Towards Display Technology Leadership in Europe

NATACHA RAPHOZ, NANOELEC/DISPLED PROGRAM DIRECTOR

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MicroLED technology is revolutionizing the field of displays by offering exceptional image quality and immersivity, with display sizes ranging from smartphones to large TVs.

The Nanoelec/Displed program uses Smart-Pixel technology, a patented key technology which paves the way for the manufacture of displays based on new display concepts in Europe.

The goal is to produce extremely bright micro LEDs and assemble them with an underlying control circuit, broken down into very high performance pixels. We use techniques for hybrid bonding of different materials, as well as LED cutting to mount them onto the display support, with extreme precision, high density and high speed: this is the "mass transfer" challenge.

In 2024, the change in Aledia's market access strategy led to work being focused on large pitch 2D-LED technologies, while the small pixel, high-resolution 3D LEDs sector focused on blue smart-pixels.

Given the changing market demands, in 2024 the partners decided to focus their efforts on integration of the 200mm process in order to speed up its industrialization. We are thus developing a low-temperature process for hybrid bonding in order to tap new and promising markets. We are also exploring new solutions for very high-end displays, notably flexible ones. •

AGENDA

TESTING MACHIN FOR MASS TRANSFERT OF THE MICROLED
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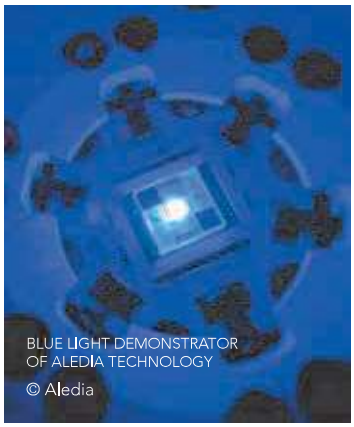
The first LED light

In 2024, Aledia achieved its very first LED light-up with the process at Champagnier.

This first LED light-up has promising performance homogeneity and a VF (applied voltage) decrease at 3V.
Nanoelec's partners are collaborating to design and develop a high-end Virtual Reality glasses solution, using 2D smart pixel. The prototype was presented at the Eurodisplay 2024 symposium in Grenoble.



BLUE LIGHT DEMONSTRATOR OF ALEDIA TECHNOLOGY
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DISPLED PROGRAM AT A GLANCE

- **Vision**
  A unique opportunity for a French & European ecosystem on large display technologies for immersive applications
- **Ambition**
  To design and demonstrate key microLED technologies for high-end, immersive displays
- **Mission**
  To develop process flows for microLED, Smart-Pixel fabrication and mass transfer onto the display
- **Partners**
  Aledia, CEA, EVGroup, SET

Mass Transfer

The radically new techniques developed within Displed allow high-volume collective chip mounting with high-precision alignment.

At the Nanoelec general meeting in November 2024, Abdenacer Aitmani, a researcher at CEA-Leti working on the Nanoelec/Displed program, recalled the advantages of microLEDs. •••

"In terms of brightness, this is the highest performance technology today available. This can create displays which remain legible even when exposed to direct sunlight, he explained. If packaged in optimal conditions, microLEDs can then function for 40,000 or even 50,000 hours, which smashes all lifetime records by comparison with existing light sources!".

