Docket #: S20-278

Tunable, On-Chip Beamsteering with Resonant, Electrically-Reconfigurable Phase Gradient Metasurfaces

The Dionne lab has developed ultrathin and compact devices for electrically driven beamsteering that fit on a semiconductor chip. These devices rely on resonant dielectric nanostructured surfaces known as "high quality factor" (high-Q) metasurfaces. By virtue of their strong light-matter interactions, our high-Q metasurfaces can be readily tuned and reconfigured, making them dynamic without mechanical manipulation. Our technology can be applied to LIDAR, LIFI, AR/VR, and optical imaging platforms where lightweight, compact and dynamic solid-state optics are desirable.

Using standard CMOS processing, we fabricate arrays of subwavelength dielectric antennas with narrow spectral features (associated with high quality factor resonances) in or nearby electrically tunable materials. The optical response of the high-Q metasurface can be modulated or reconfigured using an electric field. We have considered electro-optic materials such as Lithium Niobate. However, other effects such as localized thermal heating can also be used. The high-Q metasurfaces are only a few microns thick and can be integrated with standard optical light sources and detectors or combined in the same monolithic structure using VCSELS for extremely compact devices. Biasing can be applied across the full metasurface or across individual nanoantennas for almost complete control over the transmitted and /or reflected wavefront.

Stage of Research

- Proof of concept

Applications

- **LIDAR**
- Wearable and mobile sensors
- VR/AR
- Remote sensing and optical ranging
- Compact optical imaging and dynamic focusing

Advantages

- **Single chip design**
- High reconfigurability
- Increased efficiency and signal-to-noise over existing solid-state approaches: modulate transmission of light to a particular direction from over 70% to less than 10% with applied voltages of 10s of Volts
- Light source can be on-chip or external

Publications

- Lawrence et al. Nature Nanotechnology (2020) High quality factor phase gradient metasurfaces
- Klopfer et al. Dynamic focusing with high-quality-factor metalenses *Nano Letters* (2020).
- Barton et al. Under Review (2020) "High-Q nanophotonics: Sculpting wavefronts with slow light"
- Barton et al. Under Review (2020) "Wavefront generation and modulation with resonant electro-optic phase gradient metasurfaces"

Patents

- Published Application: WO2022060858
- Published Application: 20230350266
- Issued: 12,638,743 (USA)

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