A compact, microfabricated conductivity detector - setting a new benchmark for ultrasensitive, low volume conductivity detection

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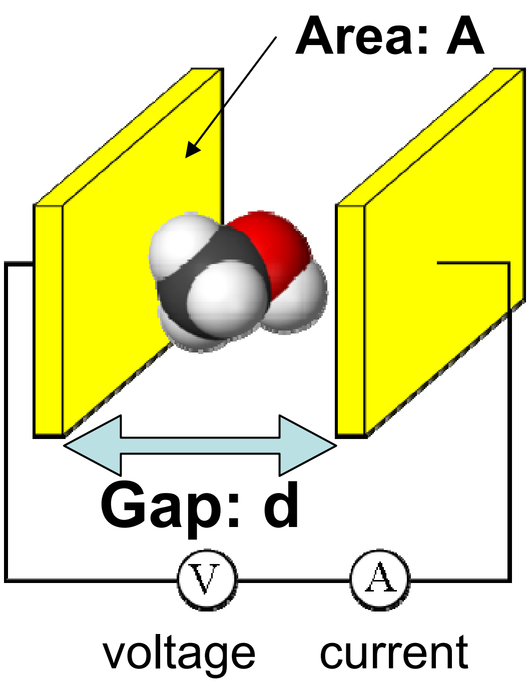
Conductivity detection

Applications:

- bench-top, portable, process
- characterize materials
- water quality (pharma application, drinking water, environmental monitoring)
- detectors for chromatography (IC, HPLC)

Typical portable/ bench-top conductivity detector:

Conductivity and dielectric constant detection



Resistor: i = V/R = G•V

Capacitor: q = C•V

⇒ i = dq/dt = C•dV/dt

• In a typical electrical measurement, a voltage is applied between two electrodes, and corresponding current is measured.

• Conductive and capacitive currents per unit voltage are proportional to G and C, respectively:

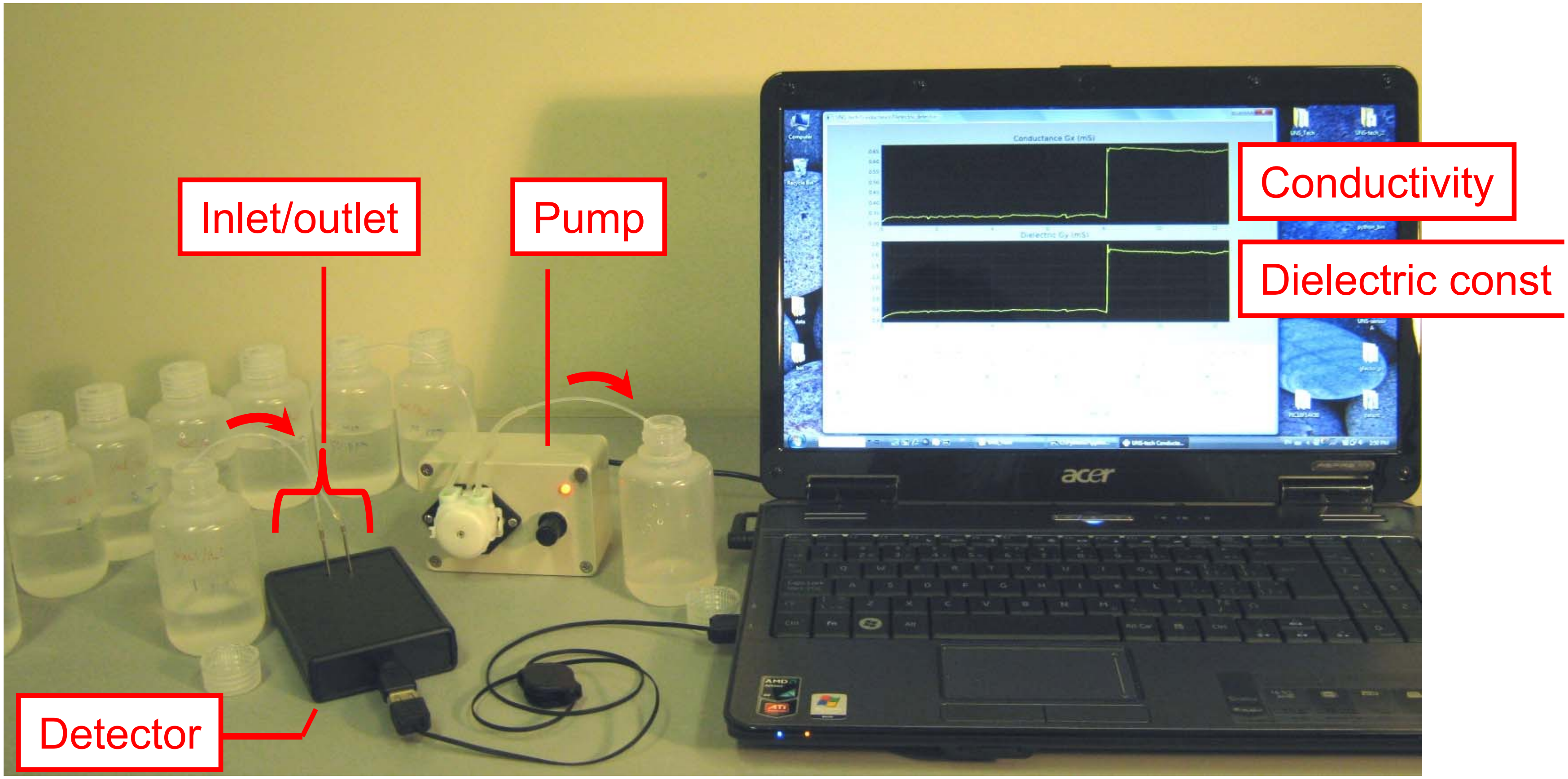
- $G = \sigma A/d$ (current in phase with voltage)
- $C = \varepsilon A/d$ (current out-of-phase with voltage),