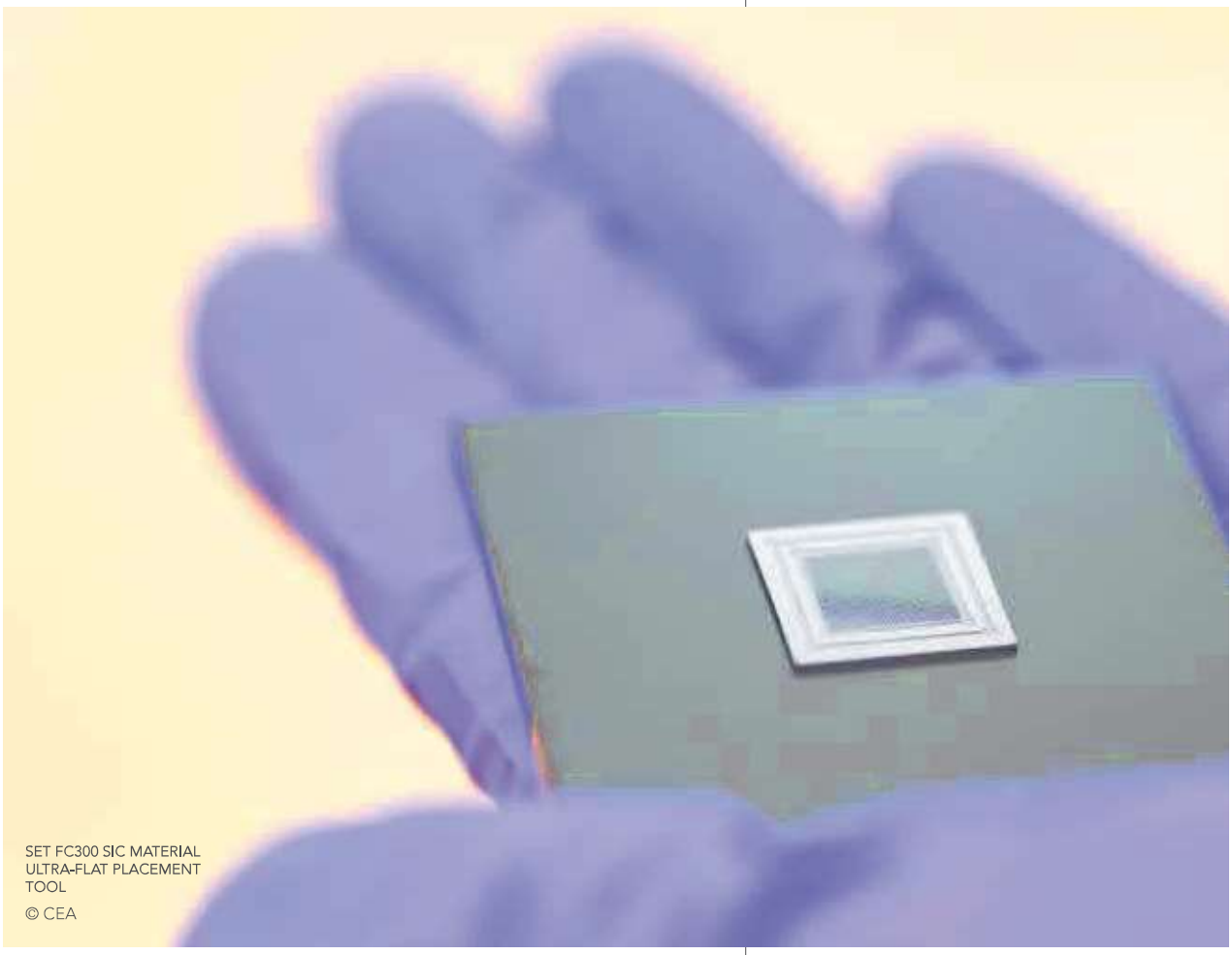
Abdenacer is more particularly interested in transfer to the display support, which is one of the major challenges for industrial deployment. *"A large number of chips have to be transferred, rapidly,"* he points out. This is the technological hurdle known as mass transfer.

"Let's take the example of a display, I would say an equivalent 8K[1] display. Today, if we wanted to manufacture it with microLEDs, based on gallium nitride, and if we assume three chips (red, green and blue), plus the related operations, that would mean more than 100 million chips to be transferred to the display, according to Abdenacer's calculations. Even if the most sophisticated automated instruments can achieve 100,000 components per hour, that's not enough to obtain an end-product that is economically affordable for the public."

As part of the Displed program, the SET and EVG companies, along with CEA, are developing strategies for handling brighter chips and placing them rapidly on the display support.

