EPFL-TTO

EPFL Innovation Park J
CH-1015 Lausanne
Switzerland
+41 21 693 70 23
http://tto.epfl.ch/

Research Contact

Giulia Tagliabue
+41 21 693 89 91
giulia.tagliabue@epfl.ch

TTO Contact

Ghislain Singla
+41 21 693 54 77
ghislain.singla@epfl.ch

Licensing Opportunity

TTO – Technology Transfer Office

Ultrafast Optical Modulation Using Amorphous Silicon Metasurfaces

Ref. Nr

6.2637

Keywords

Ultrafast optical switching, optical modulation, thermo-optical nonlinearities, metasurface

Intellectual Property

PCT/IB2025/062095

Publication

O. C. Karaman et al., *Decoupling Optical and Thermal Dynamics in Dielectric Metasurfaces for Self-Encoded Photonic Control* Laser Photonics Rev. 2025, e01014
DOI: 10.1002/lpor.202501014

Date

16/12/2025

Description

Conventional optical modulators rely on bulk electro-optic materials, free-carrier injection, or thermo-optic effects. These approaches typically suffer from large footprints, limited modulation speed, high power consumption, and restricted spectral flexibility, limiting their integration into compact photonic platforms.
This invention introduces an all-optical modulation method based on an amorphous silicon metasurface composed of an array of subwavelength nano-disks supported on a substrate or layer.
The metasurface is engineered to support electric and magnetic dipole Mie resonances, each producing a well-defined resonance dip in the transmission spectrum. An optical signal at a selected operation wavelength is transmitted through the metasurface and modulated by optically shifting the resonance wavelengths via photo-excitation.
Optical modulation is achieved by illuminating the metasurface with a pump (photo-excitation) electromagnetic wave, which dynamically shifts the electric (λ ED) and magnetic (λ MD) dipole resonance wavelengths.
This shift alters the transmission at the operation wavelength, enabling intensity modulation without electrical actuation.

Advantages

- Fully all-optical modulation (no electrodes, no contacts)
- Exploitation of both electric and magnetic Mie resonances
- Compact, planar, and CMOS-compatible architecture
- High modulation efficiency with low pump energy
- Flexible operation wavelength selection
- Suitable for ultrafast optical switching

Applications

- Integrated photonics and optical interconnects
- On-chip optical signal processing
- Ultrafast optical switches
- Optical communications and modulation platforms
- Photonic computing and neuromorphic optics
- Tunable optical filters and sensors