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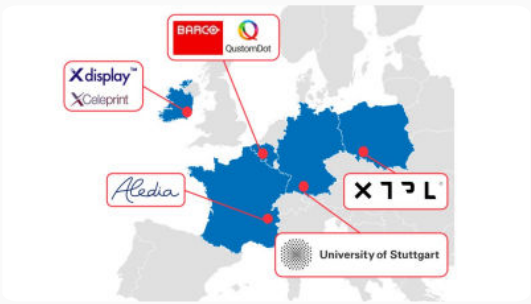
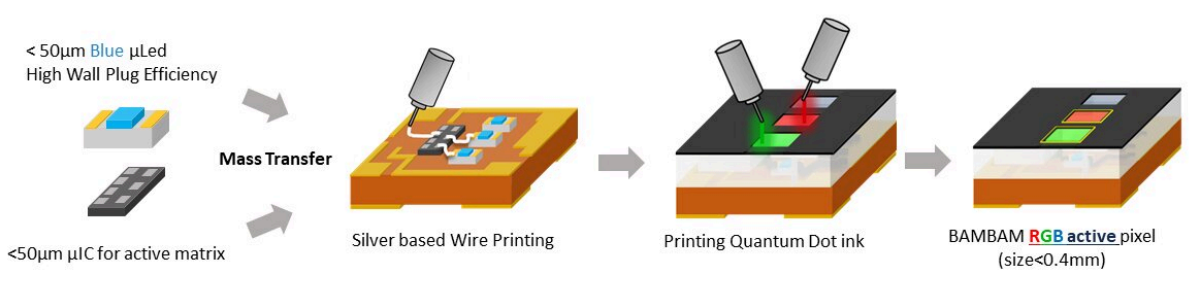
The BAMBAM project



With funding of 4.3M€ from the Horizon Europe programme, the BAMBAM project brings together 7 European partners to develop key technologies to bring back the display production industry to Europe.
The TFT panels that drive most OLED and LCD displays are manufactured in energy- and CAPEX-intensive factories located in Asia, making the relocation of display production to the EU environmentally and economically unattractive. BAMBAM is developing an Additive Manufacturing process that eliminates the need for TFT panels and overcomes TFT limitations regarding energy consumption and design of flexible displays or seamless video walls.
BAMBAM builds on the unique skills and facilities of the Institute for Large Area Microelectronics (University of Stuttgart) to combine cutting-edge technologies developed by 5 European SMEs into a demonstrator meeting the market requirements of BARCO, a major European display provider.



In the first 18 months, the consortium has used an Eco-approach combined with experimentation to define specifications for the material, process and demonstrator. The key component is a digital RGB pixel with a size below 0.5 mm and that is not operated by a TFT panel. This pixel integrates Aledia's blue microLED, XDC's microIC to drive the microLED, and the colour conversion technology from QustomDot. To beat the P0.5 wall and achieve a disruptive pixel size, BAMBAM leverages the unique resolution (1µm) of the Ultra Precise Deposition (UPD) technology (XTPL) to print conductive micro connections. In the targeted process, microLEDs and microICs are mass-transferred (X-celeprint) to a substrate and the conductive connections are printed with UPD

before the packages are isolated for Pick & Place on the display substrate. This process has been derisked with the recent light-up of a 4x4 pixel test vehicle.
In parallel, an extensive collaboration between Aledia, QustomDot and XTPL has allowed significant development on the colour conversion module. XTPL and QustomDot demonstrated an excellent compatibility of InP-based quantum dot (QD) inks with the UPD printer. They successfully printed these inks into cavities designed by Aledia to cover the microLEDs and accommodate the colour conversion module.

After these successes, the consortium is now moving into a consolidation phase, which will culminate with the production of a demonstrator corresponding to the section of a tile for a seamless video wall for luxury home theatres. The consortium is also benchmarking the environmental and economic performance of the developed solutions against LCD and OLED technologies.

BAMBAM Publications

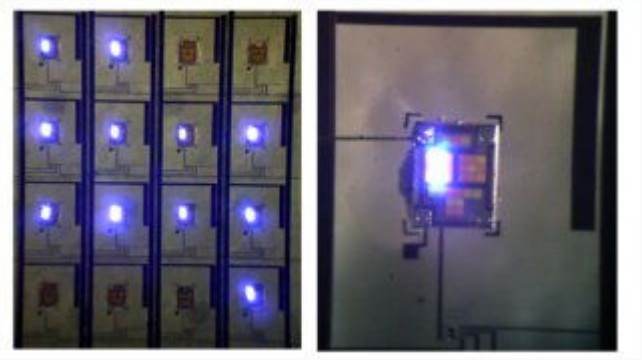
In the first phase of the project, the BAMBAM consortium has published 4 Articles in conference proceedings. Most of these articles are available through the BAMBAM website.

