Docket #: S21-247

Dynamic Optofluidic Flat-Optics System for Compact Optical Element Control

Stanford researchers in the Brongersma Lab have developed an integrated dynamic flat-optics system as part of a comprehensive optofluidic platform, enabling unprecedented compact configurations. This technology features a microfluidic system where liquids with varying refractive indices flow over an optical phased array, which includes a subwavelength-thick silicon nanoresonator array on a transparent substrate. It facilitates dynamic intensity and spectral control of diffraction efficiency for various transmissive optical elements and phased arrays at visible frequencies. This innovation allows for ultra-compact, flat optical elements like lenses, prisms, gratings, and holograms to be activated or deactivated as needed, and can also serve as a sensor to monitor refractive index changes in the flowing liquids.

This technology is part of a portfolio showing how the convergence of optofluidics and metasurface optics can lead to new platforms for dynamic control of light fields. Explore more:
S21-246 – an integrated dynamic flat-optics system enabling microlens-free metasurface planar light-field displays.
S21-249 – a new type of reflective display technology for achieving transparent displays.

Stage of Development
The Brongersma team has demonstrated that their comprehensive platform offers a **wide range** of fundamental dynamic control functions, is realized using the **same material** and by the **same processing**, and is **compatible** with mature microfluidic integration technologies.

Applications

- **On-demand dynamic flat-optics**
- **Ultra-compact (spectrometer-free) refractometer** for chemical and biological sensing
- **Micro-refractometers** that may enable new opportunities in medical diagnosis and treatment
- **Human Machine Interfaces**

Advantages

- **Compact Configuration**
  - Light fields probe liquids in an unprecedented compact configuration
  - No bulk optical elements such as prisms and spectrometers
- **Dynamic Control** - Liquids make on-demand optical elements dynamically
- **High resolution** - Unprecedented sub-wavelength spatial resolution
- **On/Off Functionality**
- **Sensing Capability**

Publications

- Li, Q., van de Groep, J., White, A.K. et al. Metasurface optofluidics for dynamic control of light fields. *Nat. Nanotechnol.* (2022).

Patents

- Published Application: WO2023214995
- Published Application: 20250271594
- Issued: 12,585,044 (USA)

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