

Towards a recycling paper based platform for printed electrochemical biosensors

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MOTIVATION

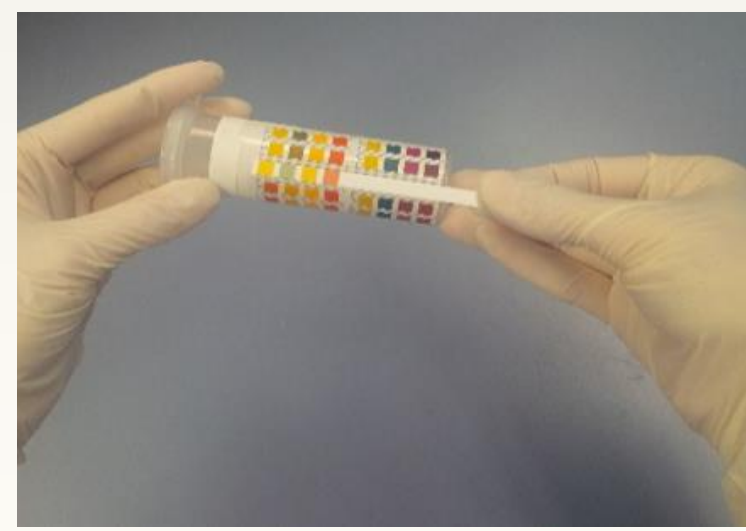
The **decentralization of the health care system**, driven by the demographic change, creates a strong demand for sustainable **high volume and low cost biosensors** that enable molecular diagnostics outside of laboratories.

To **overcome these limitations**, we aim to realise an electrochemical **single-use sensor**, which i) is based on **recycling paper** as substrate to enable environment-friendly production and disposal, ii) detects quantitatively glucose and ketone bodies in urine to permit the diagnosis of ketoacidosis [1], iii) is able to contactless communicate the measured values.

State of the art: Single-use test strips using color indicators

Urine test strips

- Plastic substrate
- Subjective visual perception
- No electronic data recording
- Detect only acetoacetic acid, no reaction with acetone or β -HB [1]



➔ No present point of care system can detect beta-hydroxybutyric acid and acetoacetic acid