where σ and ε are conductivity and dielectric constant of material between the two electrodes.

• Note that geometrical factor, A/d, works as amplification factor in measuring current (d/A is called “cell constant”)

• In a typical conductivity detector, only σ is measured by measuring currents. Typically, A/d is too small in insulating solutions to enable measurements of ε.

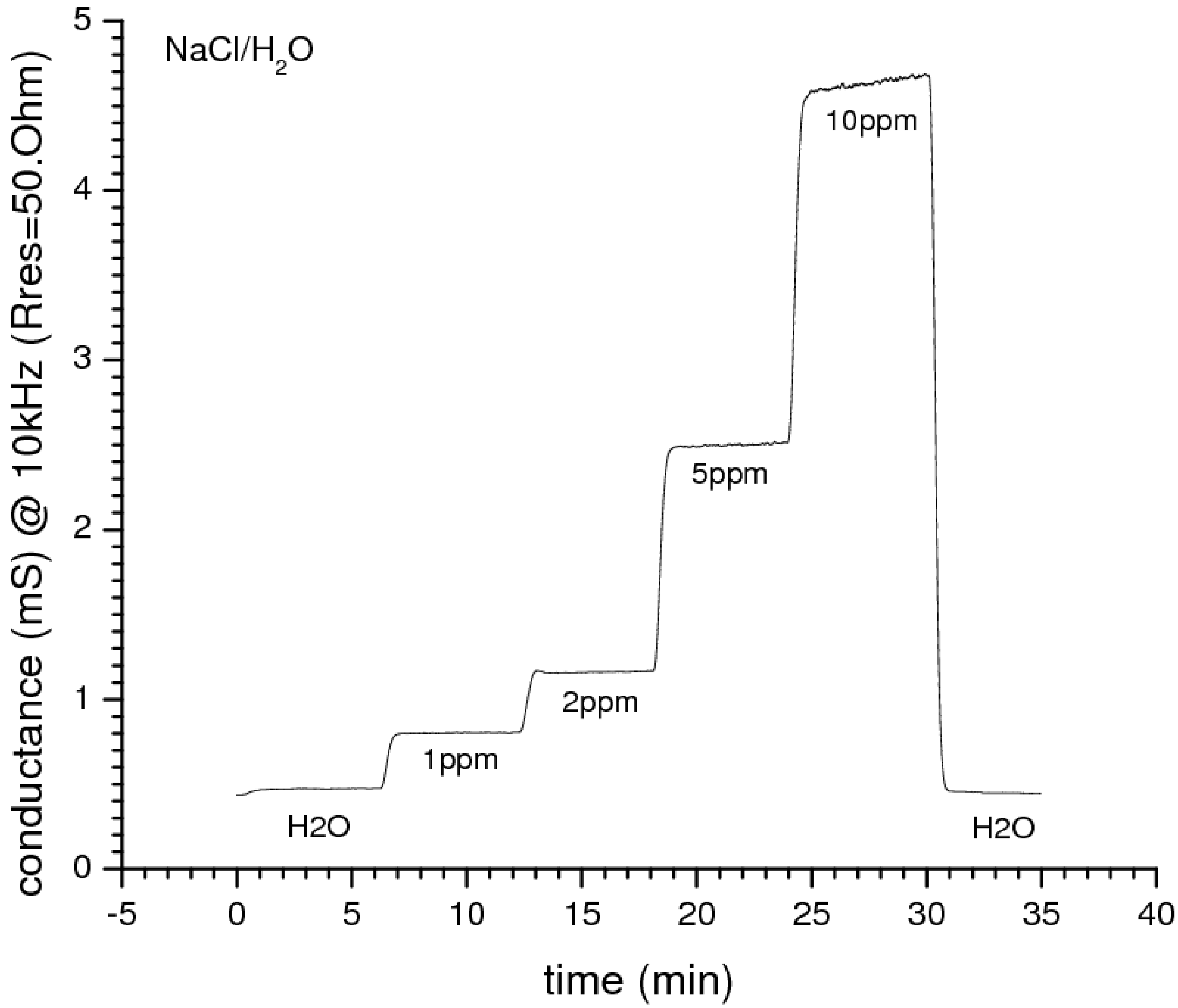
Our novel microfabricated conductance detectors: leveraging microchip technology

