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Technology Offer

(Differential) Refractive Index Measurement with low Uncertainties and Dimensions using an Asymmetric Nanofluidic Grating Detector

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Abstract

This invention relates to a novel method for measuring the refractive index n of substances with minimal uncertainties, particularly valuable when the refractive index differences Δn are small (Δn<0.02). The technology utilizes an asymmetric nanofluidic grating detector that facilitates highly sensitive and contactless detection of molecule concentration or process conditions across various applications. The innovation enables direct background subtraction in refractive index measurements, enhancing accuracy and reliability. This development holds potential for significant improvements in precision and miniaturization of refractive index measurement tools.

Background

Refractive index measurement is essential for understanding the physical and chemical properties of substances. Existing technologies include various microfluidic solutions, but challenges remain in reducing uncertainties and device dimensions. The pharmaceutical industry, environmental monitoring, adulteration detection, and biosensing extensively use refractive index measurements. The push towards further miniaturizations and enhanced sensitivity necessitates the development of advanced technologies, such as the proposed asymmetric nanofluidic grating detector, to meet the increasing demands for precise and reliable measurements.

Technology

The technology features an asymmetric nanofluidic diffraction grating device where reference and detection nanochannels are arranged asymmetrically (Fig. 1A). This design creates a non-mirror-symmetric diffraction pattern ($I_{-m} \neq I_m$), which is instrumental in detecting changes in the refracting index. The asymmetric pattern only emerges when the refractive indices of the reference (yellow) and the detection channel (green) differ ($\Delta n = n_{Ref} - n_{Det} \neq 0$).

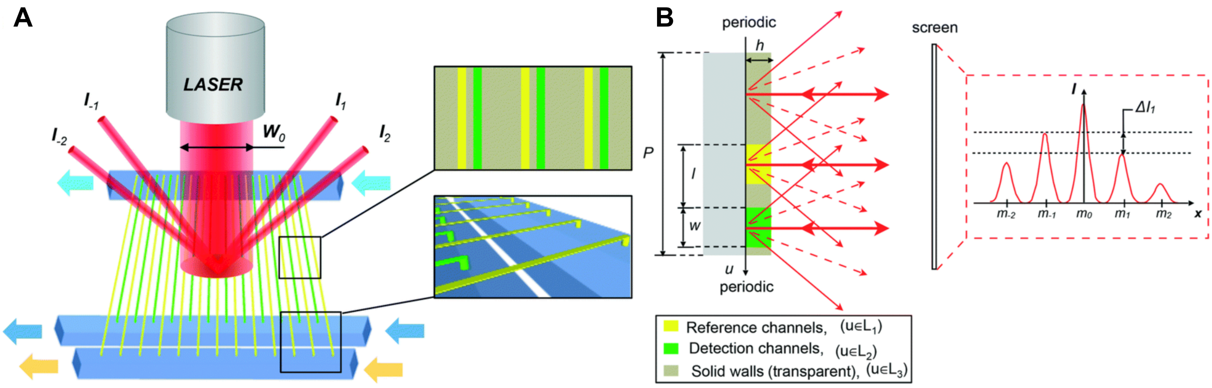

Fig. 1: A: Schematic showing the nanofluidic diffraction grating with an asymmetric arrangement of detection and reference nanochannels. Open vias connect each nanochannel to the larger supply microchannels;
B: Cross-sectional schematic view of a single grating period. This grating reflects the incident coherent optical beam into several orders with an intensity profile that depends on the geometric parameters of the grating and on the refractive index of the fluid in the detection and reference nanochannels.[1]

When a collimated laser beam (λ=635 nm, beam diameter 360 μm, for example) impinges on this nanofluidic gratin, the resulting diffraction pattern is reflected onto a mirror and then directed into a CCD camera that records the intensity (Fig. 2). This mirror, crafted from a glass wafer coated with a reflective gold layer, includes a central slit that permits the passage of the incoming laser beam while reflecting the diffraction pattern towards the camera. The design strategically excludes the 0^{th} maximum, which also passes through this slit, to avoid interference with other maxima, enhancing the accuracy of the signal processing.
This setup exploits the asymmetric distribution of the diffraction pattern to precisely measure the refractive index within the detection nanochannels. By measuring the difference in intensity $\Delta I_m = I_m - I_{-m}$ between the reference and detection channels, it enables accurate detection of refractive index variations (Fig. 1B).[2] This capability provides a robust solution for application requiring precise and noncontact measurements.