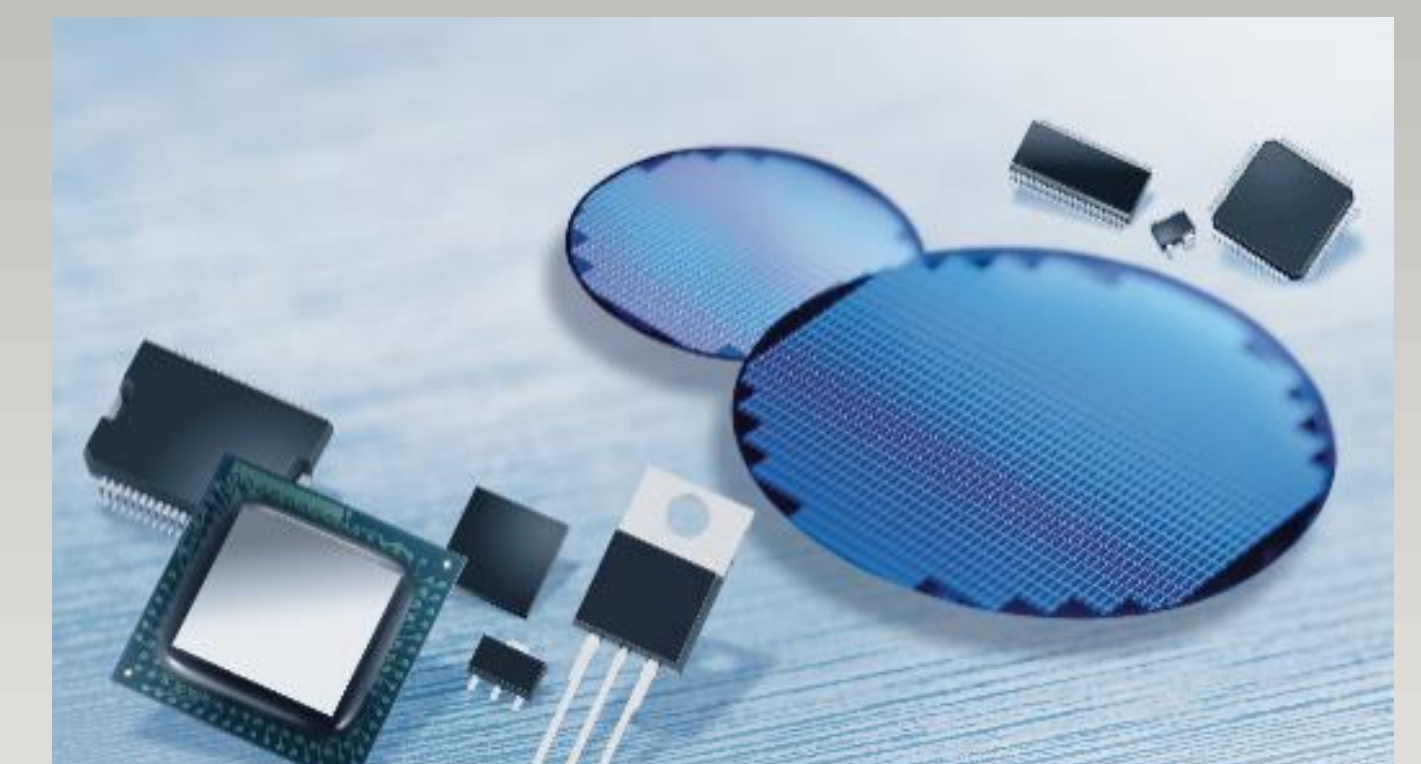
Paper manufacturing

- Cellulose matrix for biofunctionalisation
- Surface for electrodes



Roll-to-roll printing

- Electrodes
- Hydrophobic barriers



Microelectronics

- Printed antenna
- Assembly of bare dies

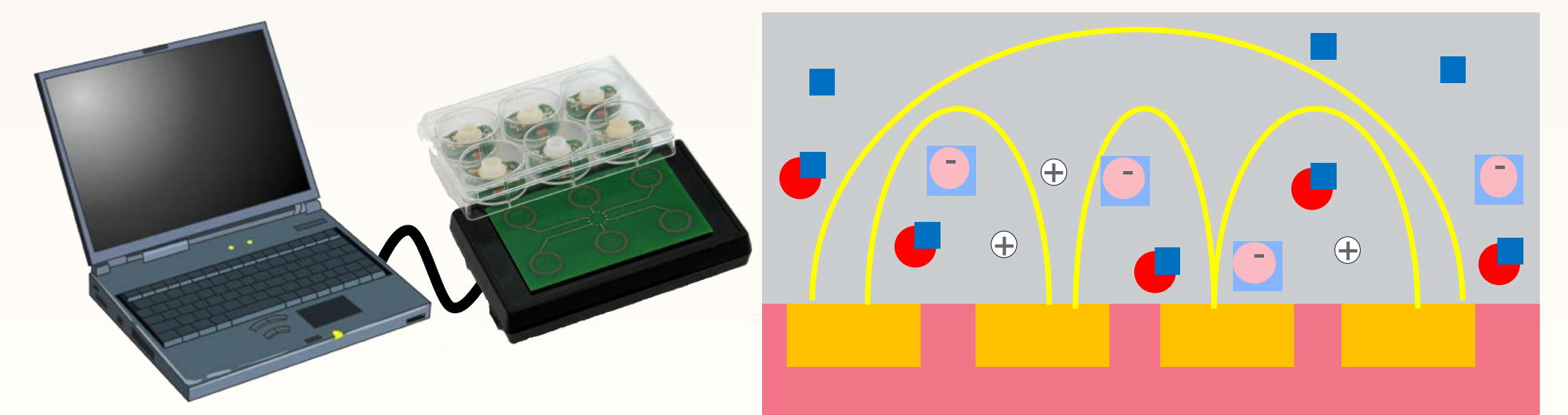
Electrochemical biosensing for the quantification of glucose and ketone bodies (beta-hydroxybutyric acid and acetoacetic acid)

PIONIER demonstrator

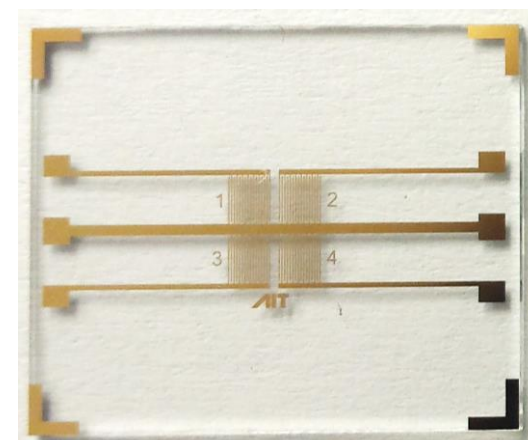
- Paper substrate
- Quantitative results
- Contactless read-out
- Battery-free
- Automatic data recording
- Environment-friendly

