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CAPELLA

CAPillary ELectrophoresis for *in-situ* Life Analysis

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Outline

- Introduction LioniX BV
- Capillary Electrophoresis for planetary exploration
- Micro System Technologies
- CE in the Netherlands / CAPELLA initiative
- SMILE consortium
- Conclusions

Mission Statement / Core Activities

LioniX is a leading *provider in development and production* of innovative products based on *micro/nano technology* for its (OEM) customers in Telecom, Industrial Process Control, Life Sciences and Space:

- components for datacom systems based on integrated optics (optical chips)
- components and systems for lab-on-a-chip and sensor applications

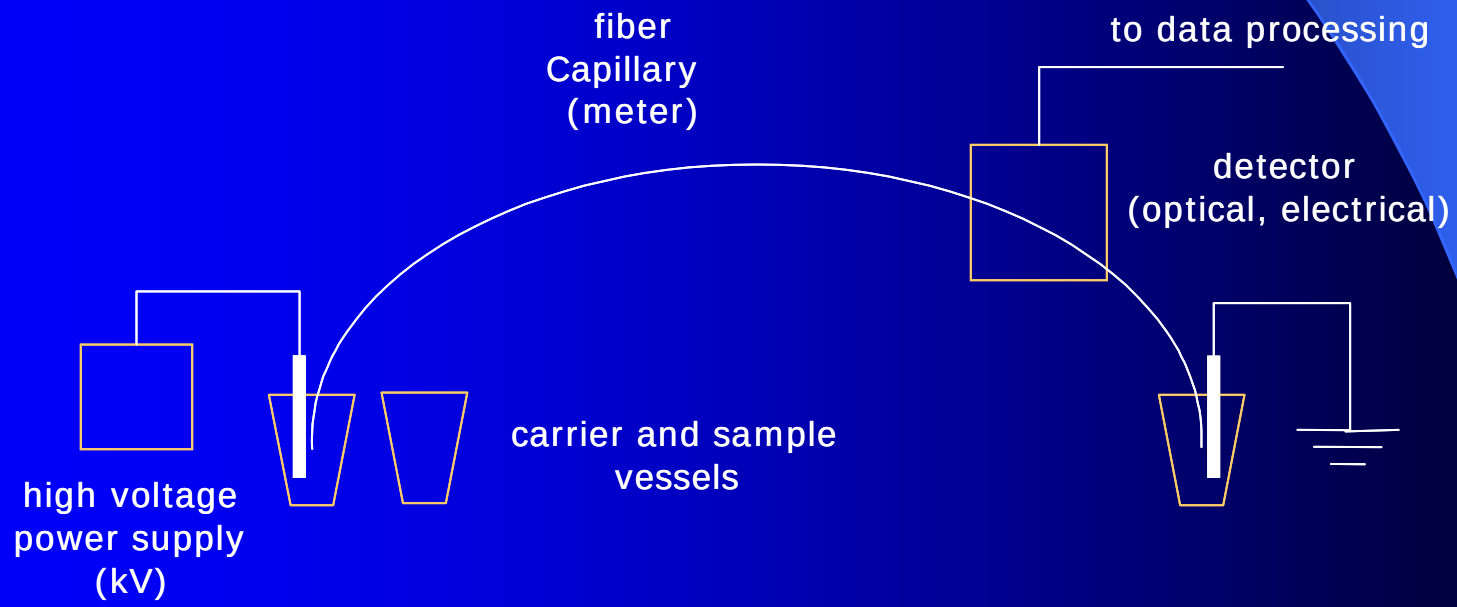
LioniX offers *design for manufacturing* and *horizontal integration* by partnering with foundries and suppliers of complementary technologies

Overview

- located at the Science Park University of Twente
- 18 people, mainly highly educated
- private company (BV), venture capital
- participation of MESA+ / Univ. of Twente (IPR integrated optics and microfluidics) and 3T BV
- experienced management
- profitable company