"These operations must be performed with no chip losses, no alignment errors and no damage to the chips being handled." The process must also enable defective chips to be replaced: *"Just think, you are transferring millions of chips and five or six of them are defective, you would be unable to sell that display,"* adds Abdenacer. •••

1. According to Samsung's definition, an 8K television has a display consisting of 7,680 horizontal pixels and 4,320 vertical pixels, or a total of almost 33 million pixels.



SET FC300 SIC MATERIAL ULTRA-FLAT PLACEMENT TOOL

© CEA

The radically new techniques developed under Displed allow high-speed, collective chip mounting with high-precision alignment.The processes developed could thus make it possible to take hundreds, thousands or even tens of thousands of chips at a time.

"All these tasks are the preliminary steps needed to develop the industrial equipment essential to the deployment of a display production industry in France or in Europe," concludes Abdenacer.

HANDLING MICRO-TOOL FOR MASS TRANSFER OF MICROLEDS

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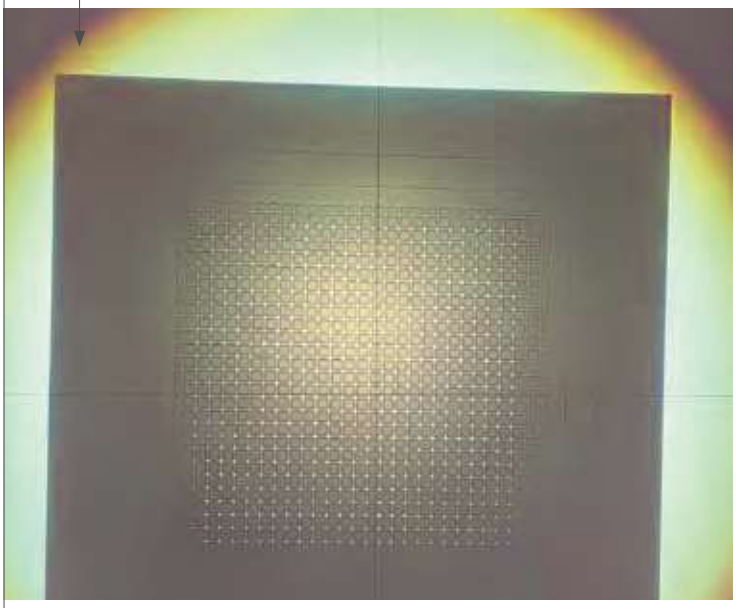

