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Mid-infrared Waveguide Spectroscopy for sensing in Liquids

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

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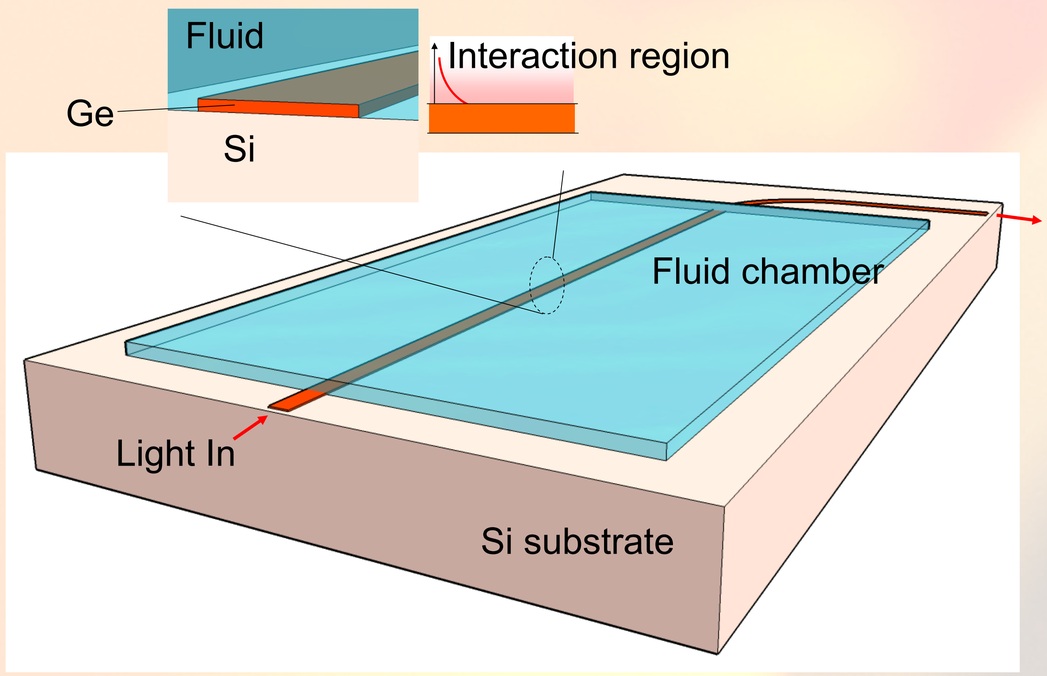
Abstract

Mid-infrared waveguide spectroscopy is used to detect cocaine with a Ge on Si single-mode optical waveguide in liquid environment. A quantum cascade laser (QCL) [1] emitting light at 5.8 μm is coupled to the waveguide. Cocaine in the evanescent field absorbs the light in this wavelength and changes the transmission. A micro fluidic channel is integrated with the waveguide for sample handling and preparation [2,3]. Cocaine is dissolved in tetrachloroethylene with different concentrations. The lowest measured concentration is 100μg/ml.

Introduction

Evanescent wave sensing

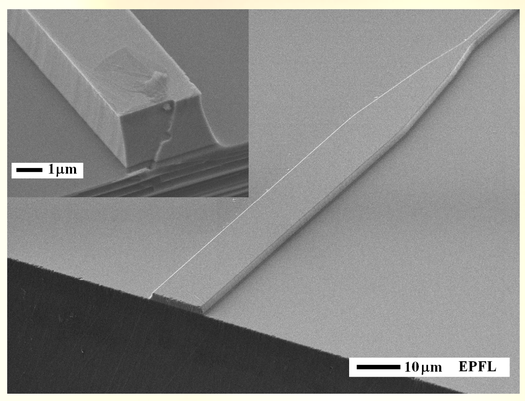
Light is absorbed by an analyte in the evanescent field of a single-mode optical waveguide. Compared to other spectroscopic sensing methods, the use of waveguides enables a compact device, inherent measurement reproducibility, and easy to integrate in various spectroscopic schemes.

