Fiber-based glucose sensing for an artificial pancreas

Silje Skeide Fuglerud, Dag Roar Hjelme
Department of Electronic Systems, Norwegian University of Science and Technology,
Trondheim, Norway

ABSTRACT

Reliable continuous glucose monitoring is vital for the success of an artificial pancreas, a device that should enable diabetic patients to have automatic control of their blood glucose levels. The current state of the art is electrochemical measurements measuring in the interstitial fluid, where the glucose dynamics are delayed compared to the blood glucose. The delay is a problem for the control algorithms which should decide to administer insulin based on the measured glucose values. We work on measuring glucose in the intraperitoneal fluid with infrared spectroscopy. The goal is fiber-based *in vivo* continuous measurements.

INTRODUCTION

Continuous glucose monitoring (CGM) devices are a prerequisite to achieve fully automated insulin delivery for diabetes management, known as closed-loop systems or an artificial pancreas (Åm 2018; Jernelv, 2019). The current gold standard is minimally invasive electrochemical devices that measure the glucose concentration subcutaneously in the interstitial fluid. The disadvantage to this sensing site is slow glucose dynamics (Åm, 2018). We therefore aim at sensing the glucose concentration in the intraperitoneal fluid that can be found in the peritoneal cavity. Optical sensors are of interest, as we avoid having a reagent that can be depleted.

APPROACH AND CHALLENGES

In our group, we have investigated several optical glucose sensing approaches; surface-enhanced Raman spectroscopy (SERS), near-infrared (NIR) spectroscopy, and mid-infrared (MIR) spectroscopy. SERS has the benefit of being very specific, but the intensity of the scattered light is low. MIR spectroscopy can make use of recent developments in quantum cascade laser technology and covers the fingerprint region with high absorption cross-section values (Jernelv, 2020). However, the availability and maturity of optical fibers in this wavelength range is limited.

NIR spectroscopy provides opportunities due to high availability of components and optical fibers. Several studies of aqueous glucose sensing by NIR spectroscopy make use of wavelengths in the first overtone (1500 – 1800 nm) and/or combination band (2100 – 2300 nm). However, the NIR absorption bands are weak and broad, water absorption dominates, and it is a challenge to measure very small changes on the order of 1 – 2 mM accurately. This puts constraints on the signal to noise ratio (SNR) and we require very low noise levels in the sensing system (Fuglerud, 2019).

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