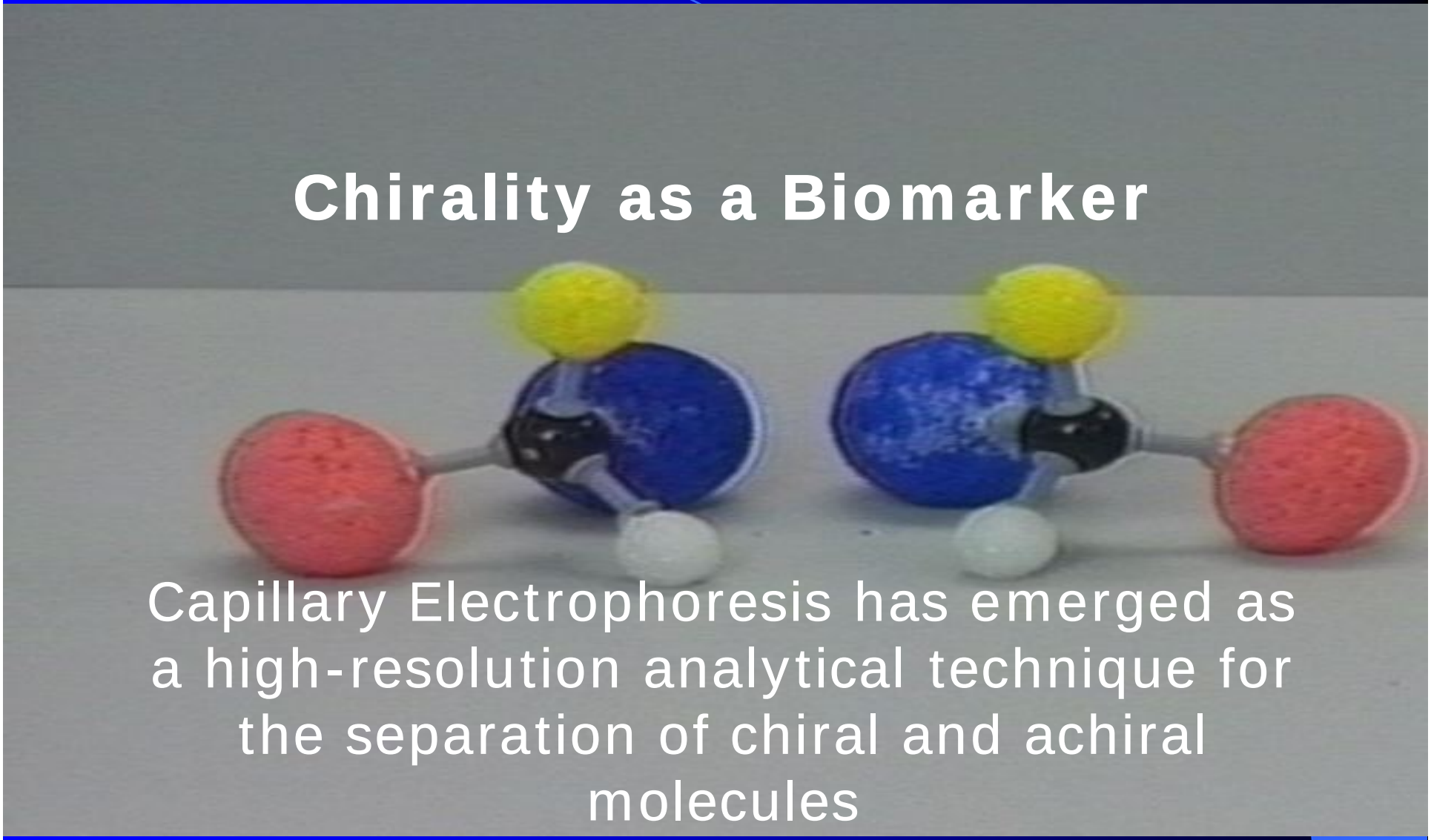
CE basic principle

- working mechanisms
  - Electro-Osmotic Flow (EOF)
    - HV induced ‘pump’ effect due to interaction of dielectric glass walls of capillary and ion charges in solution
  - Electrophoresis
    - HV induced velocity difference due to mobility properties of ions or charged molecules in carrier solution



