

MICRO-OPTICS IS...

Phabulous



Annual Report 2024



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Phabulous

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Closing a chapter, but continuing the vision

As we mark the conclusion of the PHABULOuS funded project, we also reach an important milestone in the life of our association. One of our primary objectives - the successful implementation and completion of the PHABULOuS Pilot Line project - has been achieved. This marks not just the end of a project phase, but the beginning of a new chapter.

Over the course of this journey, we have been able to support many different companies across Europe to implement advanced micro-optics into their products. The collaboration among the members have been valuable and reflects both the strength of the technology and the commitment of those involved in this mission.

It is also a moment to pause and look back in appreciation. I want to personally thank Jessica van Heck for her dedication and ability to steer this initiative through its many stages. From developing the front office to managing complex partner interactions and keeping the association vibrant and visible.

Now, as we turn the page, it is also time to look ahead. With the project formally ending, a natural transition is taking place. A new legal entity has already been established in the Netherlands as this is from where the association has effectively been managed for the past years. This transition not only reflects a geographic and administrative change but positions us well for the future based on a strong foundation already in place.

I am confident that the spirit of collaboration, innovation, and excellence that defined PHABULOuS will carry forward. Let's continue to build a strong and phabulous future together towards new opportunities, new partnerships, and new applications of micro-optics technology.

Thank you to everyone who has been part of this journey. Here's to what comes next.

Toralf Scharf

President PHABULOuS Pilot Line Association



The Association

The PHABULOuS Pilot Line Association is established to function as the entry point for (potential) customers interested in the services of the Pilot Line members. The Association is an independent legal entity with legal capacity governed by the bylaws signed by its thirteen Founding Members.

Objectives

The PHABULOuS Pilot Line Association is established within the framework of the H2020 European research project entitled "Pilot-Line Providing Highly Advanced & Robust Manufacturing Technology for Optical Free-Form Micro-Structures" funded by the European Commission ("PHABULOμS Project").

The main objectives of the PHABULOuS Pilot Line Association are to:

- Implement the PHABULOμS Project in accordance with the Grant Agreement n°871710.
- Unify European research and technology organisations and industrial partners into a Pilot Line for the design and manufacturing of free-form micro-optics solutions.
- Test the efficiency of the pilot line concept through the validation of requests for piloting services within the implementation of the PHABULOμS Project.
- Promote advanced micro-optics technologies and solutions and offer a single-entry point (one-stop shop) in order to facilitate access to comprehensive problem-solving competency for the complete production chain.
- Represent the interests of the micro-optics community on a national and international basis.

Board of Directors

The PHABULOuS Pilot Line Association is owned by its members and managed by its board of directors:

- Toralf Scharf (President), Director Technology at Focuslight Switzerland (Switzerland)
- Paul Hartmann (Vice-President), Director of Institute MATERIALS at Joanneum Research (Austria)
- Philippe Steiert, Director of CSEM Regional Centers at CSEM (Switzerland)
- Jan-Matthijs ter Meulen, CTO and Co-Founder at Morphotronics (Netherlands)
- Veli-Pekka Leppänen, CEO and Co-Founder at Nanocomp (Finland)



Pilot Line Front Office

The daily operations of the PHABULOUS Pilot Line Association are run by the Pilot Line Front Office (PLFO):

- Richard Clark, Director General
- Jessica van Heck, Chief Operations Officer
- Ton Offermans, Technical Coordinator
- Piotr Pucko, Sales & Project Manager



Members

The PHABULOUS Pilot Line Association has 12 members from 9 countries:

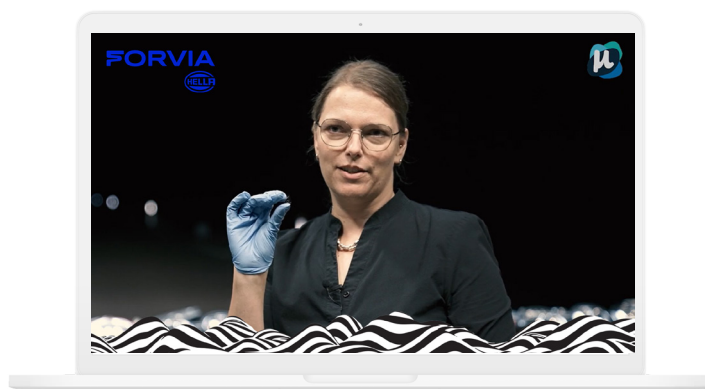
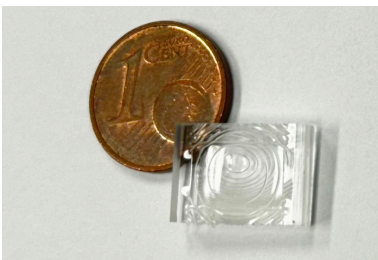
- CSEM (Switzerland)
- Joanneum Research (Austria)
- Fraunhofer FEP (Germany)
- CEA-Leti (France)
- Focuslight Switzerland (Switzerland)
- Morphotonics (Netherlands)
- Nanocomp (Finland)
- Wielandt UPMT (Belgium)
- LASEA (Belgium)
- PowerPhotonic (United Kingdom)
- EPIC (France)
- AMIRES (Czech Republic)



Use cases

Advanced FMLAs for next generation headlights

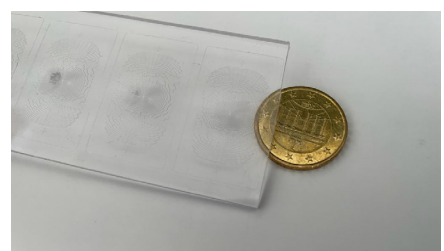
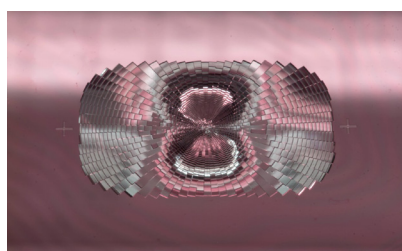
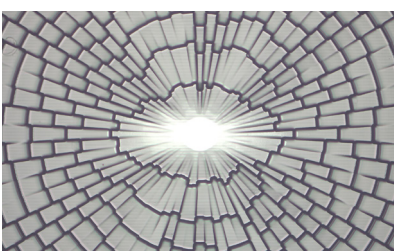
HELLA developed double-sided free-form micro-optics (FFMOs) for compact, lightweight automotive headlights. With support from PHABULOuS, they achieved precise mastering and replication of complex Fresnel and free-form surfaces, demonstrating the feasibility for industrial use in headlamp systems.



Watch the video

Free-form micro-optics for Rail Lighting

SEISENBACHER developed ultrathin LED luminaires using free-form micro-optics to create uniform light with fewer LEDs. With PHABULOuS support, they designed, replicated, and integrated advanced optical films, successfully completing environmental tests for rail vehicle applications.



Asymmetric Lighting for Architecture

Zumtobel designed FMLAs for uniform, asymmetric lighting in architectural applications. Collaborating with PHABULOUS partners, they benchmarked manufacturing methods and validated high-shape precision replicas, setting the stage for innovative, ergonomic lighting products.



ZUMTOBEL



Watch the video

Sparkling Luxury Foils

Swarovski explored free-form microstructures to replicate the brilliance of cut crystal on large-area foils and panels. By testing laser ablation and diamond ruling for mastering, and using roll-to-roll replication, they achieved high-sparkle designs suitable for premium decorative applications.

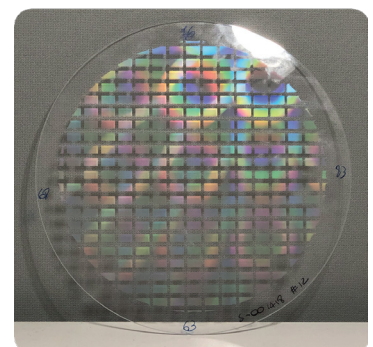
SWAROVSKI



Brightness Enhancement for OLED Displays

MICROOLED worked with PHABULOUS to create free-form microlens arrays (FMLAs) for improving the brightness and angular control of their low-power OLED microdisplays. Mastering and replication methods were compared and optimized to support future AR eyewear products with enhanced visual performance.

micrOOLED



Pilot Cases & Feasibility studies

Autofocal Eyewear Using Free-Form Optics

Morrow is revolutionizing smart eyewear with autofocus glasses that use electro-tunable liquid crystal lenses to switch between near and far vision on demand. Working with PHABULOUS, Morrow scaled up from wafer-based to roll-to-plate nanoimprint manufacturing of Fresnel lens structures embedded in multilayer foils. These were combined with flexible ITO coatings and processed using femtosecond laser ablation and cutting techniques. The project confirmed the feasibility of scalable, cost-effective production, moving Morrow closer to delivering high-performance, electronically adaptive eyewear to market.