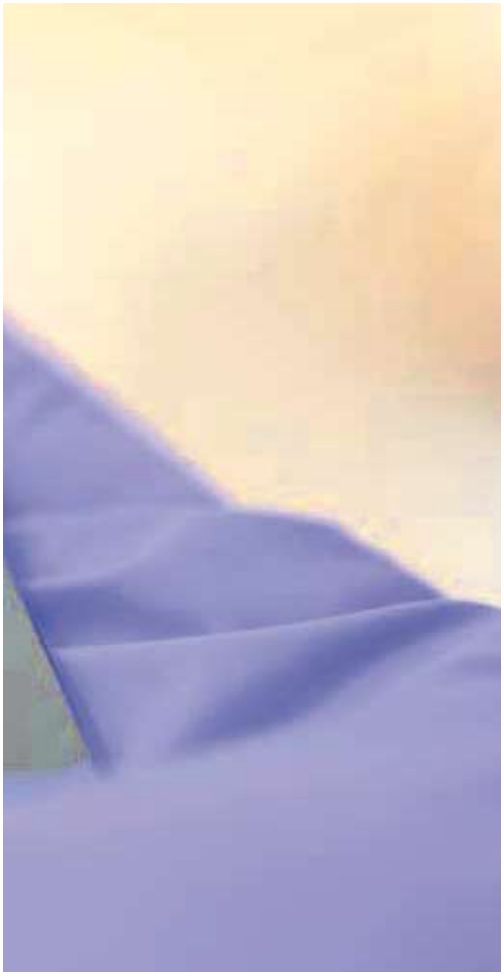

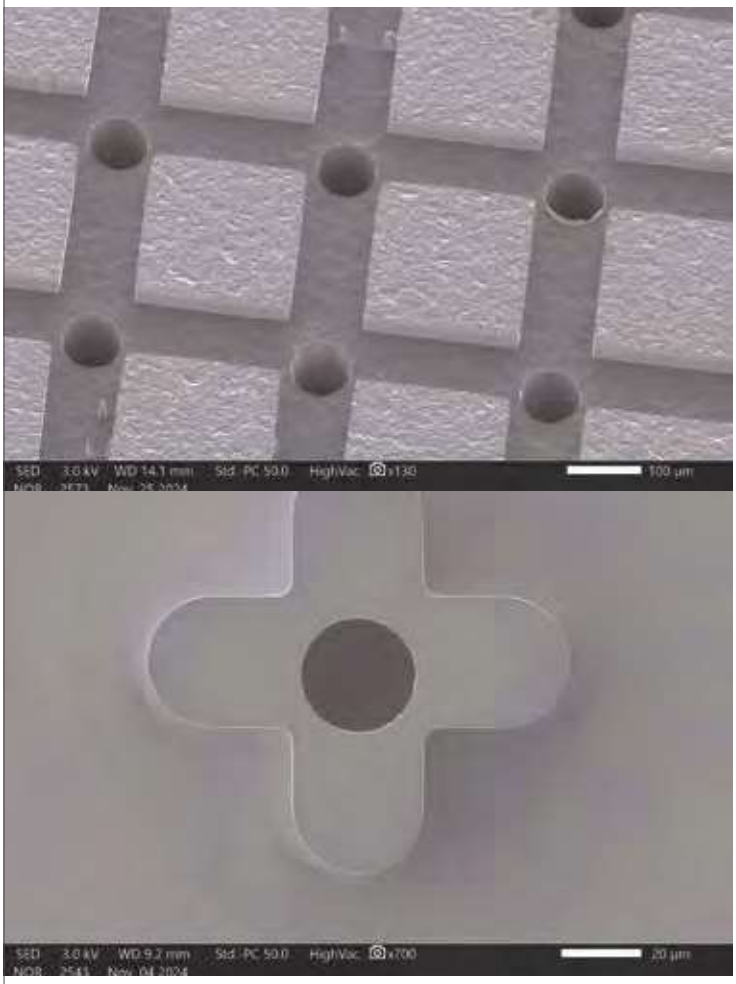

Abdenacer Aitmani, researcher at CEA-Leti for the Nanoelec/Displed program, inspects prototype large-scale chip transfer tools

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Frédéric Berger (CEA-Leti) testing new tools for mass transfer of microLEDs

Vacuum bonding of LED chips

Within Nanoelec, SET and CEA teams have used equipment from their portfolio to test transfer of small dies, individually and collectively.

"We're developing a silicon micro-tool, in which holes are made, which suck in many chips at once and move them from an original wafer to a display," explains Pascal Metzger, Managing Director of SET. The first-generation vacuum-based micro-tool for mass transfer of microLEDs is undergoing testing on an upgraded version of the SET-FC300 tool. *"We have already obtained some encouraging proofs of concept, handling individual tiny chips. To improve accuracy pick-up for smaller dies, we have modified the entire closed-loop system of the robot on one of our machines, adds Pascal Metzger, Our goal is to finish the R&D phase by end of 2025, and then 2 or 3 years to start prototyping and industrialization."* The redesign of the robot of the SET/ACCµRA Plus has achieved better placement accuracy of the dies, as required by their tiny dimensions and the small pitch. The results are encouraging, either when handling one single die, or performing mass transfer. All these experiments will be continued in order to adjust the different parameters for efficient mass transfer and optimized bonding.

