PUBLISHABLE Summary

SCOOP is a European funded project (FP7 project number 287595 – SCOOP). It is focused on OLED technology, microdisplays based on the combination of OLED with CMOS technology, and innovative visualization systems. OLED microdisplays are based on "Above-IC" integration with the principal value chain being located in Europe. SCOOP intends to improve the competitiveness of European industry by helping the industrial partners to maintain and improve their technological advance and to extend their market share by enabling new products. The project will also contribute to strengthen Europe's scientific and technology base in the field of OLED and thin film encapsulation, which can be leveraged for a variety of applications through the institutional partners and the material supplier involved in the project. The project will also provide system integrators with components with outstanding features enabling innovative products like informative eyewear or augmented reality glasses.

The main S&T objectives of SCOOP are:

- **To provide OLED stacks with improved reliability** in order to widen the field of application of OLEDs for displays and lighting in general, in particular
    - Increased operation and storage temperature range
    - High luminance operation
    - >10000hrs of lifetime as well as Reduced luminance decay over time (marking) and
- **Provide improved thin film encapsulation** for better environmental resistance, in order to widen the field of application for OLEDs for outdoor, defense and automotive applications, in particular:
    - Compatibility with high operation and storage temperature range (up to 105°C)
    - Enhance process robustness against defect density (very critical for OLED microdisplays compared to general lighting or display applications).
- **Development of a new OLED device concept** which will enable high luminance full color microdisplays, simplify the manufacturing process, and improve manufacturing yield by integrating solution processed, photo-patternable hole transport layers (xHTL) developed by UCO into the OLED. In particular, with this approach we expect
    - To be able to tune the color spectrum of emission on subpixel level
    - Enable high brightness levels, locally up to 5000cd/m²
    - Reduce the defects density, in particular due to imperfect substrate topography
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    - Simplify the manufacturing process by eliminating the color filter deposition and alignment

  We will develop a new, water-based chemical approach that will allow patterning of the xHTL in the final step of the CMOS fabrication.
- **Test and qualify the new OLED stacks** and the encapsulation stack in high image quality emissive microdisplays as a pilot application
- **Demonstration of the new emissive microdisplays in innovative visualization systems**, in particular head mounted displays with optical see-trough function for augmented reality and outdoor applications

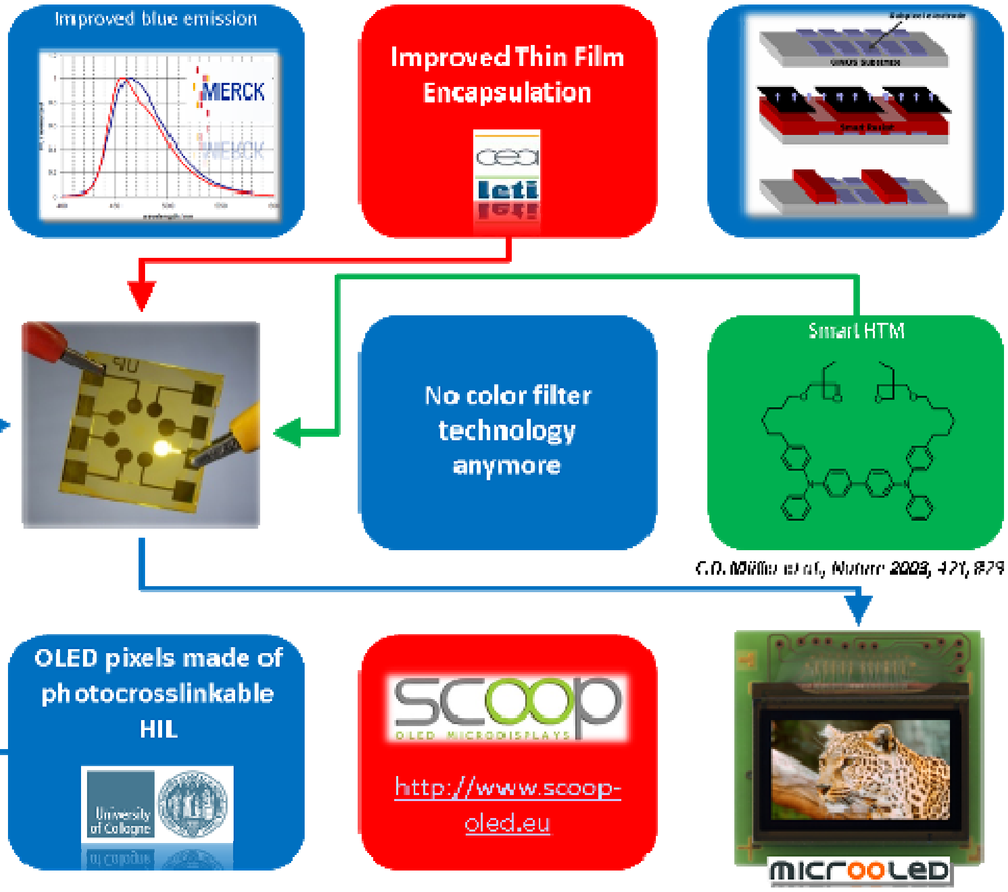

Figure 1 *Diagram showing the technological points addressed in the SCOOP project (OLED picture courtesy of Jeroen Verrejt, Dutch Polymer Institute)*

The partners cover the whole value chain, from research, materials and components to systems. All industrial partners have their main manufacturing sites located in Europe. The outcomes of the project are not limited to microdisplay applications but can apply to many OLAE (Organic Large Area Electronics) devices like biosensors, small to large size direct view displays, lighting devices, or solar cells.

