Prototyping evanescent waveguide devices for quantum sensing biochips

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Abstract: Sensitive and compact evanescent-waveguide sensors have been developed and prototyped for detecting pollutants in water. The results show limits of detection of a few ppb for copper, mercury, zinc and lead in water samples.

Water is essential for sustaining human life, and its quality is directly linked to well-being. In addition to its natural chemical elements, water can, mainly due to anthropic activities, contain hazardous substances that pose serious risks to human health, such as heavy metals and emerging micro contaminants (EMCs) [1]. Optical biochips can provide accurate sensing with superior limits of detection (LoD) compared to current analytical methods [2–4].

Sensitive and compact refractive-index sensing systems have been designed and engineered to evaluate the concentration of analytes in liquid samples, based on the principle of evanescent-waveguide sensing [4-5]. In Figure 1 is reported a fabricated prototype (left) and a microscope image of the system (right). A 1 cm^2 prototype, monolithically integrating the sample–light interaction site with an SU-8 polymer waveguide and a low-noise p-i-n amorphous silicon detector on a glass substrate, has been employed in various scenarios. First, it was applied in detecting sugar content in commercial beverages, displaying an LoD of tens of ppm [2]. Subsequently, the sensor's capability to detect heavy metal ions in water was evaluated. The device demonstrated sensitivities of 25 pA/ppm for Cu, 17 pA/ppm for Hg, 16.6 pA/ppm for Zn, and 16.2 pA/ppm for Pb, with corresponding LoDs of 6 ppb for Cu, 9 ppb for Hg, 10 ppb for Zn, and 10 ppb for Pb [6]. Given its compact size, low cost, ease of fabrication, and user-friendliness, the proposed device shows promising potential for integration into biochips for quantum sensing applications in health and environmental monitoring.

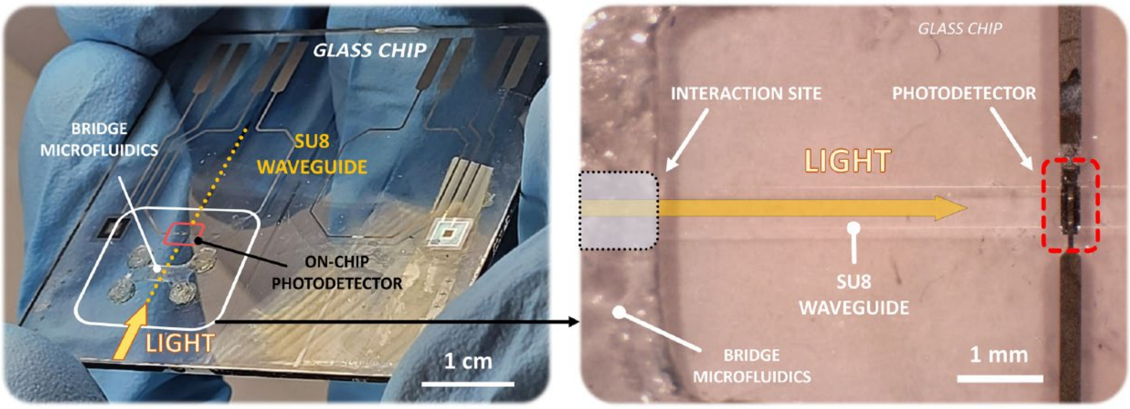

Fig. 1 Fabricated prototype of a photonic sensor detector with a microscope image of the system.

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