REALHOLO

Developing Real World Technologies for Mixed Reality Worlds

Phase modulating micro mirror array for real holographic mixed-reality displays

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Budget

€ 6 Million
100% EU-funded

Consortium

8 Partners
6 countries

Duration

48 Months
01/2021 - 12/2024

Message from the Coordination Team

At this point of the REALHOLO project we look back to a successful first year. The first results were created in form of simulations, validated specifications, component and systems development plans and the start of design and manufacturing activities. In December 2021 the REALHOLO consortium met virtually with representatives of its Industry (Advisory) Board from Holoeye, Mycronic, Philips and X-FAB MEMS Foundry. The feedback was very positive and the consortium is looking forward to the upcoming activities in this challenging and interesting topic. The development of real holographic MR applications will have a revolutionary impact on many fields of our daily life. In the second edition of the REALHOLO newsletter we would like to focus on the project status, the next steps and the first published papers. For more detailed information about the project, we invite you to visit our project website, which is constantly updated with the latest project related news: www.realholo.eu.

The REALHOLO Consortium

The REALHOLO consortium consists of eight partners from six different countries:

Technikon Forschungs- und Planungsgesellschaft mbH, Austria

OmniChip Sp. z o.o., Poland

Fraunhofer – Institute for Photonic Microsystems, Germany

Sencio BV, Netherlands

SeeReal Technologies GmbH, Germany

Valeo, France

nSilition SRL, Belgium

X-FAB Silicon Foundries SE, France

More information about the consortium can be found on the project website:
https://realholo.eu/partners/

REALHOLO project status and next steps

REALHOLO researches and develops a new type of spatial light modulator (SLM), a micro-mirror array (MMA) component with a unique set of properties, as well as a projection display based on this reflective micro-electro-mechanical system (MEMS). The newly developed MEMS technology and MMA will be especially suited for real holographic MR displays but also for many other applications from high value to high volume that also benefit from the fast modulating MMA's for a precise phase modulation with a large number of pixels. In the first 12 months since the project began, target specifications for key components and demonstration systems have been compiled and finalized for practical development and fabrication. The design of the SLM is well advanced in the individual subsystems: the semiconductor portion of the SLM, the MEMS micro-mirror array, and the package. Individual fabrication steps of the MEMS process have now been developed and tested with a high success rate. In addition, the first simplified MEMS-only test devices have been designed and are currently in production. Also, some concepts and basic designs have been created for the later real holographic head-up display (HUD) application demonstrations. As a next step, the second REALHOLO application demonstration will focus on structured illumination to illustrate the benefits of energy redistribution to increase peak brightness in small areas and overall contrast for a given light source. In order to achieve these goals the next months of the project were dedicated to the topics described in the following.

MEMS structured micro-mirror-array

The MMA's actuators are the core technology of the SLM. They are realized as micro-electro-mechanical-system (MEMS). The respective fabrication technology and the design are developed by REALHOLO partner Fraunhofer IPMS. The basic concepts for this have already been worked out by IPMS and SeeReal in previous studies. It was found that classical parallel-plate actuators used in known MMAs may not be feasible for this task. Drawbacks of such prior art mirror-based attempts, especially high stroke precision and tilt avoidance with densely packed small pixels, can be overcome by a new comb-drive actuator. The novel comb-drive micro actuator array and micro mirrors will be fabricated in a surface-micro machining process that will be developed and optimized for this purpose.

Principle Package Concept

The purpose of the package is to mechanically hold the SLM stable within the package and the whole system over life time, mechanical stress and temperature variations. The high bandwidth electrical connection will be achieved by a package substrate printed circuit board for contacting the driving electronics to the bond wires towards the MMA chip. An optical beam combiner will, for the complex-modulating variant of the SLM, be mounted directly on the die and the whole structure will be encapsulated by a cost-effective plastic moulded package.

Design of the CMOS backplane chip driving the MMA

The mirrors of the MMA are controlled by electrostatic means. The purpose of the backplane chip is to act like millions of digital to analog converters (DACs) that generate the control voltage needed on each mirror. This voltage is proportional to the digital representation computed by the holographic image processor. In practice, high-speed serial data links, demultiplexing and specific pixel addressing are techniques used in order to obtain a feasible CMOS IC design from size and power dissipation point-of-view.

The design activities have first focused on two important topics. The first was to check how to receive and deserialize the massive stream of data down to lower speed for further processing. The power consumption is an important metric, the signal integrity on gigabit serial links too. Then, the way to, address and store the pixel voltage for the duration of one frame has been studied. The effect of layout parasitics has been taken into account from the early stage of the design, since the impact on performance. The design of the pixel drivers has been started. A specific architecture is needed, since the high number of instances and the need to maintain the lowest possible power consumption.

With all these developments (design and layout) achieved during the first year, nSilition will pursue the design of the remaining functional analog blocks needed to finalize the addressing and writing to the pixels. Details of the format of the data received from the processor will be worked out so that the details of the digital decoder can be implemented. These blocks will be then assembled and the top level behaviour verified. And the chip will be finally sent for manufacturing.

Complex-modulating variant of the SLM

For the use in the further HUD demonstration, the pros and cons of basic phase modulating variant of SLM and complex modulating variant of SLM are validated. Both SLM variants have their specific advantages for the holographic Mixed Reality (MR) system and it is an integral part of the project to evaluate which variant might be preferred for real holographic HUD.