CE in planetary research

Chirality as a Biomarker



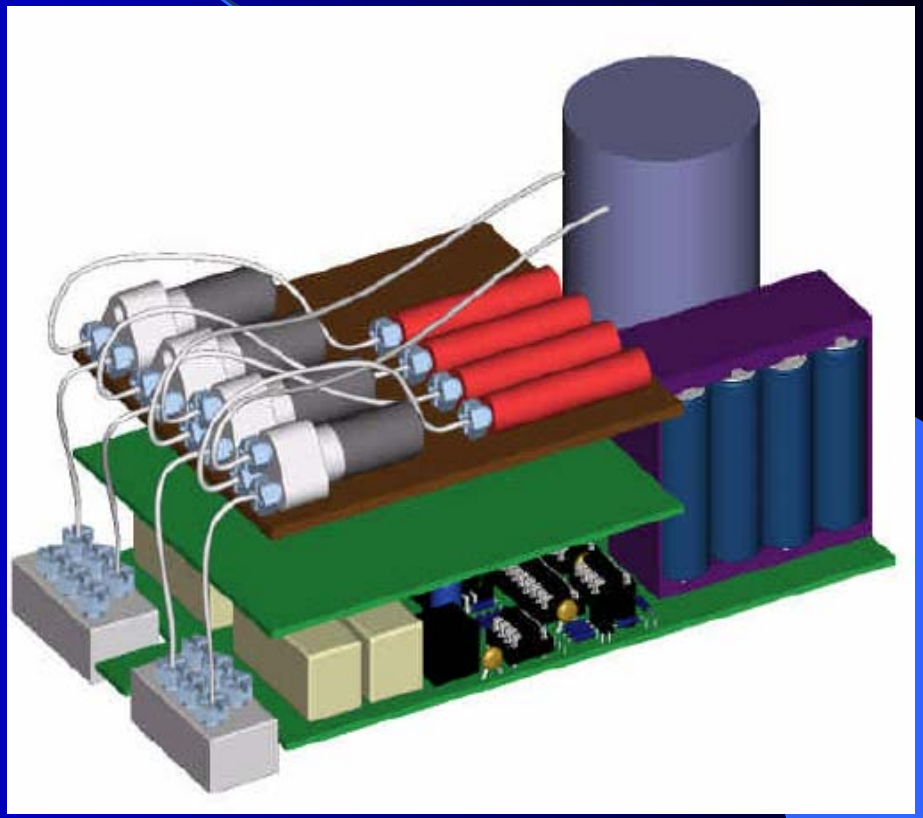
Capillary Electrophoresis has emerged as a high-resolution analytical technique for the separation of chiral and achiral molecules

CE space system

CAPELLA:

miniaturised system, including sampling, CE chips, detector(s), microfluidics, data management system, power supply and batteries

Nanokhod, ESA's future planetary rover (courtesy vH&S)



Artist impression of µCE System

Microfluidics history

1983 CME

1984 world's first micropump (van Lintel)

1988 3T BV

1993 start microfluidics system development

EC-project

2000 MATAS system integration presented

2002 LioniX BV

MATAS IPR

2004 CAPELLA

Micro System Technologies

- µFluidic components based on silicon
  - flow sensors, ISFETs, conductivity (EC)
- µFluidic components based on glass
  - channels and capillaries for CE
- System integration
  - fluidic & electronic interfacing
  - MATAS integration technology

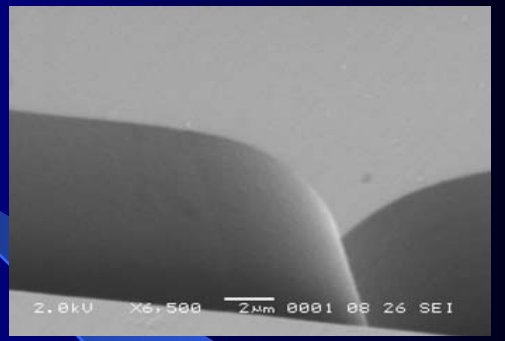
Silicon technology

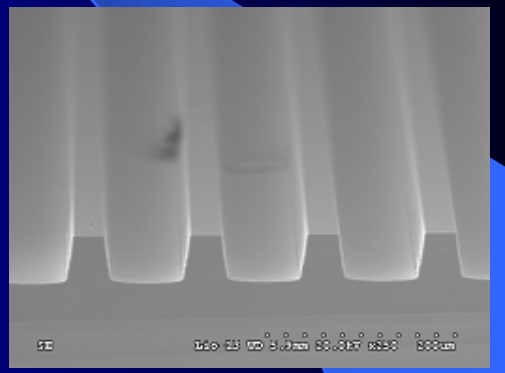
- Why silicon
  - semiconductor background
  - optimal processing flexibility
    - controlled etching (KOH, DRIE) for things like membranes and complex channels and capillaries
    - semiconductor properties
  - analysis applications - with respect to glass
    - less accepted
    - no Electro-Osmotic Flow (EOF)
    - less inert
- Technologies
  - “almost everything“