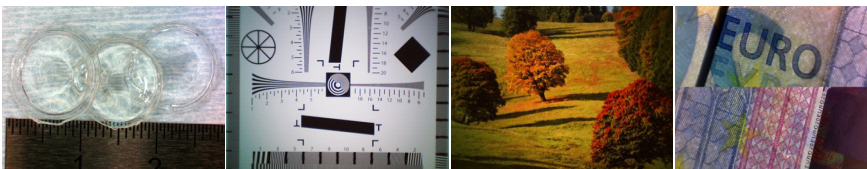


MORROW

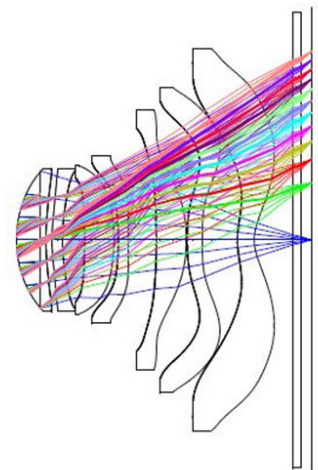


Free-Form Lenses for Imaging Systems

mcd (modern camera designs GmbH) demonstrated their scalable UV-replication technology for manufacturing complex free-form imaging optics. Partnering with PHABULOUS and Wielandts UPMT, they created high-precision master structures through diamond machining, enabling production of aspherical lens stacks with low form error and surface roughness. The replicated optics met strict imaging requirements and were successfully integrated into prototypes for smartphones, medical endoscopes, automotive cameras, and AR/VR systems. The process combined low tooling costs with high volume capabilities, making it a compelling alternative to injection molding.

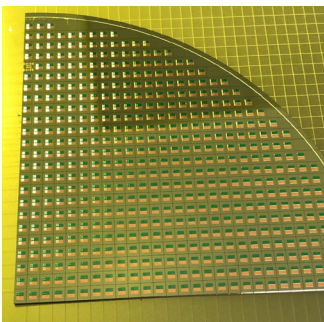


mcd
modern camera designs



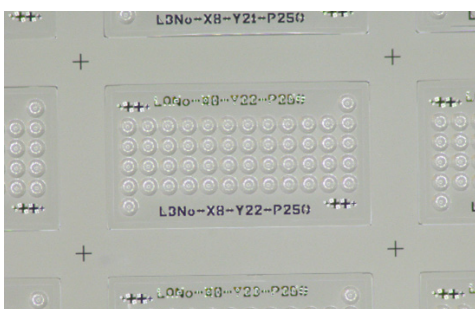
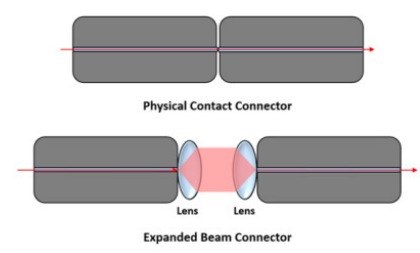
Innovating Miniaturized IR Illumination

4K-MEMS leveraged PHABULOuS' expertise to develop compact microlens arrays for their broadband NIR emitters used in embedded sensing systems. With both circular and square-shaped lens designs, the project emphasized free-form optics, scalability, and thin-film coatings. High-precision replication and coating analyses confirmed optical performance through detailed beam shaping and spectral characterization. The lenses were integrated with emitter chips in a compact module, paving the way for miniaturized sensing in consumer electronics such as wearables, mobile devices, and healthcare tools.