Hologram computation

In REALHOLO, the „Sub-hologram“ approach is followed. This reduces the requirements on the number of pixels on the SLM and the computational load. For the structured illumination use case demonstration, pre-computed holograms may be used and the phase-only variant of the SLM is used due to its simplicity and lighting efficiency. REALHOLO partner SeeReal will undertake some research efforts to adapt alternative hologram algorithms to a real-time capable solution using the phase-only variant of the SLM.

Driving electronics

Within the project framework of REALHOLO, the partner OmniChip will develop driving electronics that will be able to drive the SLM for development purposes, during characterization and evaluation of use cases. Furthermore, the electronics could potentially be used later on to perform parts of the hologram computation.

Automotive HUD systems

REALHOLO plans to demonstrate its developments in a real holographic MR application implemented as a prototype head-up display (HUD) that may be used in future vehicles. Preparation for validation of the use case will occur concurrently with development and fabrication of the functional MMA components. A HUD demonstrator will be built and characterized with subsequent evaluation of selected features. Both variants of the SLM will be evaluated for use with the HUD demo which will be developed and evaluated by REALHOLO partners Valeo and SeeReal.

Structured illumination in active headlamps

The preparation of the validation of the active lighting use case will also be done in parallel with the development and fabrication of the mentioned components. Optimization of light efficiency is the primary goal in this demonstration case; real-time computation is secondary so that pre-calculated holograms could be used. The headlamp use case will be developed and subsequently evaluated by REALHOLO partner SeeReal.

There still is a variety of steps and activities planned for the next project phases to implement the full scope of the REALHOLO project in order to achieve the expected revolutionary impact for our society.

Papers

The following papers were published and are available on the REALHOLO website.

Paper:

MEMS Spatial Light Modulators for Real Holographic 3D Displays

Peter Duerr, Andreas Neudert, Christoph Hohle, Hagen Stolle, Johannes Pleikies, Hagen Sahm

Submitted at MikroSystemTechnik Congress 2021 on 8-10th November 2021

The demand for 3D displays for virtual, augmented and mixed reality is increasing rapidly. While there are a number of such displays already available, there is still a need for improvement of the user experience. The best possible solution is the full reconstruction of a natural light field by real holography for perfectly realistic images. For this, a novel type of piston mode micro mirror spatial light modulator (SLM) is required, with pixels of only a few micrometers pitch precisely addressable to one of many deflection states. Fraunhofer IPMS and SeeReal together with consortium partners started developing such an advanced MEMS (micro electro mechanical system) SLM with unique properties.

Paper:

MEMS Piston Mirror Arrays for Computer Generated Holography

P. Duerr, A. Neuderta, M. Nitzschea, C. Hohlea, H. Stolle, J. Pleikies

Submitted at SPIE Photonics West 2022 on 1st March 2022

Computer generated holography (CGH) offers the best possible solution for very interesting applications like virtual, augmented and mixed reality. To get the images from the computer into the real world, spatial light modulators (SLMs) are required that fulfil very demanding specifications. Unfortunately, none of the currently available kinds of SLMs can meet this challenge fully. Within the European Union funded Project REALHOLO we are therefore developing a novel kind of MEMS (micro electro mechanical system) SLM especially for CGH applications. The challenge is to modulate the phase of incoming coherent light with millions of individually controllable pixels. The pixels have to be only a few micrometers in size for acceptable diffraction angles and still have a stroke range of half the wavelength of visible light, about 350nm. Within this range, each pixel needs to be set very precisely to one of many deflection levels at frame rates of more than one kHz. This paper discusses the challenge and our solution: an innovative MEMS comb drive actuator array, monolithically integrated on top of a CMOS backplane. The advantages of this design are compared to other types of SLMs and its superior performance is shown by FEM simulations. We also discuss the impact of effects like charging and fabrication imperfections on the deflection precision. Our newly developed MEMS technology and SLM will also enable many other applications that may benefit from the fast and precise phase modulation by a large number of pixels, like wave front shaping or quickly re-programmable diffractive optical elements (DOEs).

Paper:

Challenges of Monolithic MEMS-on-CMOS Integration for Spatial Light Modulators

Christoph Hohle, Sebastian Döring, Martin Friedrichs, Andreas Gehner, Dirk Rudloff, Matthias Schulze, Ronald Stübner and Daniela Trenkler

Submitted at SPIE Opto 2021 on 5th March 2021

In this paper, we will discuss essential requirements and upcoming challenges for the monolithic integration of surface micro-machined optical MEMS on foundry-fabricated CMOS backplanes, as conventional (i-Line) lithography is approaching patterning limits. We will present approaches of tuning the planarization of the CMOS chip surface to achieve an excellent mirror array flatness with CMOS compatible inorganic sacrificial layer techniques. Concepts like Mix&Match lithography for achieving high overlay accuracy and the litho stitching technique for the patterning of large chips will be reviewed and a brief outline of our roadmap for the implementation of DUV lithography will be presented.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101014977.

This project is an initiative of the Photonics Public Private Partnership.

Upcoming Events

Digital Holography and Three-Dimensional Imaging - OPTICA (formerly OSA)
August 01-04, 2022
@ Cambridge, UK

Past Events

SPIE Photonics West 2022
January 22-27, 2022
@San Francisco, USA

Technical, General Assembly and Industry (Advisory) Board Meeting
December 15-16, 2021
@Online Meeting

MikroSystemTechnik Kongress 2021
November 8-10, 2021
@Ludwigsburg, Germany

SPIE-Webinar, Journal of Optical Microsystems (JOM)
October 07, 2021
@ Online Meeting

MEMS World Summit, Europe
September 07-08, 2021
@ Munich, Germany