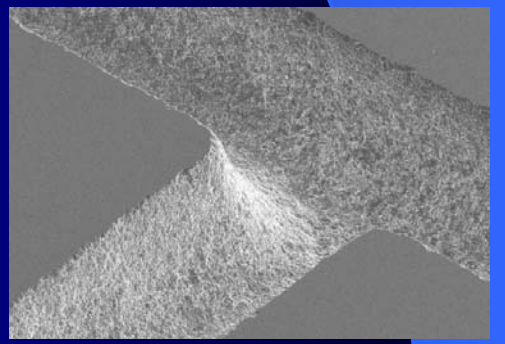
Glass technology (1)

- Why glass
  - electro-osmotic flow (EOF)
  - widely accepted in biotech
  - but, less processing flexibility as silicon
- Technologies
  - wet etching of capillaries
  - DRIE etching of capillaries
  - Powder blasting of channels and holes
  - wafer bonding
  - integration of electrodes

  Future:
  - integration of waveguide sensors

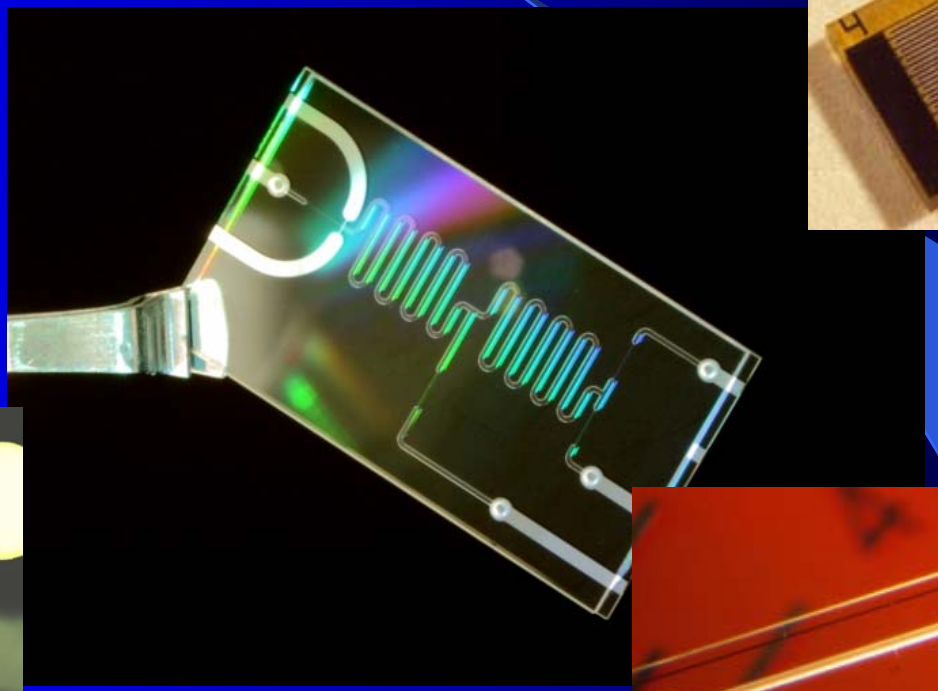


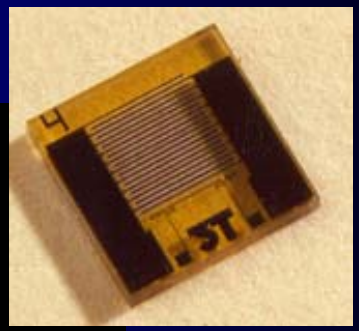


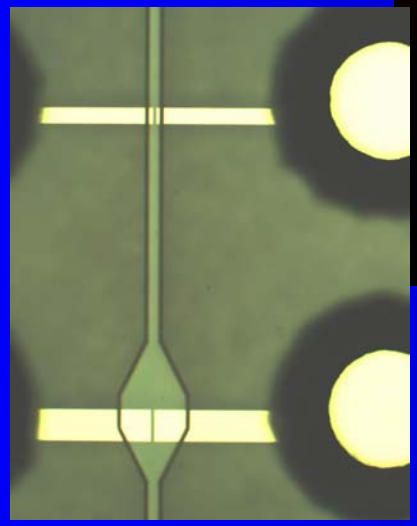