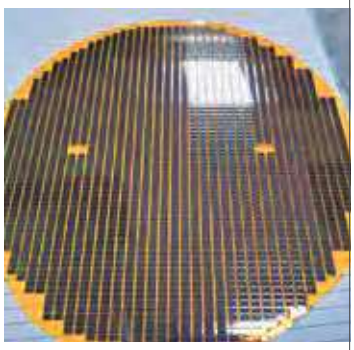
ACCµRA PLUS FROM SET IS USED TO TEST THE PICK-AND-PLACE STRATEGY FOR THE MASS TRANSFER OF DIES

© SET

The move to flexible displays

Advanced applications of the Smart-pixel microLED displays concept, such as flexible displays, or the new functionality based on the addition of sensors, are truly promising.

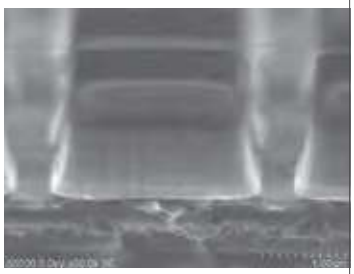
The Augmented Reality market is notably the most demanding in terms of performance. The teams involved in the Displed program identified the design and technical challenges for development, such as pixel-pitch reduction, high-density interconnects reliability. Specimen wafers based on a new process flow have been prepared by CEA-Leti and delivered to Aledia in 2024.



Nanoscale layer etching

A tool capability to etch GaN-based µLEDs has been tested: one process was implemented, based on inputs from Lam Research.

The tool supplier Lam Research and Nanoelec collaborate on a joint development program aimed at advancing nanoscale layer etching processes for a wide range of applications from GaN microLEDs to materials used in RF devices and MEMS.
One process evaluated using Lam Research equipment is the etching of a GaN-based µLED stack, preventing damage to the underlying aluminum contact layer. The landing capability has been successfully demonstrated despite the minimal etch rate difference between Al and GaN.



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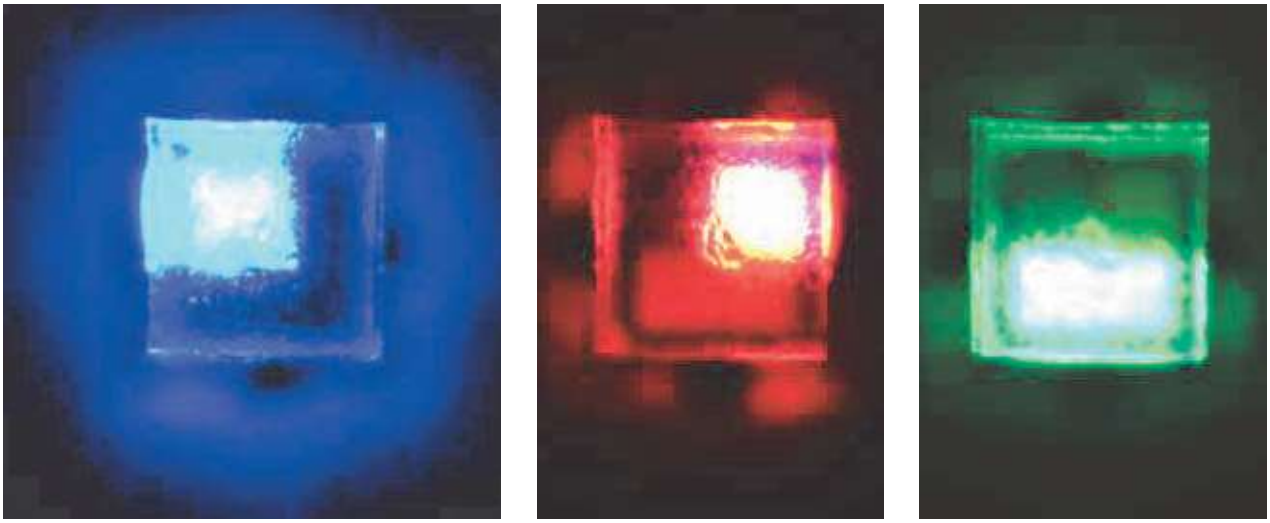
Blue digital LED product

In 2024, Aledia built a demonstrator including a matrix of new-generation 2D-LED Smart Pixels on a fully operational PCB. Severine Cheramy, Product Line Manager at Aledia, presented results at two international conferences[2].

