

# Standing-wave microsensor for adaptive analysis of spectral coherence

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**Abstract:** We present an integrated microsensor for time-domain analysis of spectral coherence, with a tunable coherence detection range. The  $0.2 \text{ cm}^3$  device includes a partially transmitting GaAs/AlGaAs photodiode and a large-displacement scanning Si MEMS mirror.

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OCIS codes: (130.6010) Sensors; (230.0040) Detectors

There has been a widespread effort to develop compact sensors for optical characterization, using miniaturized versions of traditional architectures as well as new designs utilizing optical MEMS technologies [1]. We have recently focused our attention on the 1-D standing-wave transform spectrometer [2], which consists of a MEMS mirror integrated with a partially transmitting photodetector. In this device, incident light reflects off the micromirror, creating an optical standing wave which is continuously sampled by the thin detector. As the mirror scans along the optical beam axis, an interferogram is generated. This device was developed to be an efficient microspectrometer, but here we demonstrate a different type of spectral analysis by taking advantage of a property of the unique architecture: the inherent mirror-detector spacing makes this device sensitive to the coherence length of the optical input. By varying the mirror scan range, we accomplish selective optical filtering based on spectral coherence. It can be much more efficient to directly analyze spectral coherence [3] instead of performing a full spectral analysis in applications such as selective imaging of high-coherence light (e.g. narrowband LEDs or fluorescence emission), suppression of broadband background (e.g. undesirable white light), and mobile detection of laser range-finders or targeting devices.

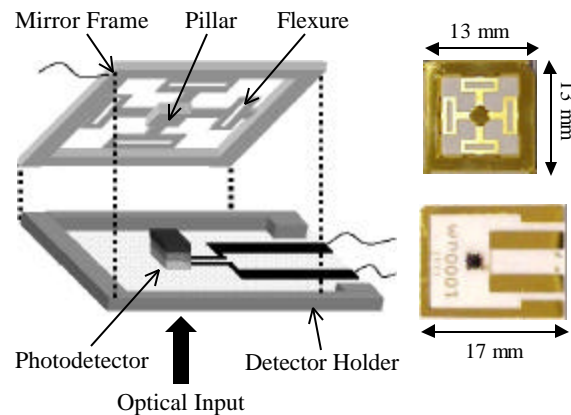


Fig. 1. Left: Near-IR microsensor schematic. Light enters from below the detector holder, traverses the photodetector, and reflects off the mirror pillar back toward the detector. Right: photos of mirror and detector components.

The  $17 \times 13 \times 1 \text{ mm}$  near-IR microsensor (Fig. 1) is composed of a GaAs/AlGaAs *p-i-n* diode with  $550 \text{ \AA}$  active GaAs region integrated with a Si MEMS parallel-plate piston-motion mirror-actuator [2]. The mirror can scan up to  $52 \text{ \mu m}$  harmonically at  $800 \text{ Hz}$ , which enables fast, continuous analysis. The actuator capacitance of  $4.2 \text{ pF}$  minimizes power consumption. The integrated device design allows the mirror to move within  $5 \text{ \mu m}$  of the detector. Fig. 2 shows an interferogram (top) from an  $866.2 \text{ nm}$  laser (FWHM  $1.0 \text{ nm}$ , coherence length  $495 \text{ \mu m}$ ) compared with an interferogram (bottom) from a  $780 \text{ nm}$  LED (FWHM  $24 \text{ nm}$ , coherence length  $17 \text{ \mu m}$ ). The spectral bandwidth of each source determines its coherence length. Decreasing the mirror scan range increases the minimum mirror-detector spacing, which increases the required optical coherence for detection. In this way we can vary the coherence detection cutoff; adapting to a new coherence analysis task simply requires changing the mirror-actuator

drive amplitude. Fig. 3 shows the square of each normalized interferogram; simple integration of different segments of these waveforms yields a measure of the coherence of each source.

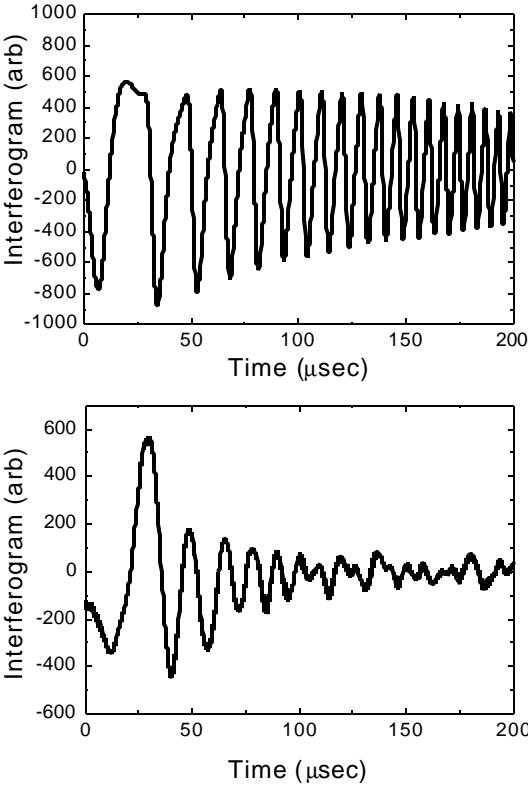


Fig. 2. Interferograms (photocurrent) from an 866.2 nm laser (top) and a 780 nm LED (bottom).

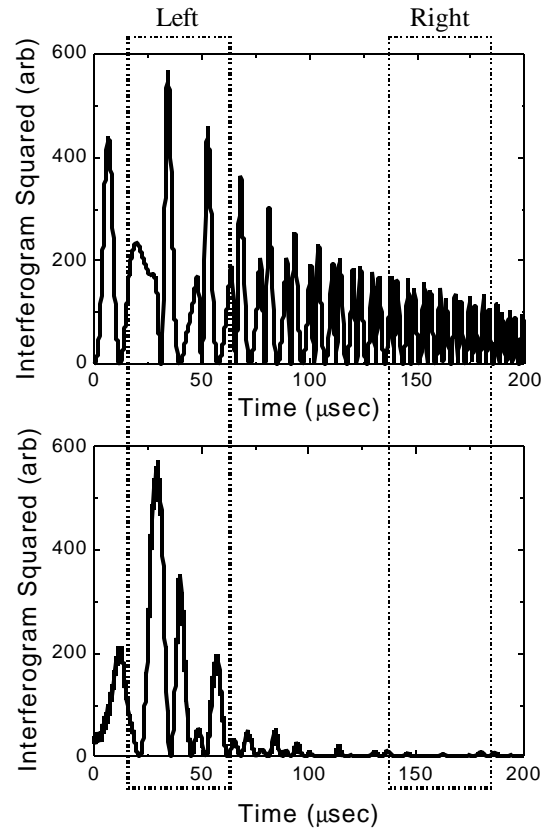


Fig. 3. Normalized interferograms from Fig. 2, squared. Two scanning zones are marked as Left and Right, accessible by full and reduced mirror scan range, respectively. When the mirror scans in the range corresponding to the left dotted box, the device ignores broadband background but detects LEDs and lasers. For the right dotted box, the device detects lasers only; it ignores any source with lower spectral coherence.

In summary, this microsensors enables adaptive analysis of the spectral coherence of incident light, without the information generation and processing burdens of traditional spectral analysis. The low volume and power consumption of this device could promote development of efficient mobile sensing systems that discriminate on spectral coherence.

### References

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