- Lebrun, *et al.*,Building Active Matrix By Additive Manufacturing (BAMBAM). Eurodisplay 2022.
- Fuchs *et al.*, Building Active matrix MicroLED displays By Additive Manufacturing (BAMBAM) – Paving the way to a sustainable fine pitch video wall. International Display Week 2023.
- Jena *et al.*, InP-based Quantum Dot Solutions for Efficient and Reliable Color Conversion in MicroLED Applications. Proceedings of the international display workshop, Vol 30, 2023.
- Waldner *et al.*, Eliminating TFT backplanes in microLED displays using ultra precise deposition (UPD) printed interconnects. ElectronicDisplays Nuremberg 2024.

Come and Meet us at These Next Events!

BAMBAM will be present at the EURODISPLAY 2024 in Grenoble, France, on September 18th and 20th. Come and meet us there.

Technical Focus: The 4x4 Test Vehicle



4x4 Pixel Demonstrator light up on glass (left) and zoomed-in single pixel (right)

Halfway through the project, the manufacturing of a 4x4 pixel demonstrator on glass combined the main, (individually developed) processes and components in one test vehicle to prove the viability towards the planned display demonstrator. The test vehicle was designed to allow the interconnection of 16 R&D µLEDs (Aledia) to as many PixelEngine^{TM} microchips (XDC) in a pixel matrix. The matrix was driven by Barco's FPGA based display driver board. The University of Stuttgart used UPD to print silver wires and connect Aledia's µLEDs to the PixelEngine^{TM} and power supply line. The same method was used to connect the PixelEngine^{TM} to row-,

column- and power supply lines. Because of the usage of early state R&D µLEDs, a sidewall insulation had to be printed first, to avoid shorts by the successively printed silver wires. Further a gold ball had to be placed on the µLEDs aluminium pads prior to silver printing to allow a good contact to the silver wires. These workarounds caused issues with the µLEDs resulting in some not operational pixels in the matrix. However, the final BAMBAM µLED will be natively insulated and has gold pads such that the final process will not encounter these issues. All interconnected drivers were functional. With the knowledge derived from the 4 x 4 test vehicle the consortium is now in the phase of finalizing the process for the final display demonstrator.

Tehnical Focus: Quantum Dot printing for color conversion

The key success factor that distinguishes the BAMBAM project from the common solution is the integration method of the elements in one pixel and filling-up process of Quantum Dot (QD) inks. The XTPL printing technology is responsible for establishing the process of precise dispensing the QD inks provided by QustomDot. The core challenge that QustomDot addresses is stabilizing colloidal QDs within proprietary inks suitable for integration processes. By leveraging its surface chemistry expertise, QustomDot has successfully developed colloidally stable QD inks that are compatible with the XTPL printing process.
Together with QustomDot's photoluminescent material, promising trials with deposition of red and green InP-based QD inks were performed in the form of dots matrix. Compatibility of ink formulation with XTPL Delta Printing system was evaluated on the glass substrate and the process stability observed in time. Generated uniform matrix proved the utility of QD with microprinting technology during the preliminary study and consumes low volume of expensive photoluminescent material. The precise deposition system is a key element to improve the performance of the wide-colour micro displays as it brings solutions for manufacturing multilayer structures with different types of photocurable materials.
Application of the XTPL's ultra precise deposition (UPD) technology is resulting in the repeatable process of control over the filling level of QD inks inside each separated cavity 50 x 50 um. To have high-quality displays, colour conversion layers require homogenous pixels with a thickness of a few micrometers to reduce the leakage of UV light. Microprinting of the QD inks secure high selectivity to each object at a given position on the sample by controllable sequence of the nozzle movement.
Those efforts are expected to deliver optimal solutions for the display industry which require fine pitch with sub-pixel in few µm and high colour gamut with possibility of multi-stacking.
The technical challenges we faced during the project were related to optimization of the printing parameters, ensuring a control over height filling in cavities and increasing the printing speed allowing large dies to be printed .In the next step, we plan to conduct tests to develop and test the method for printing the final BAMBAM Demo.

BAMBAM Gives the Floor to...

Kai Waldner
PhD Student at the Institute for large area microelectronics
(University of Stuttgart, Germany)

What is the subject of your PhD?
The subject of my PhD is the research in additive interconnecting processes for µLED displays. The focus on the XTPL's Ultra-Precise Deposition printing technology related to the BAMBAM project is the main part of this work. This includes processes in handling flexible substrates and setting desired surface properties to align with this deposition process.