"Active-matrix BLU using Aledia Blue Digital LED is now demonstrated as a possible solution for Virtual Reality applications, and other high-end BLU LCDs could also benefit from it in the medium term," commented Séverine after the Touch Taiwan conference (April 2024).
The Aledia Digital LED Manufacturing Roadmap was presented, including the present ramp-up for the production of the blue digital LED product.

2. LIDs (Grenoble, June 2024) and Touch Taiwan (Taipei, April 2024).



FOR THE DEMONSTRATION OF FULL-COLOR UNITS, THE TEST VEHICLE IMPLEMENTED BY ALEDIA TEAMS SHOWED BLUE EMISSION COMING FROM THE NANOWIRES, AND GREEN AND RED EMISSION BASED ON QD CONVERSION

© Aledia

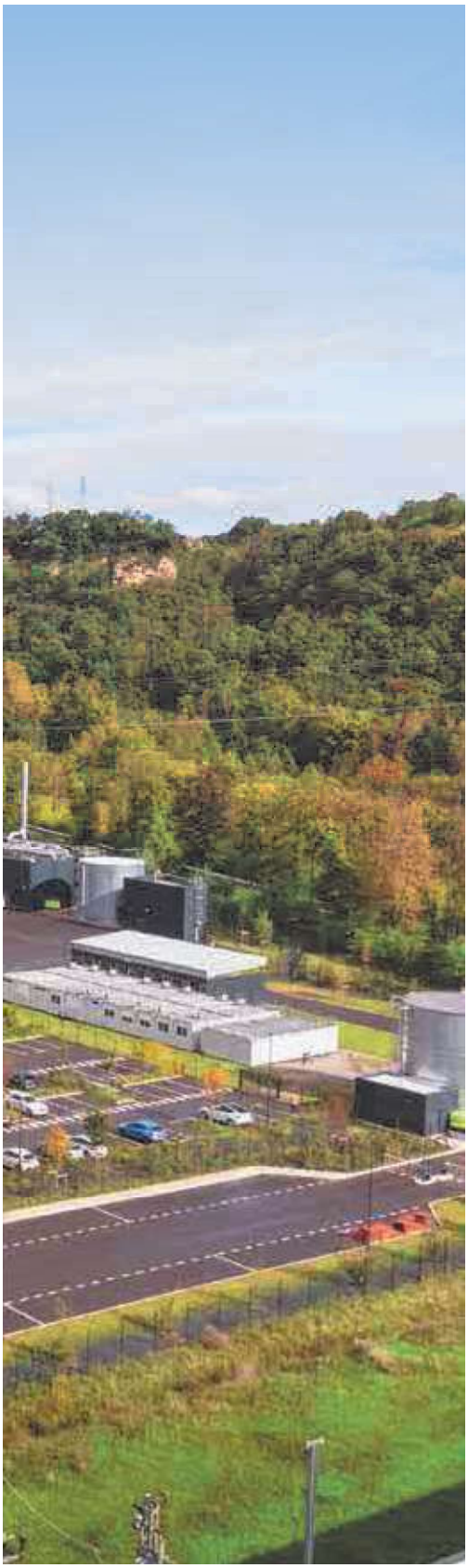
Full-color unit demonstrator

A demonstrator including a matrix of new-generation 2D-LED Smart-Pixels on a PCB is fully operational and major improvements have been obtained on the roadmap towards 300mm microLED production.

LED growth on the 300mm MOCVD system installed at Aledia/Echirolles showed an emission wavelength centered on 446.4nm with very low standard deviation among the LEDs.
3D-LED Smart-Pixel process integration was successfully demonstrated, involving two metal levels, hybrid bonding and backside grinding. For the demonstration of full-color units, the test vehicle implemented by Aledia teams showed blue emission coming from the nanowires and green and red emission based on QD conversion.

Production building now completed at Champagnier

In 2024, Aledia completed construction and installed 25 systems in the Champagnier plant (SDM). The plant now has 34 machines installed.



3D nanowires of GaN on silicone for microLED

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