Biosensing Concept

- 5 kHz
- 30 mV

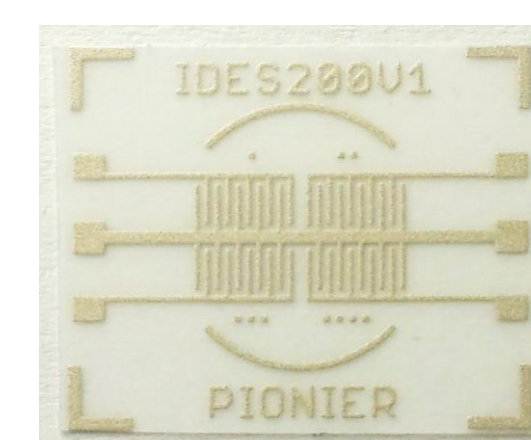


Gold Sensors on Glass



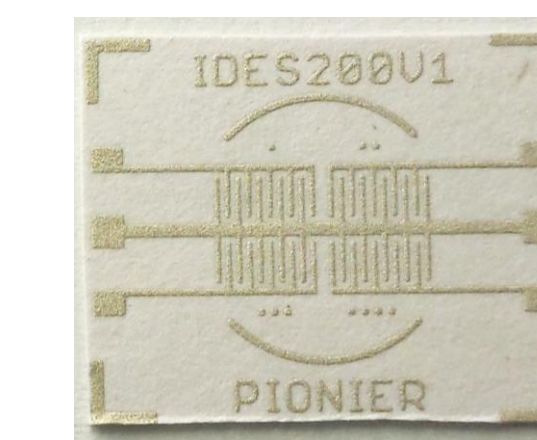
- Analyte deposition from the **front** side
- 50 μ m IDES