What is your Background?
Before I started studying at university, I completed an apprenticeship as a mechatronics engineer at

Metabowerke GmbH. I received my bachelor´s degree in Electrical Engineering at the University of Ulm. My master's thesis at the University of Stuttgart, was about the investigation and realization of analog-digital and digital-analog converters using indium-gallium-zinc-oxide semiconductor. Since 2022, I am a PhD student at the Institute for Large Area Microelectronics, University of Stuttgart.

Why did you chose to do a PhD within a European project such as BAMBAM?
The possibility to work in such a large consortium was very attractive. Being embedded into a complete display developing process, which aims for a European production, makes the work on it even more meaningful. In addition, you have the possibility to learn from project partners in different technology branches where your own work also can profit from.

Paulina Szczepaniak:
R&D Project Manager,
XTPL,Wrocław, Poland

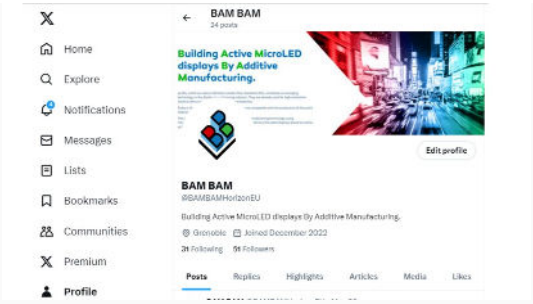
What is your Background?
By profession I am a chemist with a diploma in organic chemistry. Working as a Project Manager with a professional experience of leadership roles in R&D and process engineering in the chemical, FMCG and nanotechnology industries. With more than 10 years of industrial experience, I am responsible for the development of manufacturing technology for new, innovative products at laboratory, pilot scale followed by the successful implementation of these solutions at industrial scale. Author and co-author of 8 granted patent applications. Actively participates in EU-funded projects at national and European level, both as a participant and as a project manager.

What is your role in the BAMBAM project ?
As a project manager dedicated from XTPL side, I am responsible for the implementation of the research plan for the application research of UPD technology for printing various types of quantum dot inks on different substrates. We optimize the printing process so that it is fast, efficient and the ink layers are printed precisely with excellent resolution. In addition to printing, we also use technology such as confocal microscopy to image and size printed structures.
The implementation of an innovative project such as BAMBAM brings many challenges also in the adaptation of printing technology, so my main task is to find solutions to these problems!

What impact do you expect BAMBAM will have on XTPL?
A cutting edge technology - Delta Printing system (DPS) allows us to print conductive as well as non-conductive structures with a precision of less than one micrometre and thus opens the door to the world of microLED displays. Collaboration within the BAMBAM project makes it possible to apply DPS in a high-resolution printing process for conductors with widths in the two micrometres range which is being implemented in the laboratories of the University Of Stuttgart. Additionally, the project contributes to improving our expertise of compatibility DPS with a new generation of InP-based quantum dot inks provided by QustomDot. On top of that, a cooperation with consortium partners enables the exchange of knowledge and access to the creation of innovative solutions and be a part of the revolution in the field of microLED displays.

Do you expect that your role in BAMBAM can inspire more women to work in the microelectronics field?
Microelectronics plays a key role in the development of modern technologies such as artificial intelligence (AI), digital medicine or microdisplays. It is a field of science which is full of complex problems to be solved, which attracts people who enjoy intellectual challenges and research work. Women are persistent and able to achieve long-term goals which is crucial in the implementation of highly innovative work such as the BAM BAM project. I think that women who want to have an impact on the future of technology can see microelectronics as an opportunity to realize these ambitions.

Find us on the web!



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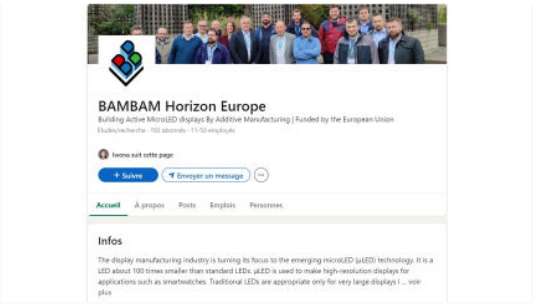

https://www.linkedin.com/company/88032360

Have a look at our website for more information on the project, its consortium and to have access to our publications.

https://bambam-project.eu/

The BAMBAM project consists of 7 partners. Their skills, expertise and experience complement one another on this project. Click here to discover the consortium!

benkei *supports the management of the project with ALEDIA.*

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