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A Fibre-Packaged Waveguide-Enhanced Raman Sensor

Waveguide-enhanced Raman spectroscopy (WERS) has attracted significant interest as a method leveraging the performance, size, and cost benefits of integrated photonics for Raman spectroscopic sensing of chemical and biological species [1]. While all the components of a full WERS system (light source, filters, interaction region, spectrometer) may eventually be integrated on a single chip, current limitations mandate using a source and spectrometer that are off-chip. The coupling of light to and from the WERS chip is most practically done using optical fibres, which can be bonded to the chip to remove the vibration sensitivity and need for expensive alignment stages inherent to lens coupling. Fibre-coupling however requires additional components to avoid the background from the fibres, notably a coupler separating the forward- and backward-propagating signals [2].
We present a fibre-packaged waveguide-enhanced Raman spectroscopic sensor with an adiabatic directional coupler enabling the collection of the backscattered signal and the removal of any signal from the fibres. Its limit of detection was quantified by measuring varying concentrations of isopropyl alcohol (IPA) in water. The signal-to-noise ratio (SNR) was calculated for each spectrum by normalizing the spectrum, subtracting a reference measurement of deionized water, and applying a penalized least squares algorithm to remove the baseline [3]. A fit of the evolution of the SNR with concentration suggests that the sensor's LoD for IPA lies at 0.03 mol.L^{-1} (0.2 wt% in water). This LoD is the lowest reported to date for a WERS sensor without surface enhancing mechanism.

References

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[2] D. Kita, J. Michon, and J. Hu, “A packaged, fiber-coupled waveguide-enhanced Raman spectroscopic sensor,” Optics Express, vol. 28, pp. 14 963–14 972, 2020.
[3] J. Ye et al. “Baseline correction method based on improved asymmetrically reweighted penalized least squares for Raman spectrum”, Applied Optics, vol. 59, pp. 10933-10943, 2020.

Figures

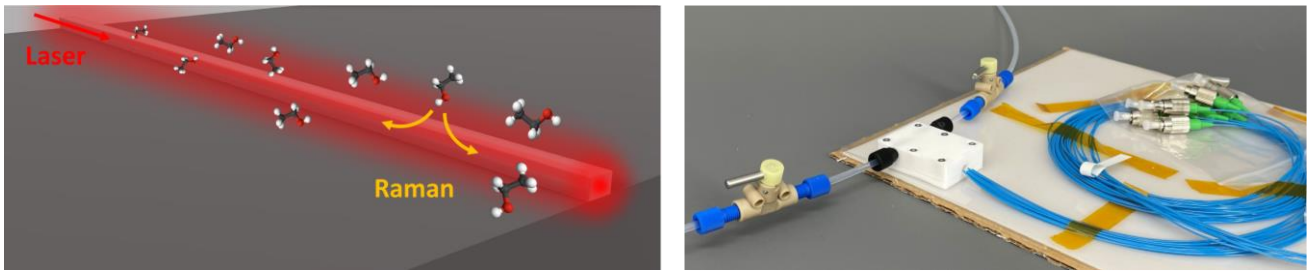

Figure: Schematic principle of WERS. A WERS sensor integrated in a flow cell for fluidic measurements.