLED. The two global consumer electronics giants: Apple and Sony have...
both eyed the introduction of Micro LED as the next generation display technology, and many smaller players have followed suit and invested in Micro LED. This investment trend has also speeded up the commercialization of speeding-up of Micro LED. The marketing and application forecast for Micro LED is projected as follows (Figure 1):

![Figure 1. Trajectory predicting MICRO-LED development.](source: LED inside)

It is estimated that in 2020, the potential market size for Micro-LED may reach over $10b while micro size series will play an ever-increasing share. The trend is also characterized by the important display industry trends: high efficiency and small size series, especially under 1mm, will be the turning-point for mass commercialization of Micro-LED.

**TECHNOLOGY BREAKTHROUGH**

The new technology breakthroughs in Micro-LED could be summarized as the follows.

1. Miniature scaling and matrixization of LED: in a small substrate implanted with a high or super high-density of LED arrays.
2. Each pixel could be identified with separate address and driven by IC circuit and the distance of pixel could be narrowed down to nano-scale.
3. The RGB configuration and IC driver for each pixel could be shown in the following Figure 2 (source and copyright of LED insight)
Significant features of Micro-LED compared with traditional LCD or LED are as:

1. High efficiency, high resolution and miniature in size
2. Self-light-emitting without back lighting source
3. Performance comparison (shown in Table-1):

<table>
<thead>
<tr>
<th>Resolution</th>
<th>A=Retina display</th>
<th>B=Micro-LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>375ppi</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Potential resolution</td>
<td>--</td>
<td>1500 ppi</td>
</tr>
<tr>
<td>Performance B/A</td>
<td>1</td>
<td>3.75</td>
</tr>
</tbody>
</table>

Note: The performance comparison is made if the touch screen of iPhone 6S is equipped with Micro-LED, instead of the Retina, the present material.

Currently Apple and Sony are leading in the pioneering interest of Micro-LED; Apple has shown high interest on this new Display Technology especially it acquired the Niche innovator LuxVue, which has patented in Arrays of Micro-LED. The current breakthroughs in these two giant makers are listed in the following Table-2.

<table>
<thead>
<tr>
<th>Maker</th>
<th>Product</th>
<th>PPI</th>
<th>Sub-Pixel QTY</th>
<th>Release Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sony</td>
<td>Crystal LED Display</td>
<td>40</td>
<td>6,220,800</td>
<td>2012</td>
</tr>
<tr>
<td>Sony</td>
<td>CLEDIS TM</td>
<td>15</td>
<td>345,600</td>
<td>2016</td>
</tr>
<tr>
<td>Apple</td>
<td>Apple Watch 38mm</td>
<td>290</td>
<td>277,440</td>
<td>2015</td>
</tr>
</tbody>
</table>

Source: LED inside, AUG. 2016.
BIG DATA AND STRATEGIC INNOVATION IN MICRO-LED

The rising and proliferating methodology of Big Data has brought wide-spread attention in business as well as academic fields[2]. The application of Big Data and its potentiality development in Engineering, Management Science, Biotech and many other industrial areas opens window of opportunity for more breakthrough and hopes[3]. In this research, the author intends to put forward an integrated decision model based upon the methodology of Big Data and agenda for future research in various industrial fields will be well discussed. The big data technology is especially important in the Industry 4.0 age, for it is vital to find out relevant and critical data automatically embedded in the system if we want the cyber and physical interface and Synchronization to be fully integrated. In the case of Micro LED Mass transfer and yield inspection, the important tasks are as follows:

1. The related comparison of license Technology in fabrication of Micro LED
2. The Precision Requirements of Mass production equipment in Micro LED for each transfer technology
3. Also, the Mass Transformation of Micro LED should overcome the following challenges:
4. The yield rate of mass transformation hinging on the controllability of fabrication process

The three critical mass transfer technologies are: Thin-film transfer, pick up (retrieval) technology, and bonding technology. The three mass transfer technologies which Data Analytics could be used are listed in Table 3:

<table>
<thead>
<tr>
<th>Core mechanism</th>
<th>Data Analytics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thin-film transformation</td>
<td>Statistical distribution of Crystal Grains on the</td>
</tr>
<tr>
<td></td>
<td>substrate film</td>
</tr>
<tr>
<td>pickup (retrieval) technology</td>
<td>Analysis of picking up speed and failure</td>
</tr>
<tr>
<td></td>
<td>percentage</td>
</tr>
<tr>
<td>Bonding technology</td>
<td>Success rate of grains being planted on different</td>
</tr>
<tr>
<td></td>
<td>substrate materials</td>
</tr>
</tbody>
</table>

Note: The data analytics are especially useful in the following areas:

- UPH (Units Per Hour) under alternative mass transformation technology
- Variance Analysis between license technology productivity and mass production
- The application and performance of alternative size spec of Micro-LED
- The mass production of each transformation technology
- Potential production capacity of Micro-LED application with Alternative transfer technology

SIPA

Basic SIPA could be depicted as follows (Table 5).
TABLE 5. CUSTOMER SATISFACTION.

<table>
<thead>
<tr>
<th>PERFORMANCE</th>
<th>H</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMPORTANCE</td>
<td>H</td>
<td>(H,H)</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>(L,H)</td>
</tr>
</tbody>
</table>

In terms of Micro-LED, cost and resolution are two KPIs relevant to customer satisfaction, while the current cost performance is still low due to bottlenecks in mass transfer especially for spec under P1. Thus the strategic issue is how to cost-down the mass transfer technology and then raise the other attributes of Micro-Led.

CONCLUSIONS

The rising and proliferating methodology of Big Data has brought wide-spread attention in business as well as academic fields[4]. In this research, the author first shows the potential of Data Analytics on the new tech issues of Micro-LED yet at the same time intending to put forward an integrated decision model based upon the methodology of Big Data[5][6] thus agenda for future research in various industrial fields will be well discussed. Strategic agenda for Micro-LED is suggested as follows (Figure 3).

![Figure 3. Strategic Agenda for Micro-LED.](image)

REFERENCES