In this way, the project is intended to improve the competitiveness of the European industry by helping the industrial project beneficiaries and technology & component developers like MicroOLED[1] (www.microoled.net) and Merck[2] (www.merck-chemicals.com/lcd-emerging-technologies/oled-materials), to considerably extend their market share in this field and to improve the technological advance in the field of OLED in general. The project will also contribute to strengthen Europe’s scientific and technology base in the field of OLED and thin film encapsulation, knowledge that can be easily leveraged for other applications through the institutional technology beneficiaries LETI (www.leti.fr/en) and the University of Cologne[3] (www.meerholz.uni-koeln.de), or through Merck as a material supplier. Moreover, the project will provide European system integrators, namely Yukon

[1] MicroOLED = MOD in the following text
[2] Merck = MER
[3] University of Cologne = UCO

Optics[4] (www.yukonopticsglobal.com) and Optinvent[5] (www.optinvent.com) with OLED microdisplay components with outstanding features that will enable new and innovative products like informative eyewear and augmented reality (see-through) glasses.

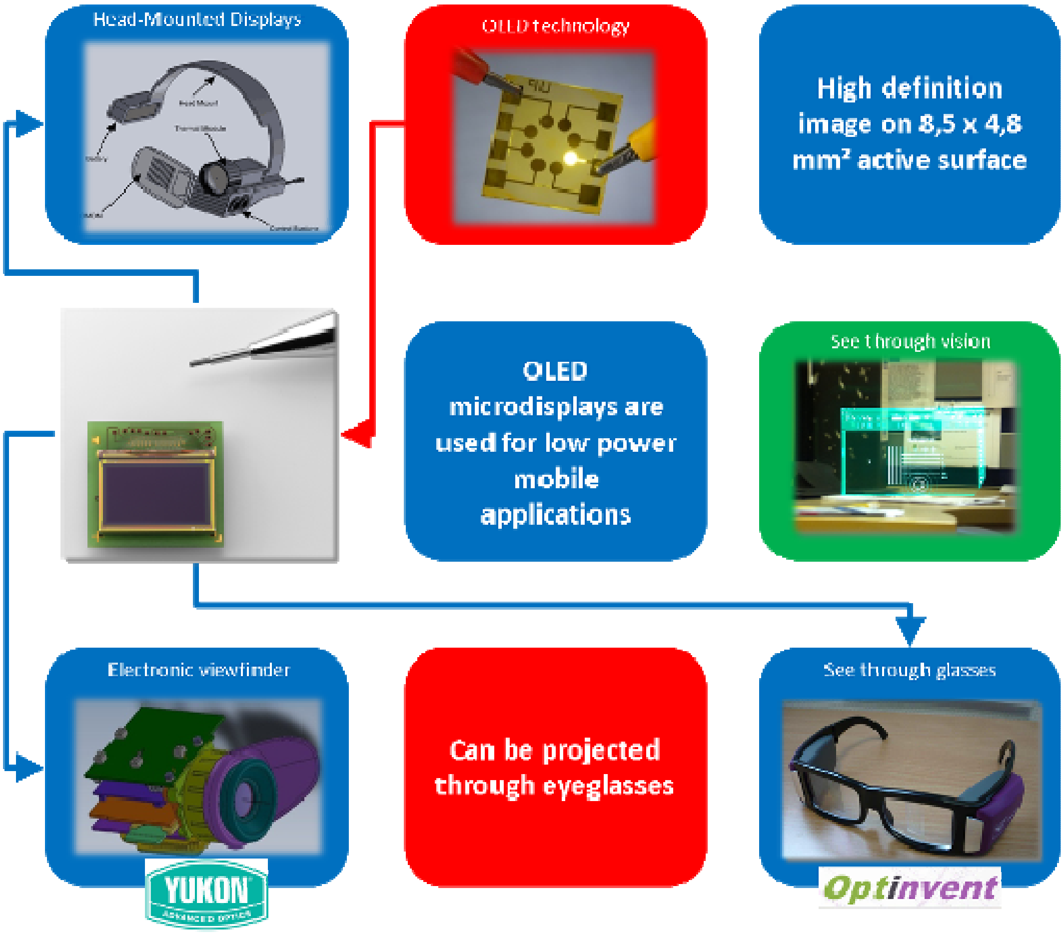

Figure 2 *Diagram showing the interaction between industrial partners in the SCOOP project (OLED picture courtesy of Jeroen Verrejt, Dutch Polymer Institute)*

In a more general manner, these new products respond to different societal challenges: In the longer term, augmented reality glasses will be used as vision aids for visually impaired people, a phenomenon touching an increasing percentage of the population mainly due to the ageing population. Video glasses and viewfinders are also very low power consumption device, e.g. video glasses consumes typically several hundred times less compared to a monitor with equivalent image size and resolution. For some specific applications, video glasses can substitute one or more monitors and present other distinctive advantages like hand-free operation, or 3D rendering, as e.g. for surgical applications, or in logistics and maintenance. Microdisplay-based visualisation systems are also getting more and more used for security related applications like firemen helmets or night and infrared vision devices.