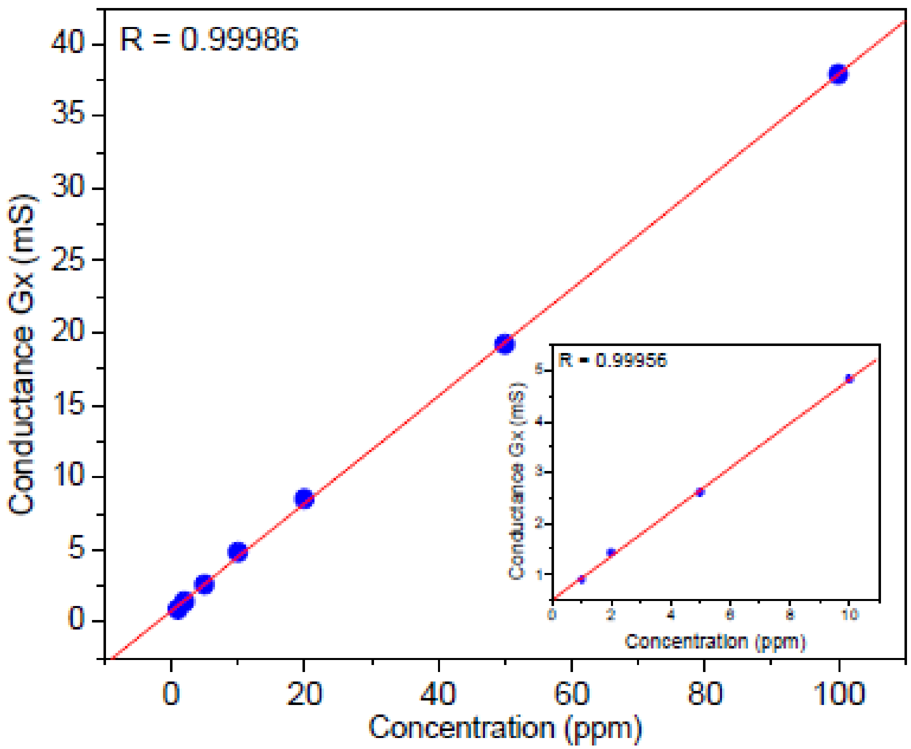


Characteristics:

-Detector volume: ~ 5uL (~typical chromatography injection volume)
-Cell constant 2 x 10^{-4} cm^{-1}
-dual channel: conductivity as well as now (simultaneously) dielectric constant
-Compact & portable

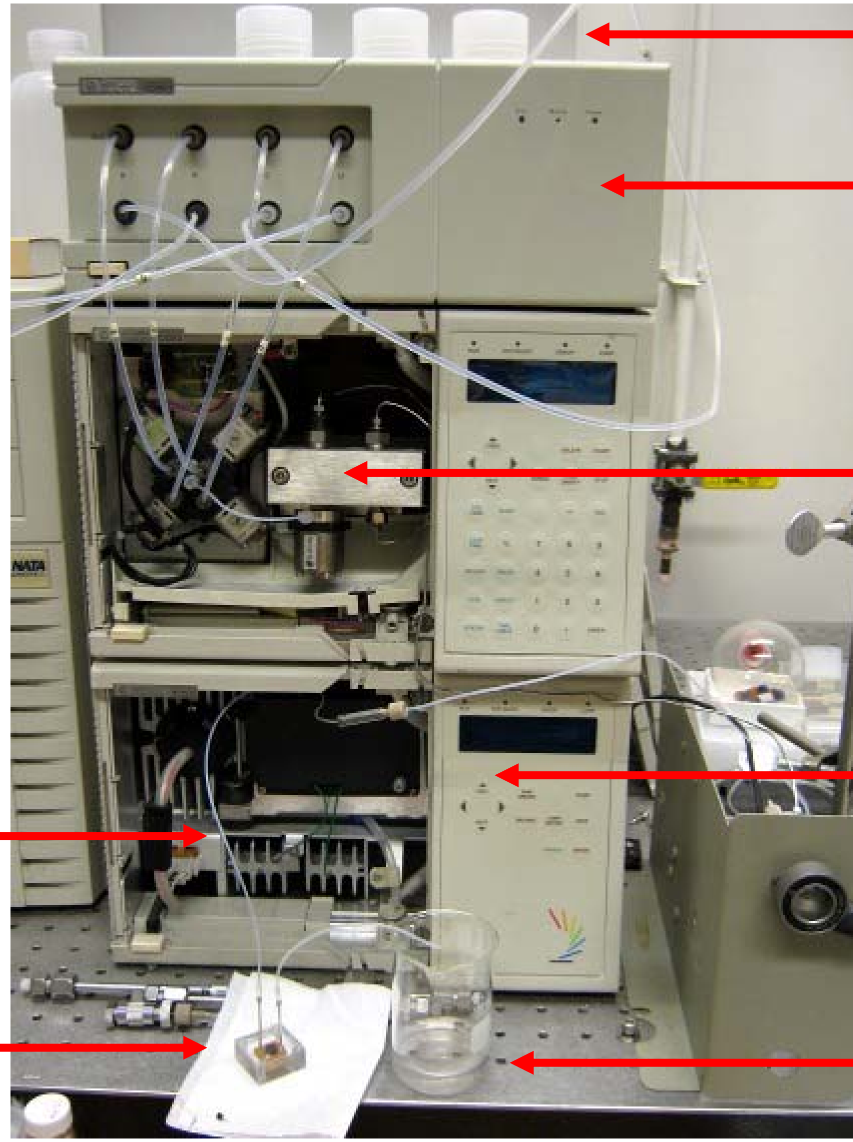
Case study 1: Stand-alone conductivity detector