Scalable optical fiber array connector for advanced datacom

FEZ Technologies developed a next-generation, high-density optical fiber connector using aligned polymer microlens arrays fabricated via nanoimprint lithography. This non-contact connector improves robustness, reduces sensitivity to dust, and relaxes fiber positioning tolerances—key advantages over traditional physical-contact connectors in datacom. The process included custom mask design, wafer-scale replication on thin glass, and ultra-precise bonding of microlens doublets. The project demonstrated that scalable, sub-micron accurate optics assembly is feasible, helping to transition SFEZ's LightBridge™ platform toward commercial production.

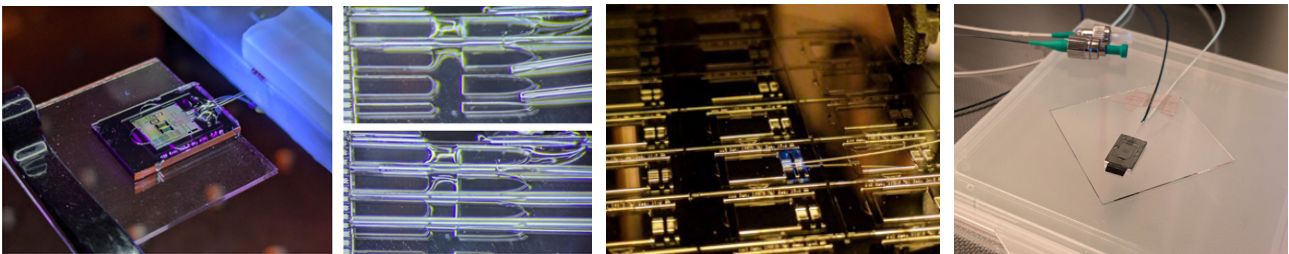


Feasibility Studies



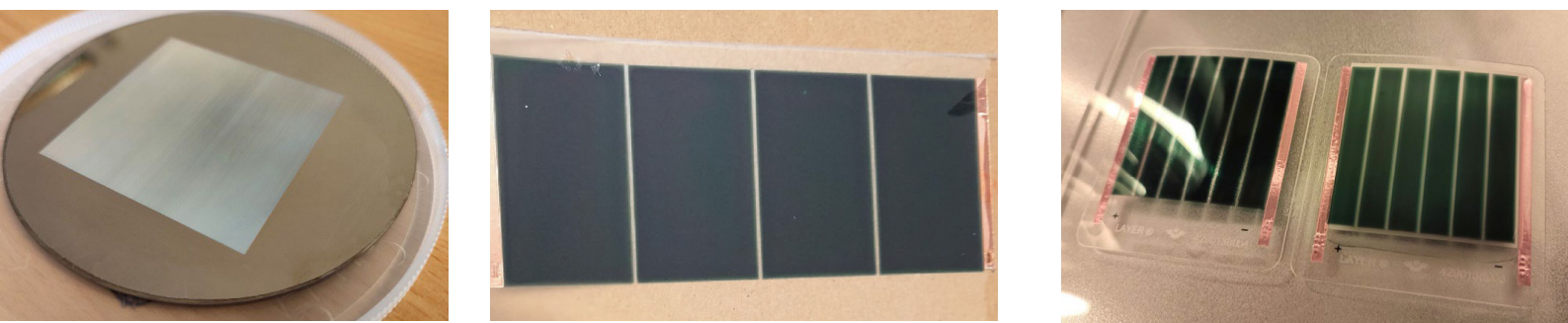
Cost-Effective Fiber-to-PIC Packaging

InSpek, a company developing integrated photonics-based Raman sensors, collaborated with PHABULOuS to explore cost-effective methods for packaging photonic integrated circuits (PICs) with optical fibers. Using nanoimprint technology, they developed passive alignment structures to avoid expensive active alignment methods. The project involved simulations, custom design, replication, and integration processes, resulting in several functional demonstrators. Successful wafer-scale imprinting showed significant potential to reduce production costs and enable scalable biosensor development for biological and chemical monitoring.