Silver Sensors on PET



- Analyte deposition from the **front** side
- 200 μ m IDES

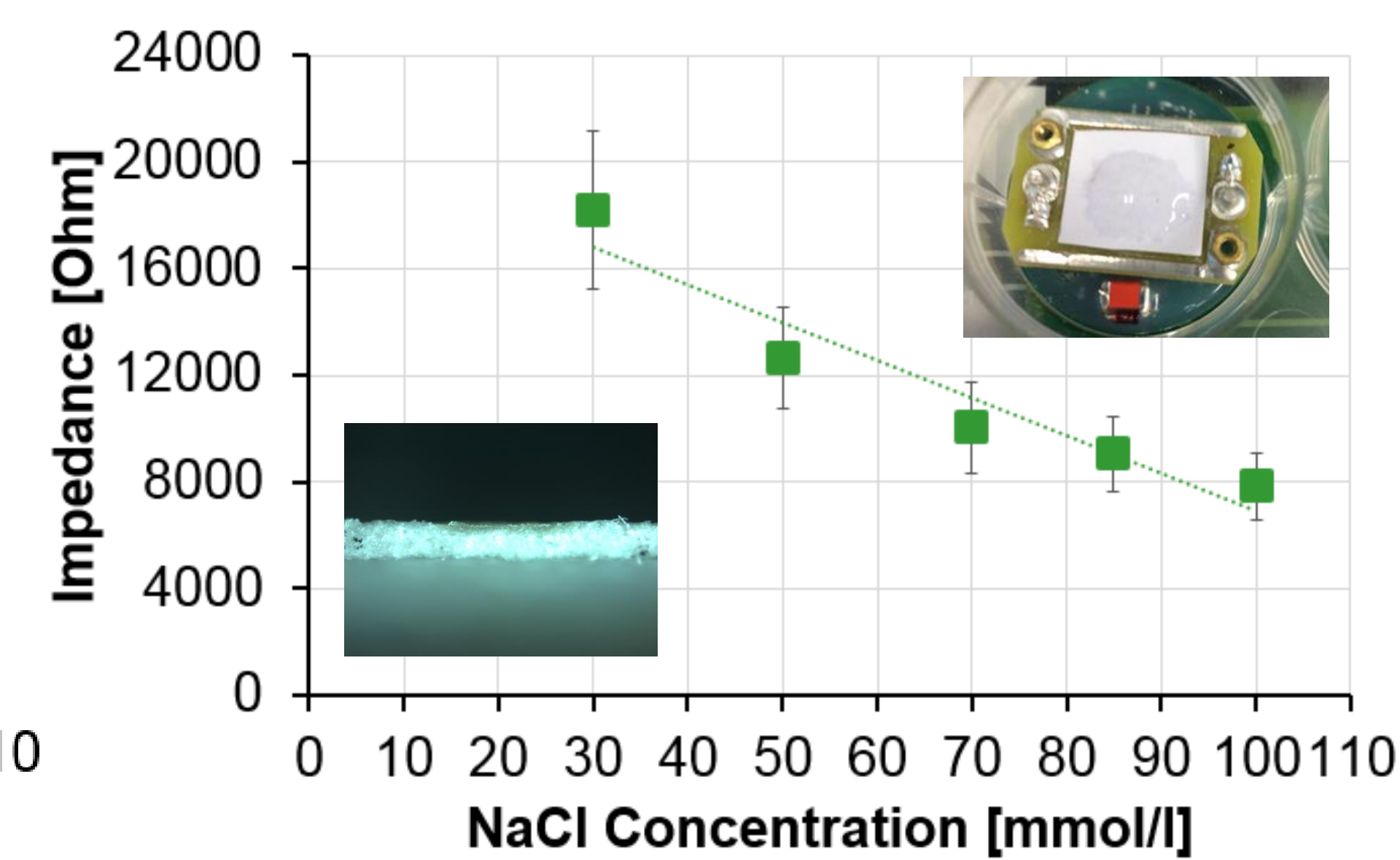