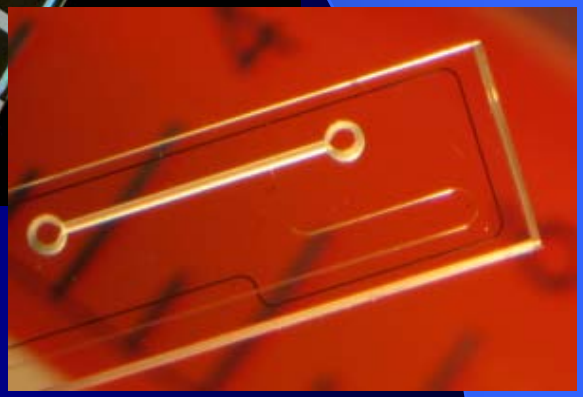
Glass technology (2)

- Examples
  - CE-chip
  - EC-chip
  - µReactor





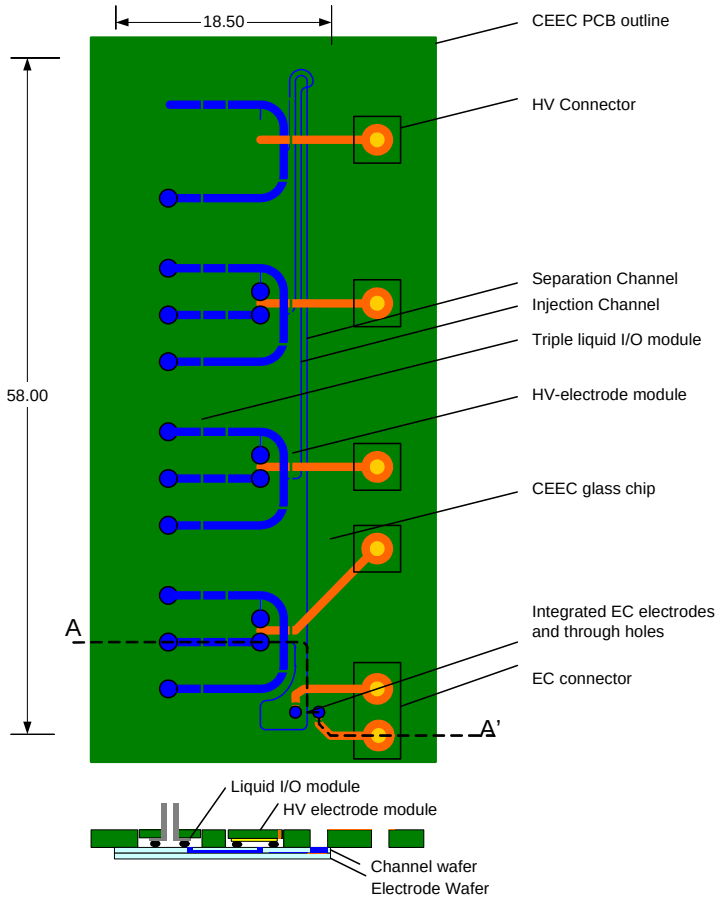




ESA funded MUSC project

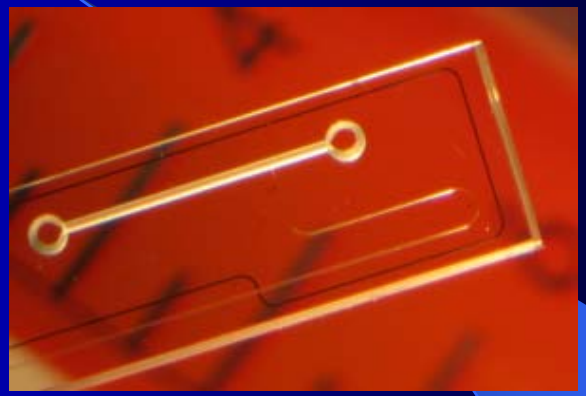
CE chip with EC detection

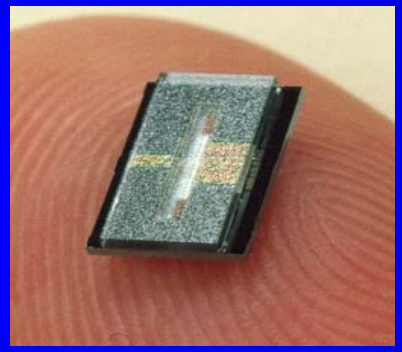
- glass chips with integrated electrodes for HV and detection
- packaging concept (for R&D)
- external LIF detection
- concept for space instrument (MATAS based)
- development: integration of waveguide sensors