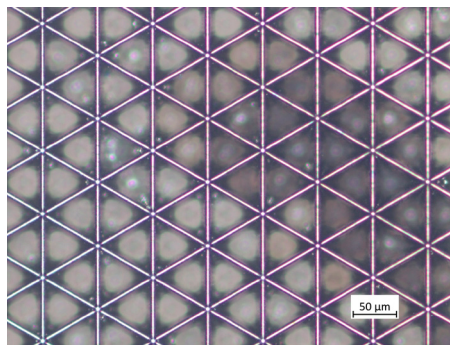
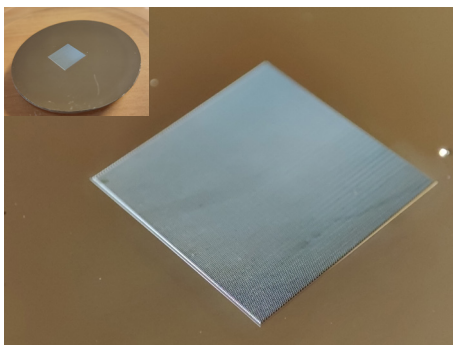
Light Management for Flexible OPVs

Dracula Technologies partnered with PHABULOuS to enhance the performance of their printed organic photovoltaic (OPV) modules, which are used in self-powered electronics. By integrating free-form micro-optics on flexible PET substrates, they increased light absorption while protecting the device surface. Design simulations, embossing trials, and ITO sputtering led to improved diffuse transmission and mechanical durability. The scalable process validated microstructured optical films as a pathway toward more robust and efficient ambient-light energy harvesting solutions for low-power smart devices.



Next-Generation Reflex Reflectors in Automotive

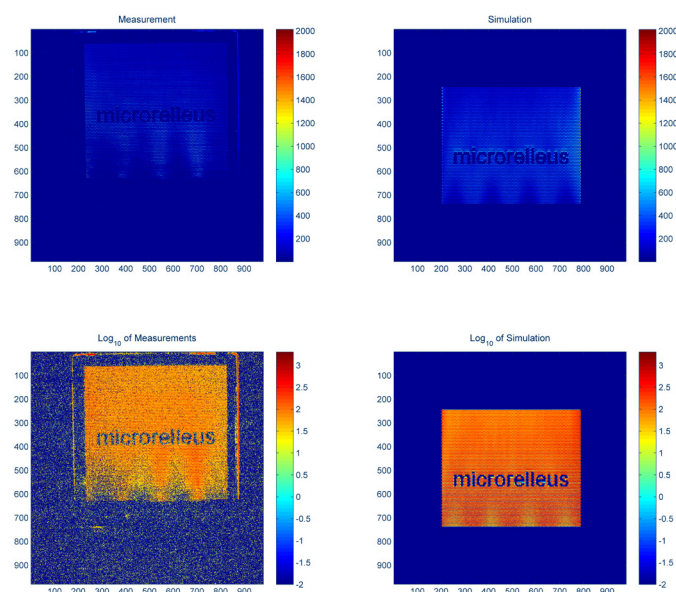
G2 Industrial Engineering sought to modernize automotive retroreflectors using microstructured pyramid surfaces instead of traditional cube-corner geometries. With support from PHABULOU S and JOANNEUM Research, they simulated and fabricated pyramid arrays for efficient light return over a 1 cm² area. Masters were created via grayscale laser lithography, followed by nickel replication and UV imprinting. While minor optical performance deviations were noted due to process calibration, the concept was validated and is now being scaled toward industrial production with enhanced precision and aesthetics.



