Technology Offer

# Towards New Optical Devices: The Electrically-Controlled Dynamic Metasurface

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**The invention relates to a new dynamic optical component based on a metasurface that can be operated electrically at visible frequencies. Realizing pixel level addressability of the metasurface properties paves the way towards the next generation of optical devices for data storage and communication.**

**Nanoantennas on a metasurface are used to directly change properties of light but are typically limited to static effects. However, state-of-the-art devices with optical reconfigurability are lacking pixel-level addressability as they rely for example on temperature variations.**

**The problem was solved by an inventive approach of using electrical addressability that is universal and works for any active material, which exhibits refractive index changes upon external stimulation. It will thus largely enrich the functionality breadth of current metasurface devices at visible frequencies.**

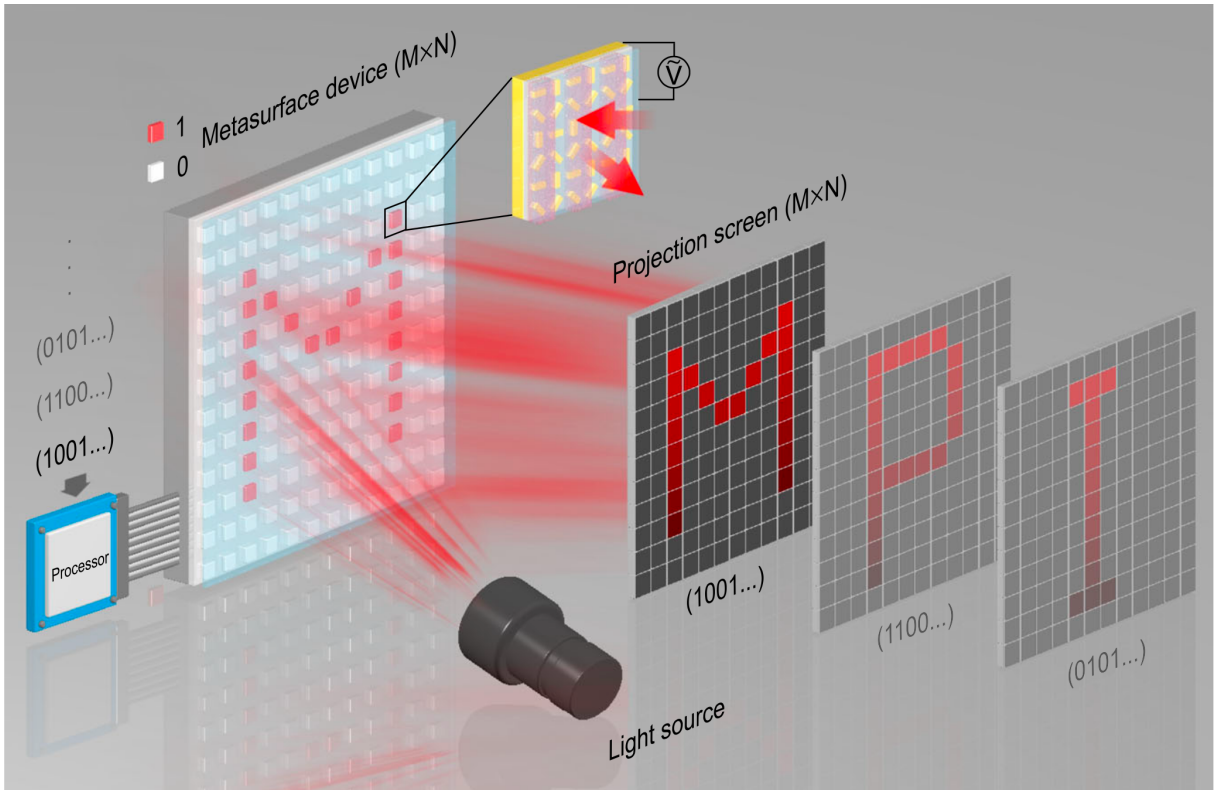


**Fig. 1:** Possible implementation of the invention. A digital metasurface device for light projection displays comprises metasurface pixels in an M × N array. The intensity of the reflection from each metasurface pixel is controlled by an addressable electrode and can be independently switched on and off. Programmable images (M × N resolution) are dynamically displayed in the far field.



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## Advantages

- Operation at visible frequencies
- First pixel level control of a metasurface
- Universal for many active materials
- Highly integrated and compact design possibilities

## Applications

- Nanophotonic devices
- Data storage
- Optical communications
- Cryptography and security

## Background

In a metasurface, meta-atoms, usually consisting of plasmonic or dielectric nanoantennas, can directly change light properties such as phase, amplitude, and polarization. So far, research has mainly been devoted to optical devices in which the individual elements are static, especially at visible frequencies. This leaves out many opportunities that metasurfaces can offer. For reconfigurability, active media can be integrated, for example liquid crystals in response to electric fields or vanadium dioxide in response to temperature tuning. However, this approach fails, because the optical antennas on the metasurface will be tuned simultaneously upon an external input, lacking pixel-level reconfigurability.

## Technology

A novel electrically-controllable dynamic metasurface has been developed to overcome the aforementioned shortcomings and improve their applicability to future devices.
The pixel-level addressability is achieved by selective combination of geometric phase and propagation phase on individual subwavelength pixels. This concept is universal and works for any active materials, which show refractive index changes upon electrical, light, thermal, or other external influences.
An implementation according to the invention is shown in figure 1. A metasurface is caged in a cell, which is filled with highly birefringent liquid crystals. Some of the antennas, i.e., subwavelength pixels, are selectively covered with dielectric pillars. This introduces an additional propagation phase on such pixels and isolates them from the liquid crystals, deactivating the response of these pixels to electrical control. Completely interchangeable functionalities like switching between different holographic patterns within a hologram, or multi-function switching among beam steering, focusing, holography and optical vortices can be successfully implemented within milliseconds and with excellent reversibility under electrical control at visible frequencies.
This invention features great potentials to achieve diversified optical functions, while keeping individual functions highly independent within a single nanophotonic device.

## Patent Information

PCT *(WO2021104902A1)*, EP, CN

## Publications

J. Li *et al.*, "Electrically-controlled digital metasurface device for light projection displays", Nature Comunications (2020)

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