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Video Holography

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Introduction

Today, despite many efforts by researchers world-wide, there are no holographic projectors that allow video-rate electronically controlled projection of complex holograms. Optically re-write-able holograms exist, but they are too slow; Acoustically-formed holograms can be switched fast but the image complexity is very limited. We identify the essential roadblock as one that we intend to clear by a breakthrough innovation coming from a combination of electronics, optics and material science. We propose a radically novel way to make and control holograms, that will be based on the direct, analog, nanometer-resolution and nanosecond-speed control over the local refractive index of a slab waveguide core over several square centimetres. Holograms will be formed by leaky waves evanescent from the waveguide, and controlled by the refractive-index modulation profile in the core. That profile will be controlled and modulated by electrical fields applied with nano-precision through one of the cladding layers of the waveguide. To that end, a novel metamaterial is proposed for this cladding. Also novel driving schemes will be needed to control the new holographic projecting method. With this combined radical innovation in architecture, materials and driving schemes, it is the goal of this project to fully prove the concept of video-rate electrically-controlled holographic projection. This will be the basis for many future innovations and applications, in domains such as augmented reality, automotive, optical metrology (LIDAR, microscopy, …), mobile communication, education, safety, etc…, and result in a high economic and social impact.

Main project results

High-quality BTO waveguides

Remaining challenges

The control of the BTO waveguide at 100 nm resolution requires close interaction with the metamaterial [1].

Main funding info

- Programme Funding: Horizon 2020
- Sub Programme Area: ERC-2016-ADG
- Project Reference: 742299
- From 01.10.2017 to 31.03.2023
- Budget: EUR 2 499 074
- Contract type: ERC-ADG

CHAPTER

ONE

TEAM

1.1 Core Team

1.1.1 Principal Investigator: Jan Genoe

1.1.2 Senior academic staff in the team

Dr. Robert Gehlhaar provides scientific input on the optical stack design and characterization.

Dr. Zsolt Tokei provides technology input on the realisation of devices in the 300mm cleanroom.

Prof. Clement Merckling provides scientific input on the material growth conditions for the BTO and STO waveguide materials.

Prof. Paul Heremans provides scientific input on the device performance.

1.1.3 PhD students

1.2 Other contributors

Diana Tsvetanova provides input on the CMP processes in the 300mm line.

Yunlong Li provides input on the process sequence in the 300 mm line.

Renauld Puybaret is in charge of the daily supervision of the process in the 300 mm line.

Thomas Raes is in charge of the Mask preparation for the process in the 300 mm line.

Deniz Sabuncuoglu Tezcan is in charge of the supervision of the process in the 300 mm line.

Jeremy Segers is in charge of the oxide-oxide bonding process between the BTO wafer and the optical transparent metamaterial.

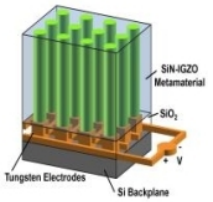
CHAPTER

TWO

PUBLICATIONS

2.1 Journal papers

Table 2.1: Journal papers

	Tsang-Hsuan Wang, Po-Chun Hsu, Maxim Korytov, Jan Genoe, Clement Merckling, **Polarization control of epitaxial barium titanate (BaTiO3) grown by pulsed-laser deposition on a MBE-SrTiO3/Si(001) pseudo-substrate**, Journal of Applied Physics 128, 104104 (September 2020), DOI: 10.1063/5.0019980
	Tsang-Hsuan Wang, Robert Gehlhaar, Thierry Conard, Paola Favia, Jan Genoe, Clement Merckling, **Interfacial control of SrTiO3/Si(0 0 1) epitaxy and its effect on physical and optical properties**, Journal of Crystal Growth 582, 126524 (March 2022), DOI: 10.1016/j.jcrysgro.2022.126524
	Guillaume Croes, Renaud Puybaret, Janusz Bogdanowicz, Umberto Celano, Robert Gehlhaar, Jan Genoe, **Photonic Metamaterial with a Subwavelength Electrode Pattern**, Applied Optics 62,F14 (March 2023), DOI: 10.1364/AO.481396

2.2 Conferences

Artur Hermans, Robby Janneck, Cedric Rolin, S. Clemmen, Paul Heremans, Jan Genoe, Roel Baets, **Growth of Thin Film Organic Crystals with Strong Nonlinearity for On-Chip Second-Order Nonlinear Optics**, Proc. IEEE Photonics Benelux Symposium, Brussels, Belgium, November 15-16, 2018.

Guillaume Croes, Nikolay Smolentsev, Tsang-Hsuan Wang, Robert Gehlhaar, Jan Genoe, **Non-linear electro-optic modelling of a Barium Titanate grating coupler**, Proc. SPIE 11484, 114840D: Optical Modeling and Performance Predictions XI (August 2020), DOI: 10.1117/12.2568032

Guillaume Croes, Robert Gehlhaar, Jan Genoe, **Hologram Wavefront Shaping by a Non-Linear Electro-Optic Spatial Light Modulator**, Holography: Advances and Modern Trends VIII, April 2023, Prague, Czech Republic

Guillaume Croes, Robert Gehlhaar, Jan Genoe, **Sub-Wavelength Custom Reprogrammable Active Photonic Platform for High-Resolution Beam Shaping and Holography**, Proc. SPIE PC12196, PC1219619: Active Photonic Platforms, San Diego, California, United States (October 2022)

Clement Merckling, Islam Ahmed, Tsang-Hsuan Wang, Moloud Kaviani, Jan Genoe,
Stefan De Gendt, **Integrated Perovskites Oxides on Silicon: From Optical to Quantum Applications**, ECS Meeting Abstracts MA2022-01, 1060 , July 2022, DOI: 10.1149/MA2022-01191060mtgabs

Tsang-Hsuan Wang, Robert Gehlhaar, Thierry Conard, Jan Genoe, Clement Merckling, **Interface Control and Characterization of SrTiO3/Si(001)**, Proc. E-MRS-fall, 20th to 23rd September 2021

2.3 PhD thesis

Table 2.2: PhD thesis

	Tsang-Hsuan Wang, **Study of Barium Titanate Epitaxy on Silicon toward Its Application in Video Holography**, PhD Thesis, KULeuven, Leuven, Belgium, Monday, February 13, 2023.
	Guillaume Croes, (PhD Thesis in preparation), KULeuven, Leuven, Belgium

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[1] Guillaume Croes, Robert Gehlhaar, and Jan Genoe. Sub-wavelength custom reprogrammable active photonic platform for high-resolution beam shaping and holography. In *Active Photonic Platforms 2022*, volume PC12196, PC1219619. San Diego, California, United States, October 2022. SPIE. doi:10.1117/12.2632022.