Optical modelling services for microstructured illumination plates

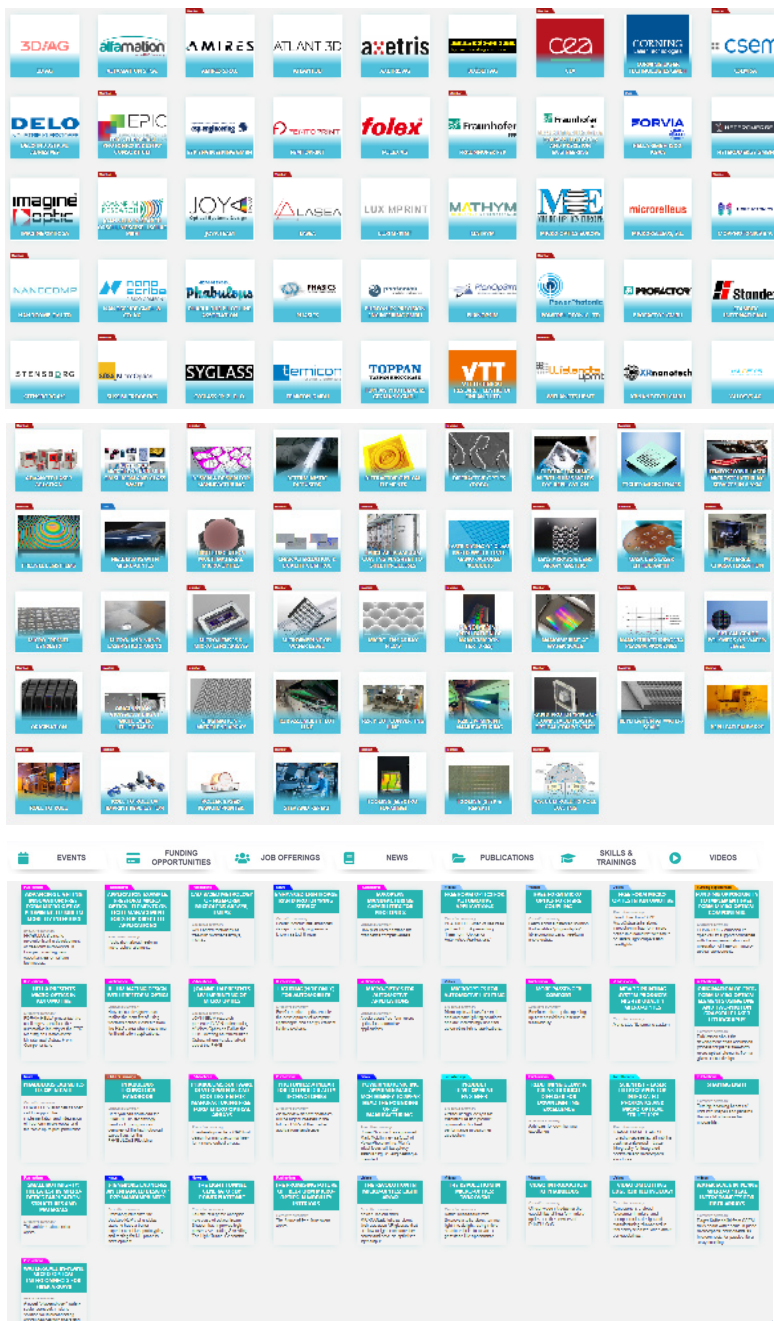
Microrelleus, specializing in laser microstructuring, worked with PHABULOU S to bridge the gap between optical simulations and real-world photometric measurements in illuminated components. They produced and tested both prototype and injection-molded microstructured plates using LED edge lighting and photometry tools. Variations in surface roughness and scattering were introduced in simulation models to better match measured results. The collaboration resulted in a validated modeling approach that improves design reliability and accelerates development for automotive and industrial lighting applications.

microrelleus

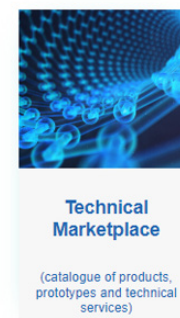


Ecosystem

One of the aims of the PHABULOUS Pilot Line Association is to represent the interests of the micro-optics community. For this a Community Management Platform was launched at the end of 2021. So far there have been over 6000 visits to the market place listings. The least visited page had 76 visits and the highest scoring page had 245 visits. Most of the visitors (72%) come directly to the ecosystem (website or presentation links), 16% through social media and 12% through searches. The demographic is showing that we are attracting an international audience with the US as the number 2 of countries generating traffic.



45 companies registered



43 service offerings



37 community posts

Collaborations

We continued our collaborations with other European projects and associations:

- PhotonHub: partner and active participation, 3 projects have been supplied to PhotonHub to implement free-form micro-optics
- EPIC: membership and event collaboration
- Photonics Austria: membership and event collaboration
- Swissphotonics: membership and event event collaboration
- Photonics Finland: event collaboration
- OptecBB: event collaboration
- Czech Optical Cluster: event collaboration
- Polish Technology Platform for Photonics: event collaboration



Social Media

PHABULOuS utilises several social media systems to reach its community and gain visibility. In 2024, the open call was a key push of information for the ecosystem, but also events, new entries in the ecosystem community platform and other relevant updates were communicated to the ecosystem. Here some statistics of our social media profiles for 2024.