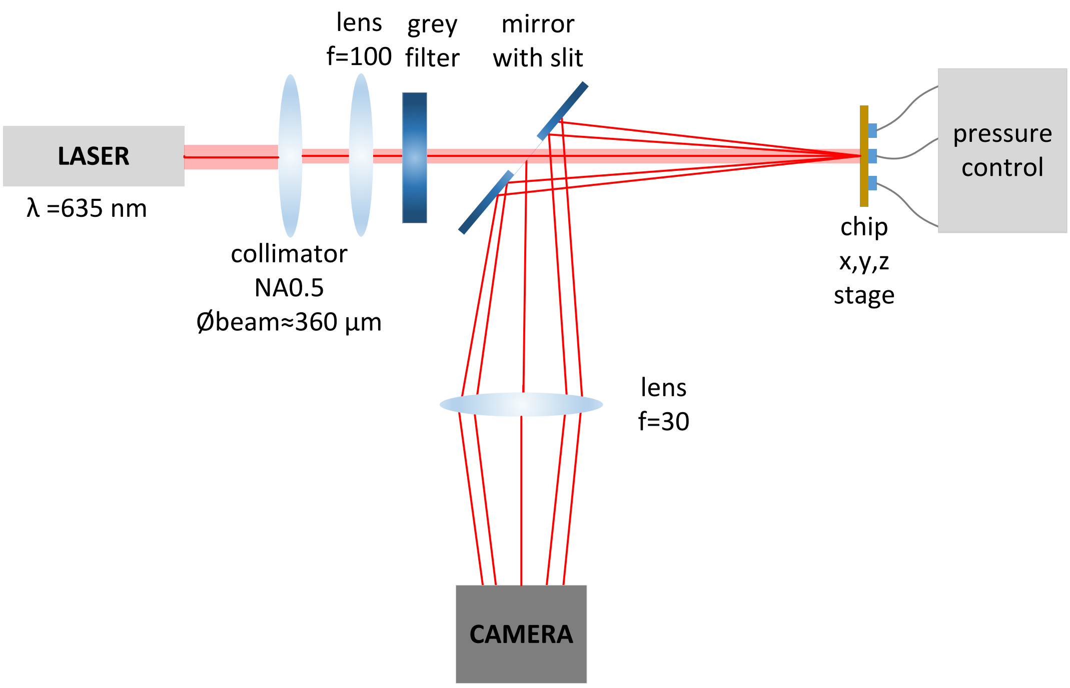

Fig. 2: Embodiment of a setup of measurement.

Advantages of this invention

- **Low uncertainties:** Precise measurements with minimal error margins.
- **Compact dimensions:** Reduced size facilitates integration into various systems.
- **Contactless detection:** Ensures sample integrity and reduces contamination risks.
- **High sensitivity:** Capable of detecting minute differences in refracting index.
- **Real-time measurement:** Provides dynamic updates on refractive index changes.

Applications

- **Concentration measurement:** Accurate determination of substance concentrations in solutions.
- **Dynamic monitoring:** Real-time tracking f refractive index variations.
- **Biosensing:** Detection of biomolecules and biological processes.
- **Environmental monitoring:** Assessment of water quality and pollutant levels.
- **Pharmaceutical industry:** Quality control and formulation development.

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Publications

[1] Purr, F., Bassu, M., Lowe, R. D., Thürmann, B., Dietzel, A., & Burg, T. P. (2017). Asymmetric nanofluidic grating detector for differential refractive index measurement and biosensing. *Lab on a Chip*, *17*(24), 4265–4272. https://doi.org/10.1039/C7LC00929A

Patent Information

[2] EP3698123B1, US11340162B2 and CN111226107B active.

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