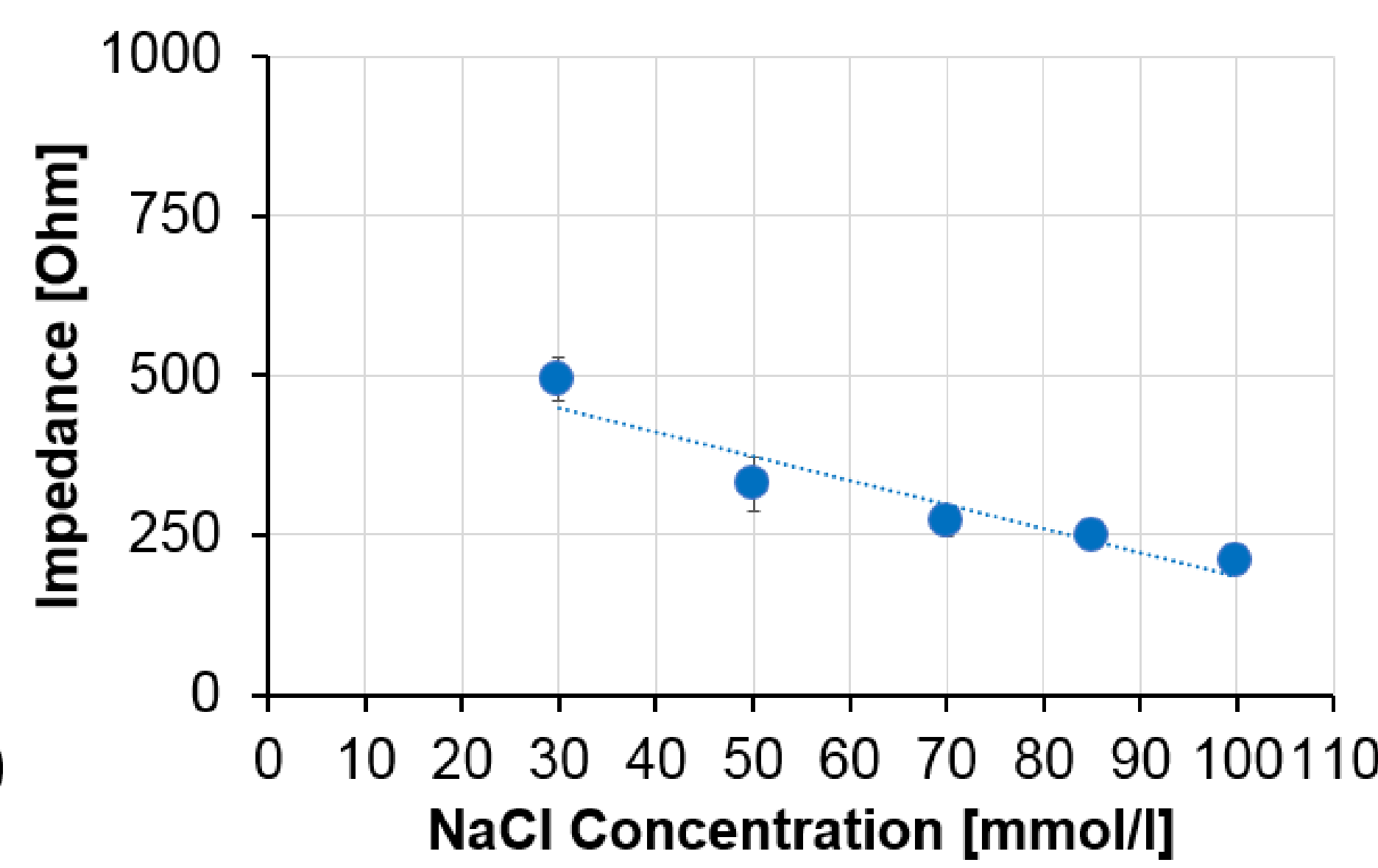
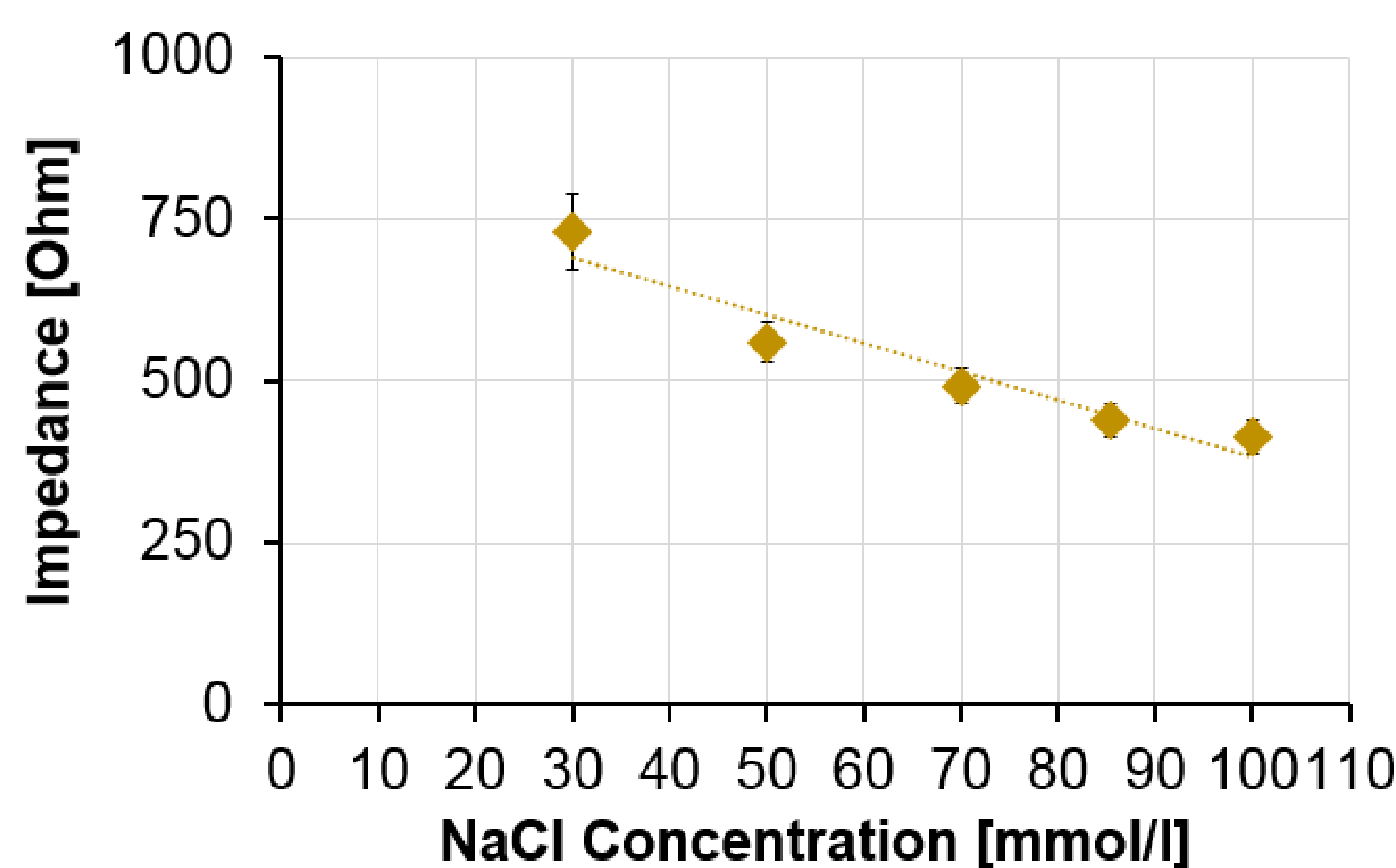
Silver Sensors on Paper