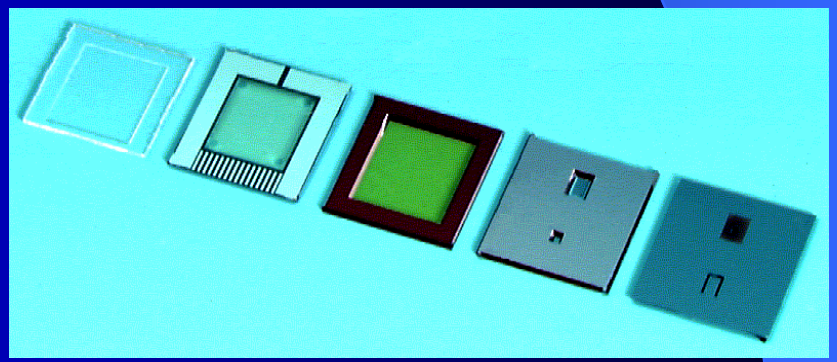


System integration - ‘true’ lab-on-a-chip -

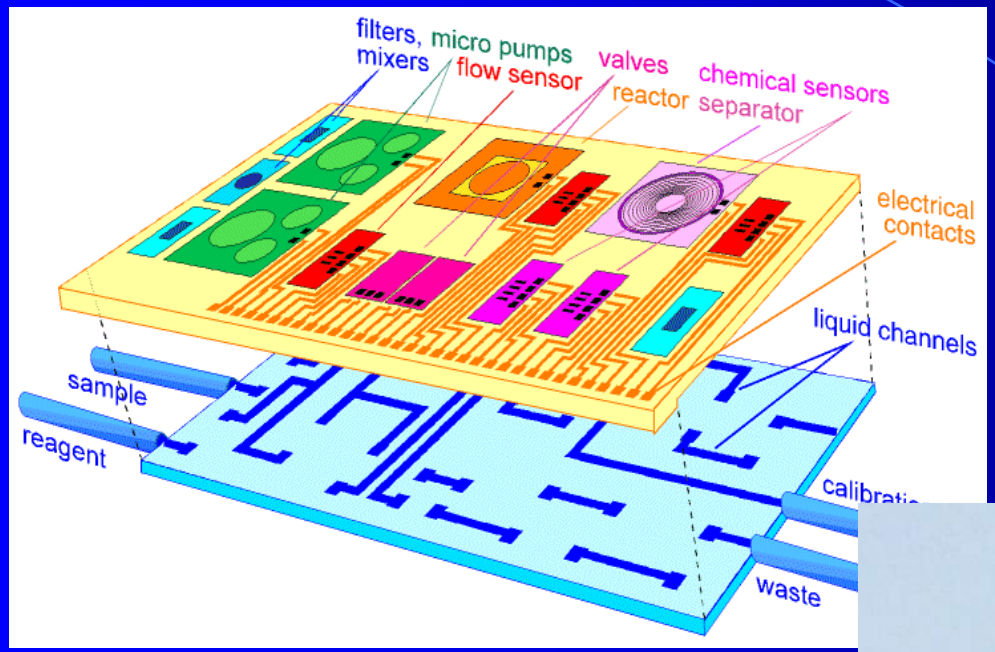
- Micro components are ‘isolated’; need for a platform
  - Fluidic interfacing
  - Electrical interfacing
  - Optical interfacing