LinkedIn:

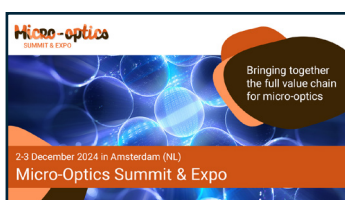
- 1210 followers (+109)
- 65 posts

X:

- 360 followers (+ 35)
- 329 tweets

YouTube:

- 86 subscribers (+ 23)
- 4 new videos

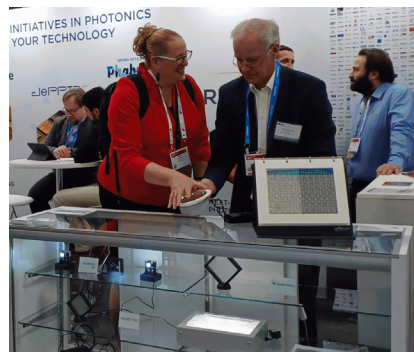


Dissemination

PHABULOuS is visible at many events, both through the efforts of dissemination and communication partner EPIC, the Pilot Line Front Office, as well as through the efforts of the its members. In 2024, PHABULOuS was visible at the following events.

Exhibitions

- Photonics West, San Francisco, USA
- SPIE AR | VR | MR, San Francisco, USA
- Light+Building, Frankfurt, DE
- Hannover Messe, Hannover, DE
- MSPO Exhibition, Kielce, Poland
- Automechanika, Frankfurt, DE
- ECOC, Frankfurt, DE
- Vision, Stuttgart, DE
- Quantum Effects, Stuttgart, DE
- SIA Vision 2024, Paris, FR
- SPIE Photonex 2024, Manchester, UK
- Electronica, Munich, DE
- SEMICON Europe, Munich, DE
- LIGHT-TECH expo, Warsaw, PL
- Light Expo, London, UK



On-site events

- AWE Europe 202, Vienna, AT
- Dutch Photonics Event, Den Haag, NL
- EPIC Annual General Meeting, Juan Les Pins, Nice, FR
- EPIC Meeting on ARVR at Microsoft, Helsinki, FI
- EPIC Meeting on Photonics for Miniaturised Optics, Salzburg, AT
- MicroLED Connect, Eindhoven, NL
- NNT (2024) NIL Industrial Day, Lund, SE
- OPTICA Advanced Manufacturing Alliance, Neuchatel, CH
- Photonics21 Annual Meeting, Brussels, BE
- Plastic Films in Mobility, Wurzburg, DE
- Women Automotive Summit Europe, Stuttgart, DE



Online events

- Enabling Smart Vision Through Meta-Optics
- EPIC Online Technology Meeting on Photonics for Automotive Lighting
- EPIC Online Technology Meeting on Photonics Hybrid Integrated Circuits
- EPIC Online Technology Meeting on Photonics Technologies for Advanced Light Sources
- Live Webinar: How are micro-optics driving next-generation optical communications?
- Optica Online Industry Meeting: PIC Manufacturing, Packaging and Testing
- PHABULOUS Online Workshop on Free-form Micro-Optics for General Lighting
- The Optical System Design of AR/VR Headsets - The Past, Present, and Future

Micro-Optics Summit & Expo

In 2024, PHABULOUS also organised the first editio of the Micro-Optics Summit & Expo on 2-3 December at the Beurs van Berlage in Amsterdam. A new event aiming to unite the entire micro-optics value chain from component manufacturers, equipment and materials suppliers, metrology experts, and system integrators and facilitate collaboration with potential customers to accelerate innovation. The program of the Summit featured more than 30 expert speakers from across Europe's micro-optics community, providing attendees with deep insights into the technology. During the breaks and at the expo attendees could see the technology and engage with the value chain to forge partnerships aimed at driving next-generation optical solutions.



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OUR MEMBERS



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The PHABULOuS Pilot Line Association was founded as part of the PHABULOuS project through funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n° 871710 as an EC funded initiative, in a public-private partnership with Photonics21. www.photonics21.org