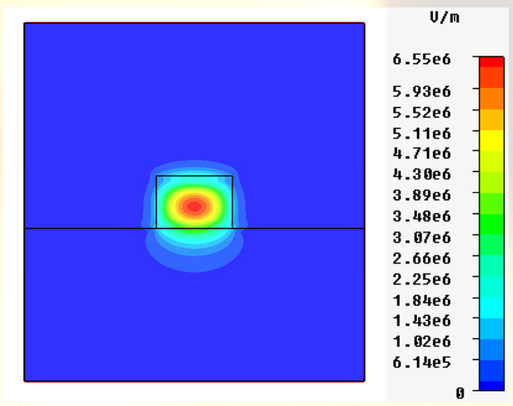


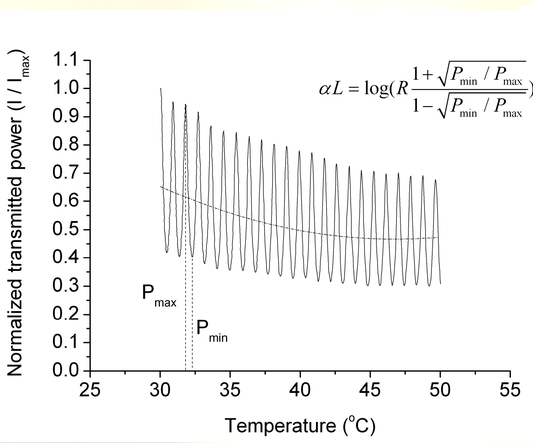
Experimental

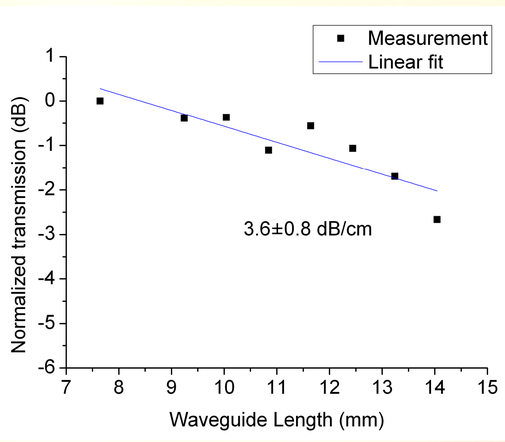
Ge waveguides on Si

Ge waveguides are fabricated on Si with standard photo-lithography process comprising reactive ion etching (RIE) using CF_4 chemistry. The propagation loss is measured to be about 3dB/cm with a QCL at 5.8μm and Fary-Perot resonance method.