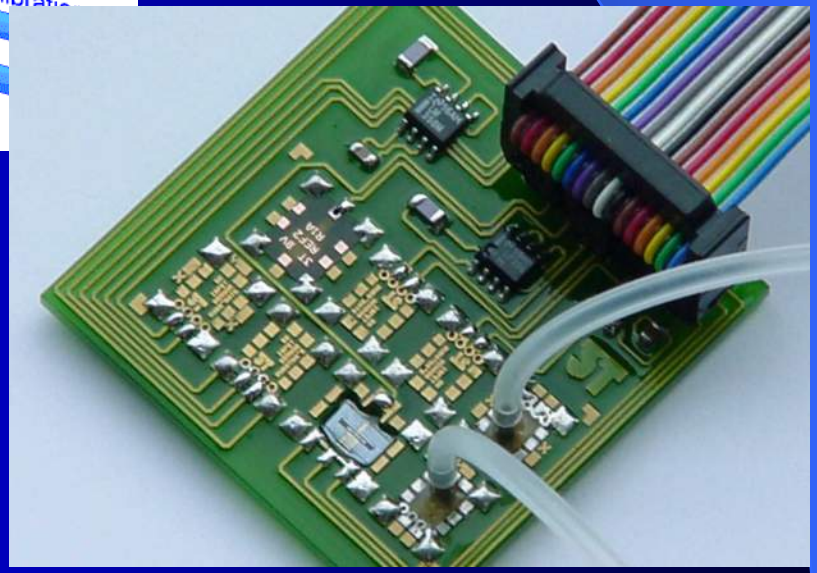






MATAS Platform





CE in the Netherlands

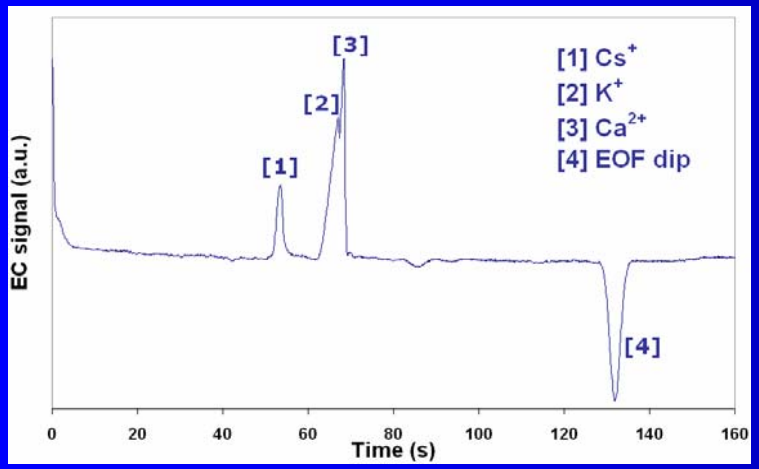
History of hardware development:

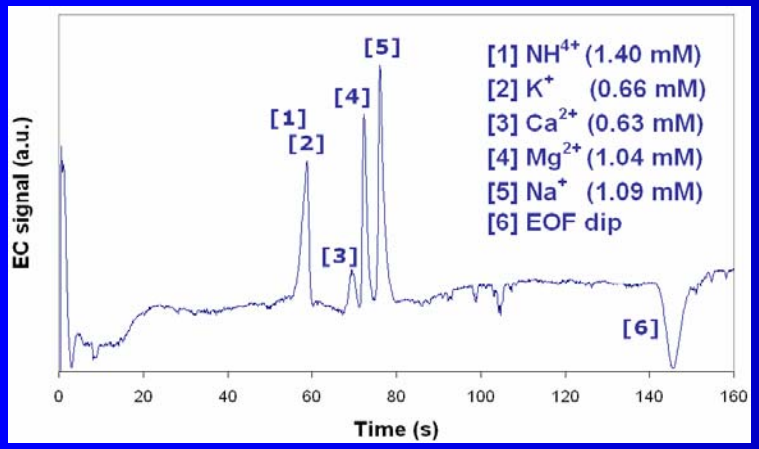
- CE for Biolab (’88-’90)
- CAELIS first hardware study (’92)
- CAELIS-2 breadboard development (’96-’97)
- MATAS technology development (’99)
- First MST based CE system demonstrator (’00)
- New detectors and system developments (’01 – ‘03)
- MUSC: CE with EC detection (’03)
- CAPELLA: focus on planetary research (’04 – now)

CAPELLA consortium

- Partners (presently):
  - LioniX BV
    - microtechnology / microfluidics / lab-on-a-chip
  - Leiden Institute of Chemistry (Leiden Univ.)
    - nanotech packings and coatings
    - astrobiology (Ehrenfreund)
  - Mesodyn BV
    - modeling/simulation of CE performance and wall interactions
  - Dutch Space BV
    - LIF detector
    - instrument development
  - Future: Bioclear, TNO-TPD, WUR, VU, ...]]
- Current project - framework
  - NIVR (Dutch space agency)
    - Pre-qualification ESA Projects (PEP)
  - Dutch Priority Area Planetary Research

