Docket #: S19-429

High quality factor phase gradient metasurfaces

High quality factor ("high-Q") photonic technology has revolutionized information processing, communications, sensing and nonlinear optics. Researchers in the Dionne Group at Stanford have developed a scheme to generate, for the first time, high-Q phase gradient metasurfaces. Metasurfaces are 2-D arrays of carefully designed nanoantennas that enable control over both the amplitude and phase of outgoing light. Using the new scheme, they have achieved a record-setting Q factor **two orders of magnitude higher than what has been achieved before.** Even greater Q-factors in the millions are within reach with modifications to the metasurface design. By significantly improving the Q factor of metasurfaces, this technology enables a suite of applications, particularly in the realm on nonlinear nanophotonics, electro-optic modulation, classical and quantum optical generation, and free-space computing.

More Metasurface Technologies from the Dionne Group:
Stanford docket S19-309 – describing a device for on-chip tissue diagnostics in real time. By assessing collagen fibers around tumor margins, this metasurface platform has the **potential to set a new benchmark** for rapid and cost-effective cancer tissue diagnostics. Additional applications in heart disease, Alzheimer's disease, diabetes, fibrosis and more.

Stanford docket S19-427 – describing a metasurface that exhibits a **100-fold enhancement** in optical chirality (the ability to sense chiral molecules of a certain handedness) among other improvements. This technology could compete with chiral column chromatography and enable highly sensitive detection of enantiopurity – of paramount importance in the biochemical, pharmaceutical, and agrochemical industries. See Nanophotonic Platforms for Chiral Sensing and Separation *Acc. Chem. Res.* 2020

Stage of Development
The researchers have demonstrated a route to high-Q metasurfaces in arbitrary phase gradients. Fabricated and tested two example transfer functions (beam steering and beam splitting metasurfaces), achieving a world-record quality factor in phase gradient metasurface (Q = 2500). Currently developing and testing metasurfaces with different and more complex transfer functions such as high-Q lensing.

Applications

- High quality metasurfaces will lead to advances in many fields
  - LiFi
  - High-sensitivity chemical and biological sensing
  - Nonreciprocal light transmission
  - Non-classical light generation
  - Novel neuromorphic photonic networks
  - More complicated phase gradient structures, e.g., geometric phases, lensing, and holography are in reach

Advantages

- Currently there are no high-Q phase gradient metasurfaces
- New scheme is highly general to any optical transfer function in a compact, nanoscale footprint
- Dynamically tunable and reconfigurable metasurfaces can be easily designed with this high-Q scheme
- Other materials (photonic crystals) can support high-Q modes but cannot perform more complicated functions such as lensing, holography, etc.

Publications

- Hu J., Lawrence M. and Dionne J.A. High Quality Factor Dielectric Metasurfaces for Ultraviolet Circular Dichroism Spectroscopy ACS Photonics 2020, 7, 1, 36-42.

Patents

- Issued: 11,391,866 (USA)

Innovators

- David Barton
- Mark Lawrence
- Jennifer Dionne
- Jefferson Dixon

Licensing Contact

David Mallin

Licensing Manager, Physical Sciences

Email