The market for microdisplays is currently undergoing rapid growth through new applications like HMD, a market that is now boosted by new 3D applications, new concepts like informative eyewear, the replacement

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[4] Yukon Optics = YUO
[5] Optinvent = OPT

of optical viewfinders by electronic viewfinders in high end digital cameras, as well as a broad range of high value professional applications like digital night vision, medical applications like vision aids, or industrial applications e.g. in logistics and maintenance. According to a study of McLaughlin Consulting Group, the total market for microdisplays will be around 500M$ in 2012 with average growth rate of more than 100% per year.

Within the first 15 months of SCOOP project, several important results have been achieved in all fields covered by the partners from materials and components up to systems.

In the field of materials for OLED microdisplays, the color coverage of the microdisplay could be significantly improved from 70% s-RGB to above 90%s-RGB. This was achieved on the one hand by developing a new device architecture for the underlying white OLED, on the other hand by implementing newly developed deep blue fluorescent emitters. Deep blue and narrow bandwidth emitters play a crucial role in improving the color coverage of the display. Within the Scoop project, Merck has developed new blue emitters which show PL spectra with peak wavelength <455 nm and full width half maximum < 50 nm with competitive OLED lifetime at the same time, allowing a decrease of the CIE y coordinate of the blue pixel compared to previously available emitters.
Thin film encapsulation has also been improved. The actual multilayer solution gives very strong performances (more than 100hrs @ 85°C/85RH) and the following tests to reach out 504 h of storage are on the way. Regarding the comprehension of defects, we have achieved also important investigations that can help to understand the defect nature and occurrence in the thin film encapsulation stack. Some tentative about the prediction of defects is something that must be developed in the SCOOP project in the coming months. However, the tests onto the AlQ_3 molecule tend to confirm the concept that the encapsulation is not universal and is rather device-dependant. Two origins of black spots have been observed: extrinsic defects coming from particles and intrinsic defects coming from microstructure of thin film encapsulation layer [Maindron et al., Thin Solid Films 520 (2012) 6876].
Within the first funding period, UCO has developed and tested several novel cross-linkable hole-transport materials (x-HTM), some of which are compatible with the restrictions associated with CMOS-processing while keeping the good hole-transport and patterning properties of previous material generations. In addition, the process parameters for lithographic patterning have been optimized, yielding a resolution of 2-4 µm. Finally, our materials have been redox chemically doped for the first time. Altogether, this progress makes the materials very promising for further investigations and industrial applications.

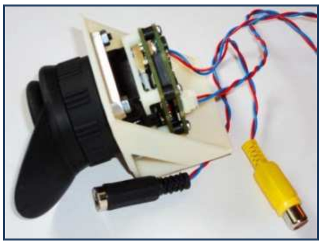
In the field of components, two types of microdisplay prototypes have been demonstrated. The first prototype is a full colour display and demonstrates enhanced sRGB colour triangle coverage and the other one is bi-colour display which demonstrates primary colour generation without the use of colour filters. The coverage for full colour microdisplay has been increased significantly from the previous 84% sRGB to the present 99%sRGB. A colour image when displayed on the new prototype shows considerably better colour saturation for red and green colours. The bi-colour prototype is based on red and green pixels. This prototype to the best of our knowledge is the world's first two colour OLED microdisplay which doesn’t incorporate colour filters. Further, this display well demonstrates the feasibility of this technique to fabricate high luminance colour microdisplays.

In the field of systems, Optinvent designed and produced Head Mounted Display using current Microoled microdisplay. The HMD was demonstrated to European Commission in 2012. The current HMD does not integrate yet the bi-color prototype. The integration of this new component should be done within the end of SCOOP. The current HMD exhibits small weight (44g) and aesthetic form factor. The HMD is a true see-through display projecting virtual image of 22deg Field of View (equivalent to 2m diagonal size image @ 5m distance). The picture below shows the HMD prototype.

Figure 3 *OPTINVENT see-through HMD prototype*

Yukon completed early stage prototyping and tested working models for all three demonstrators: electronic viewfinder (EVF), head mounted display (HMD) and see through module (STM). For all three demonstrators Yukon initially used currently produced microdisplays by MicroOLED. The picture below shows three early stage prototypes.

HMD



EVF

STM

Figure 4 *Pictures of demonstrators fabricated by Yukon*

At the end of the first period of the SCOOP project, Yukon produced more refined demonstrators with improved electronics and received and tested first samples of aspherical moulded plastic optical lenses and beam splitters of various optical properties.

Latest news on this project can be found on the website:
http://www.scoop-oled.eu/index.php?lang=eng&page=m1