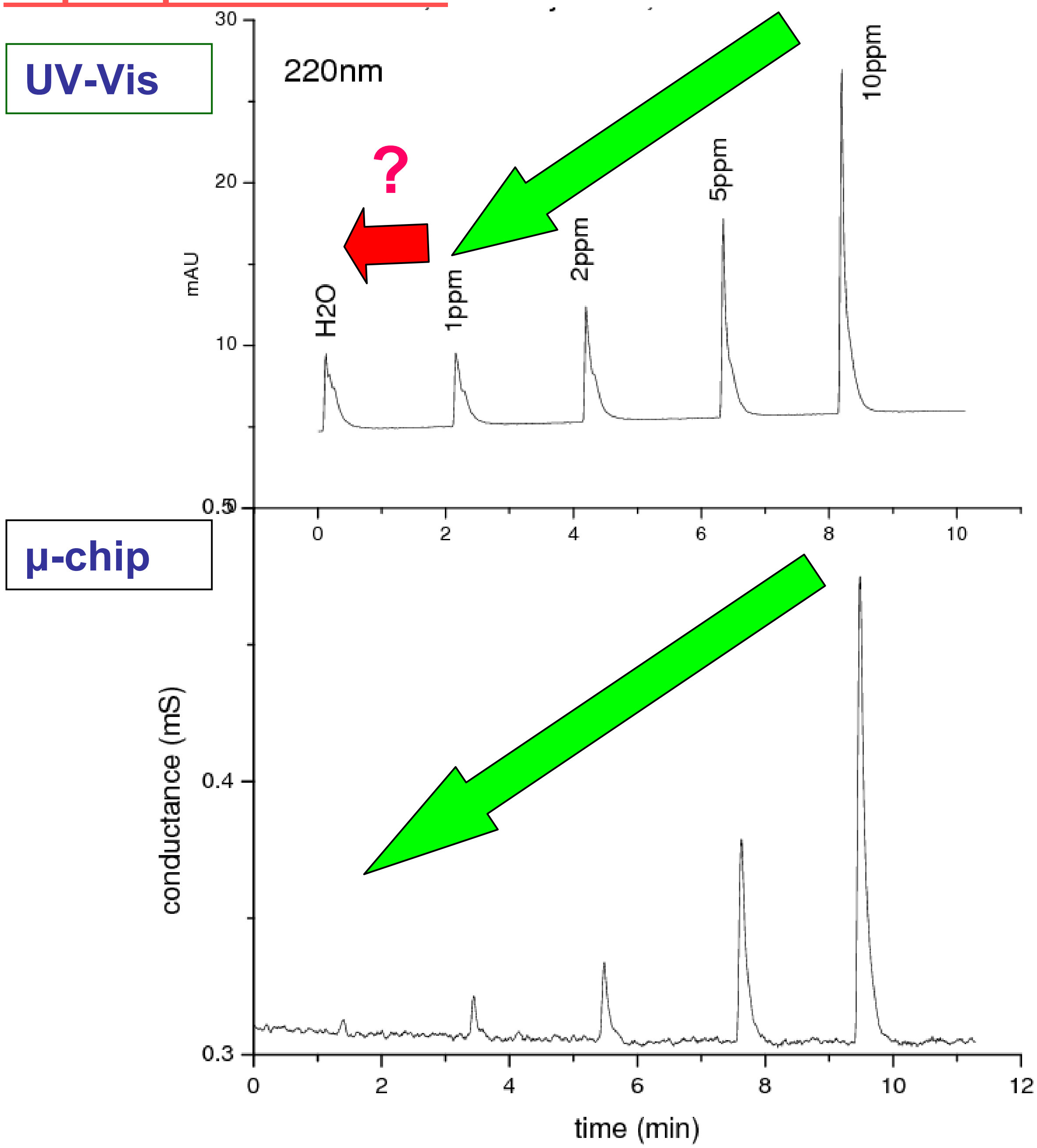


Microchip Limit of detection (3 x noise) ~ 1 ppb using
5 uL detection volume without pre-concentration

Case study 2: Head-to-head comparison between UV-Vis and μ-chip: HPLC w/ μ-chip in waste line



Case study 2: Injecting solutions of ASA in water into a chromatograph (HPLC) w/ μ-chip in waste line



1 ppm = 1 mg / L

Notes re ASA in water:

-ASA has phenyl ring and carboxylic acid

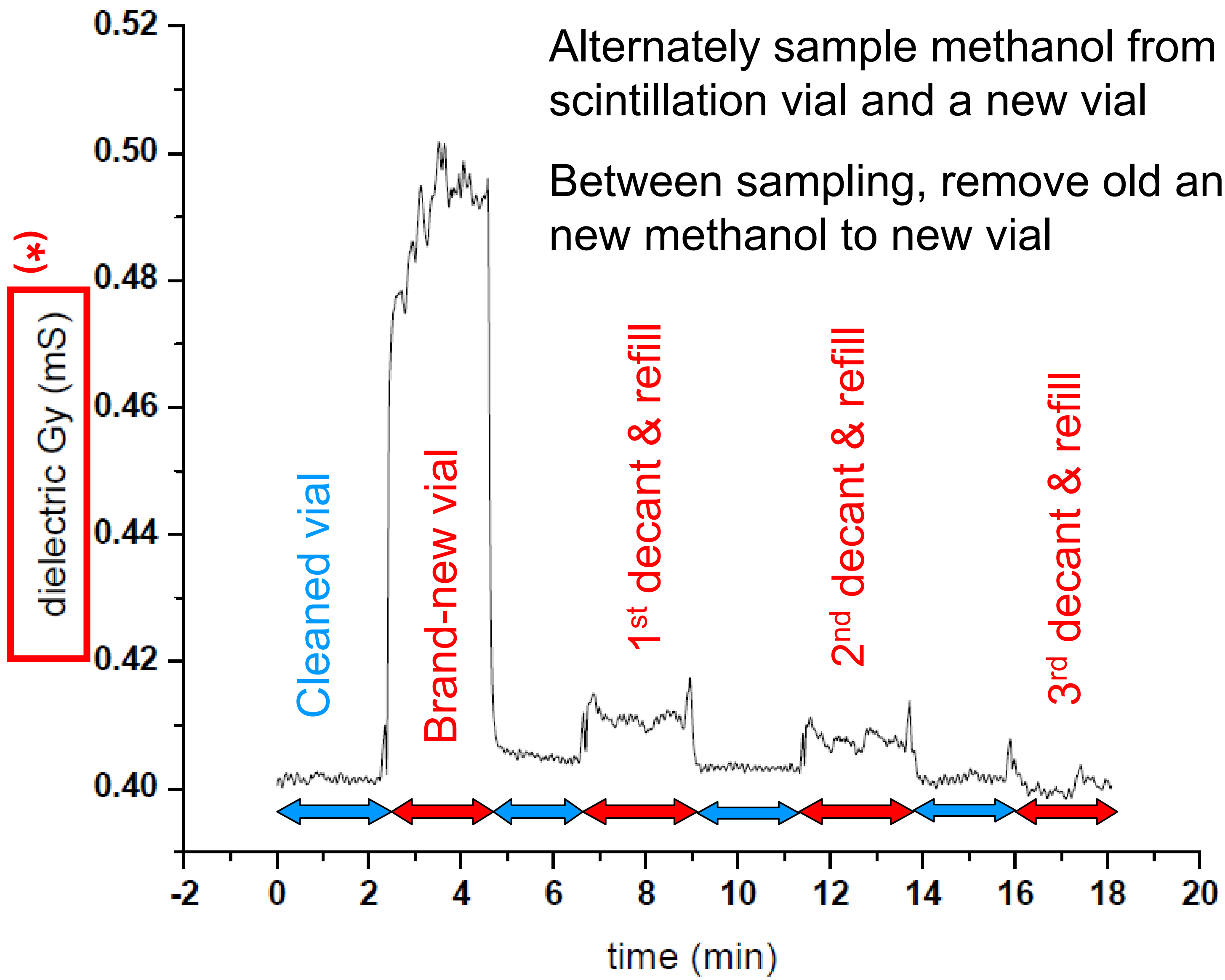
- UV-Vis favoured (phenyl strong chromophore) and conductivity handicapped (carboxylic weak acid)

- **Nevertheless, unlike UV-Vis, e-chip can detect less than 1 ppm (1 mg/L) ASA in water**

Case study 3: Utility of dielectric constant measurement

Alternately sample methanol from a clean scintillation vial and a new vial

Between sampling, remove old and add new methanol to new vial



(*) **First contamination peak can be seen in conductivity Gx signal, too, but 2nd and 3rd peaks are difficult to see in Gx**

University of Toronto spin-off ⇒

UNS TECH Universal Nanosensor Technologies Inc.

www.uns-tech.ca

Summary:

Microchip conductance detectors:

- applicable to bench-top, portable and (likely) process settings; chromatography (HPLC, IC)
- enable at least 10-100-fold lower cell constants (translates into increased sensitivity)
- conductivity and now dielectric measurements possible, simultaneously
- cost effective


THANK YOU