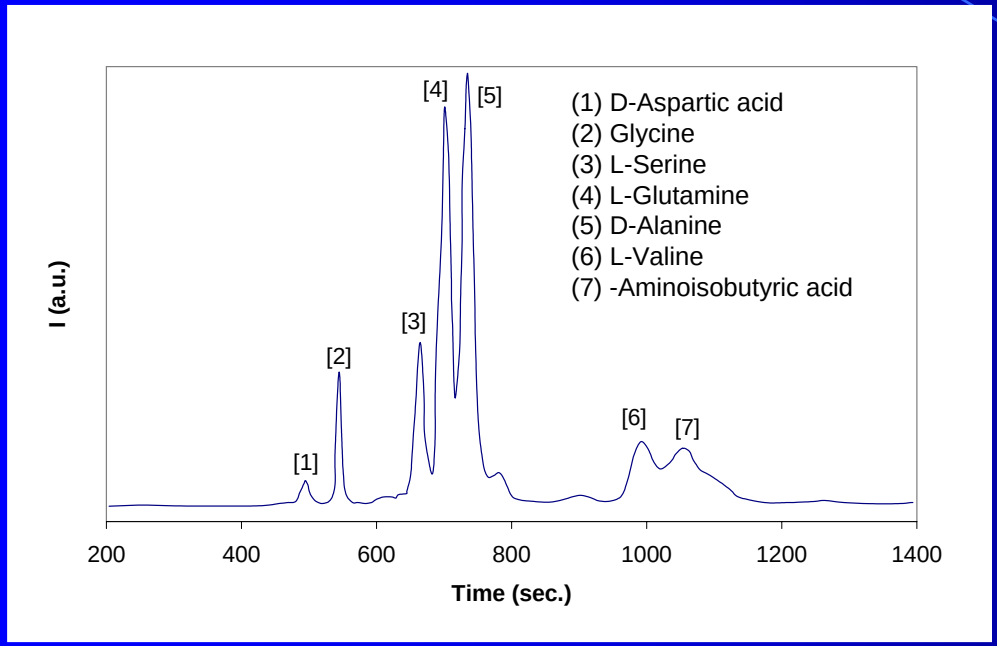
Ion separation with conductivity detection



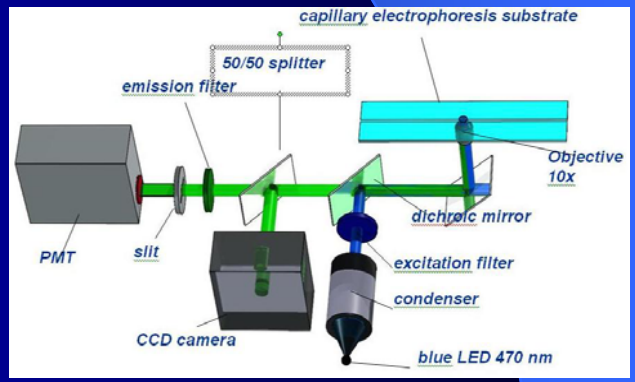


- Integrated Pt electrodes and ECU-1 unit for conductivity detection
- Injection at 1000 V (30 s)
- Separation at 1000 V (3 min)
- 20 mM MES/His buffer (pH 6.1)
- Detection limit approx. 100 µM

Amino acid separation with LIF detection



- Amino acids labelled with Fluorescein (FITC)
- Buffer 0.1 M TRIS
- Separation 800 V
- LIF detection based on PMT and LED built by Dutch Space



SMILE consortium

CAPELLA is part of the SMILE consortium

SMILE is a consortium in response to ESA's Call for Ideas for the PASTEUR Instrument Payload for the EXOMARS Rover Mission by team members from universities, institutions and industries, lead by Leicester University and Cranfield and partners from a.o. UK, Netherlands and Germany.
It is dedicated to the identification and measurement of specific organic molecules *in situ*.

SMILE: Specific Molecular Identification of Life Experiment
Goal: To detect and quantify the presence of biomarkers in the Martian environment associated with extinct and/or extant life and/or life processes.

View of Olympus Mons from the southwest, about 80 kilometers distant. Coordinates: 19N 225E.

Conclusions

- CE promising technology for Planetary Research
  - state-of-the-art biochemical analysis principle
  - compatibility with miniaturisation
  - Lab-on-a-chip systems developments
- CE competence/expertise in the Netherlands
- Strong SMILE consortium