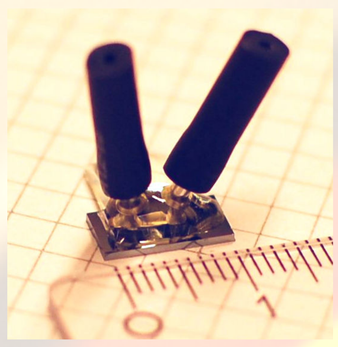


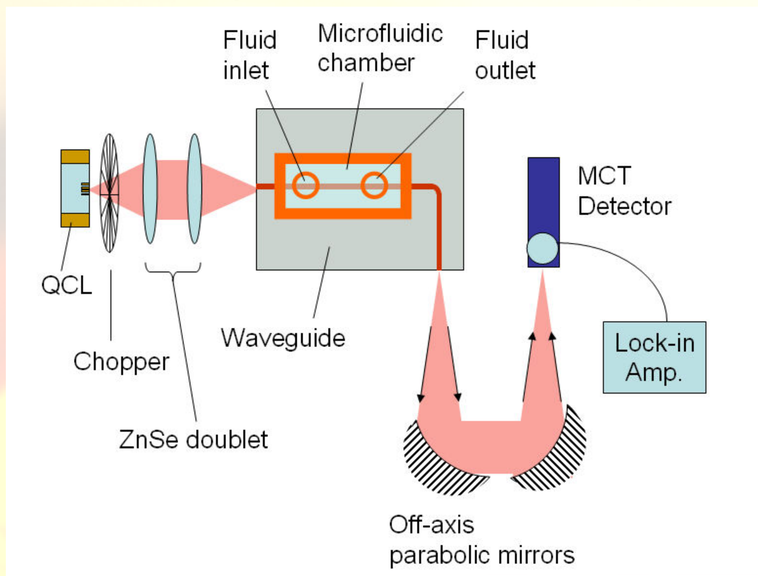


Experimental

Measurement Setup

The QCL is coupled to the waveguide with a ZnSe doublet. Light detection is performed with a liquid nitrogen cooled Mercury-Cadmium-Telluride(MCT) detector and a lock-in amplifier. The waveguide is integrated with a micro fluidic channel, and samples of different concentrations flow through the channel and change the light transmission.

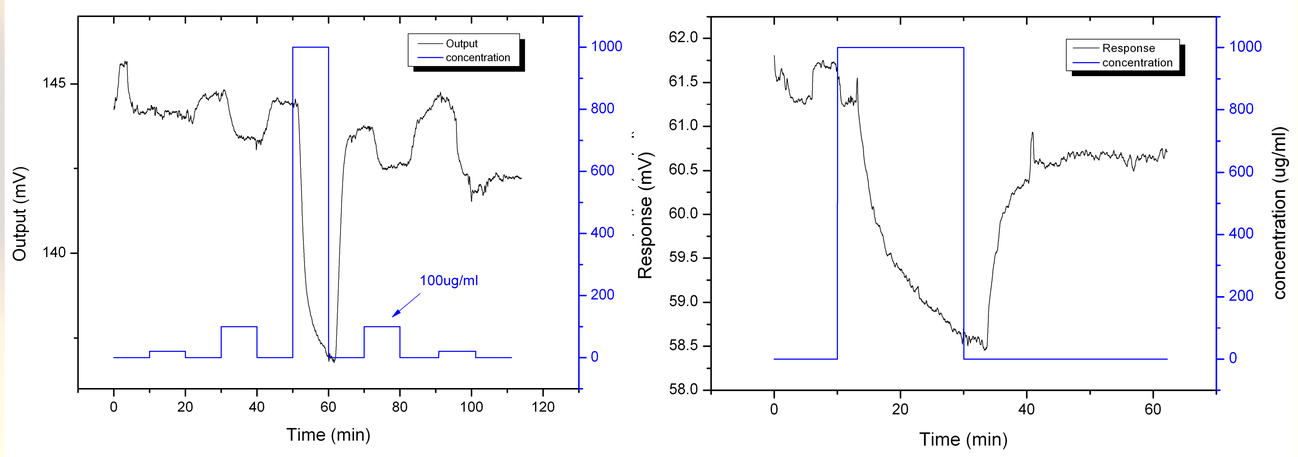




Result

Cocaine detection

Cocaine is dissolved in tetracholoroethylene (PCE) with different concentrations, and flows through the microfluidic channels. The samllest concentration we measured is 100μg/ml, which can be improved by using a longer waveguide and reducing the system noise. The response time is around 20min, which corresponds to the fluidic tubing and the flow rates.



Summary

1) Mid-IR waveguide spectroscopy is compact, sensitive, and reliable on sensing application in liquid environment.
2) A Ge waveguide on Si with low loss is tested at 5.8μm.
3) A micro fluidic channel is integrated to the waveguide.
4) Concaine detection is performed and the smallest measured concentratioin is 100μg/ml

References

[1] J. Faist, F. Capasso, D.L. Sivco, C. Sirtori, A.L. Hutchinson, and A.Y.Cho, Science **264**, 553 (1994)
[2] http://www.nano-tera.ch/projects/80.php
[3] Kristen L. Helton and Paul Yager, Lab Chip, 2007, 7, 1581–1588