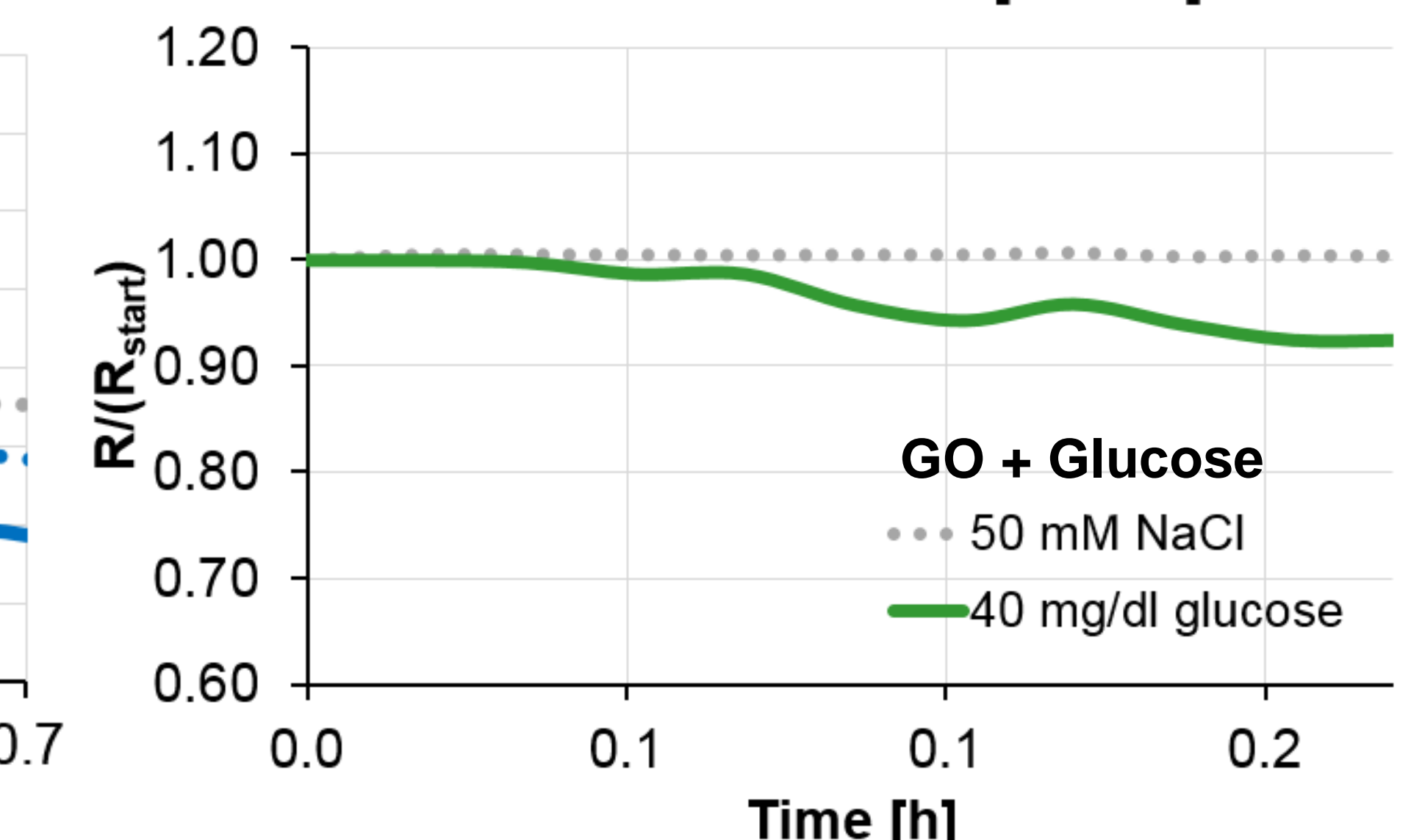
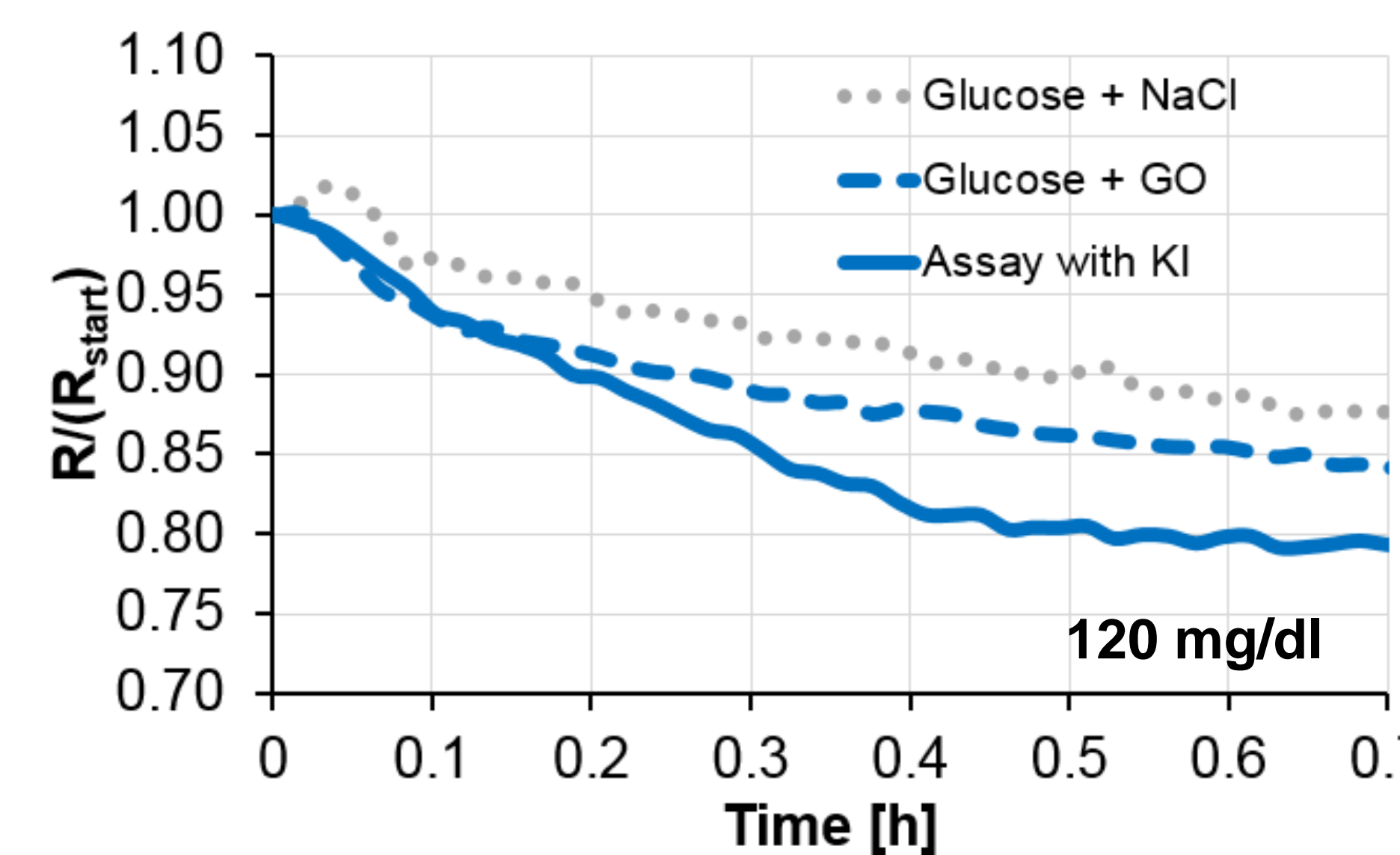
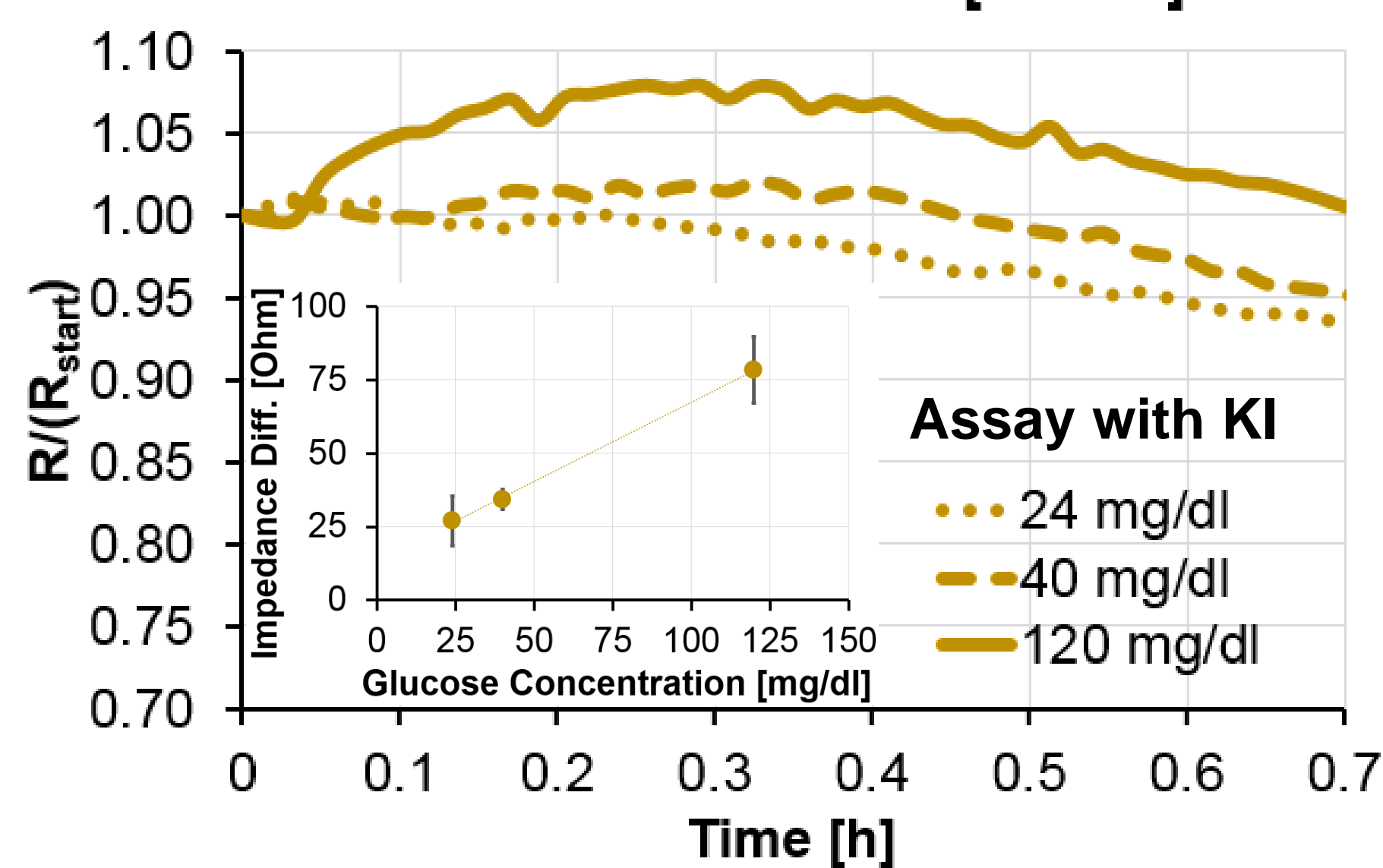
- Analyte deposition from the **back** side
- 200 μ m IDES

Sensor Type

NaCl Series



Glucose Series



Outlook & Concl.

- Different **glucose** concentrations can be measured **quantitatively** with 50 μ m **gold** sensors on glass.
- Glucose** measurements with **silver** sensors on **PET** yield different curves but still, a **change is visible**.
- Measuring with **silver** sensors on **paper** can be performed from the **back** side. Reactions between **glucose** and **glucose oxidase** are visible.
- Enzymatic hydrogel immobilized inside the paper matrix can be used for signal enhancement [4].

References

1 L. Laffel, Diabetes Metab Res Rev, 15:412– 426 (1999). 3 J. Wissenwasser, M. Vellekoop, R. Heer, Review of scientific instruments 81, 025106 (2010).
 2 A. W. Martinez., S. T. Phillips, E. Carrilho, S. W. Thomas, H. Sindi, M. Whitesides, Anal. Chem. 3699–3707 (2008). 4 R. Verma, B. Gupta, Analyst 139 1449-1455 (2014).