„3D Drucken trifft auf Biowissenschaften- von kapillaren Mikrofluidiken zu EHD Pumpen“

microTEC Gesellschaft für Mikrotechnologie mbH

12. Workshop Kleine Volumenströme in der Medizintechnik
BioMedTec Wissenschaftscampus Lübeck

Committed to Customer Success Since 1996

microTEC

3D printed solutions for innovations

Customer Idea

microTEC Business model:

- B2B
- R&D, Simulation
- Prototyping
- Direct Mass Production
- Technology Licensing
- RMPD Machines

✓Customer Product Innovation

Active in growing markets:

- Consumer electronics
- Sensor technologies
- Life Science

microTEC is active in EC and BMBFI co-funded cooperative R&D projects.

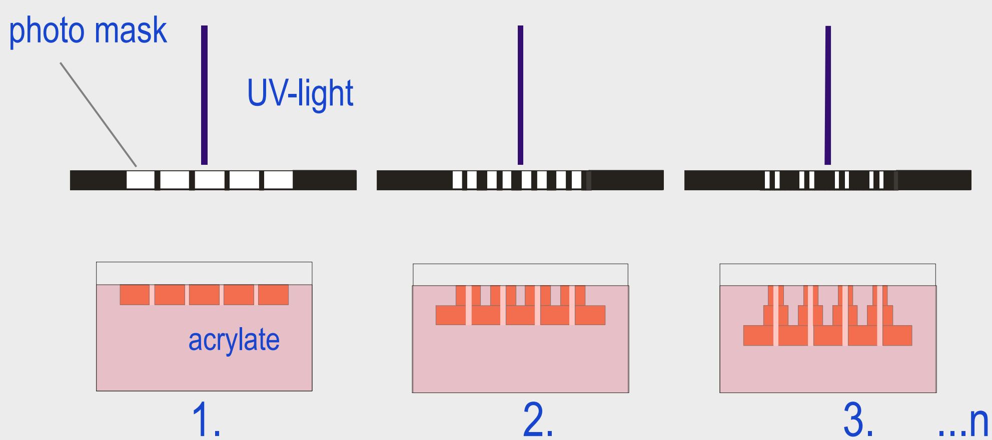
Bundesministerium für Bildung und Forschung

THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION
HORIZON 2020

microTEC

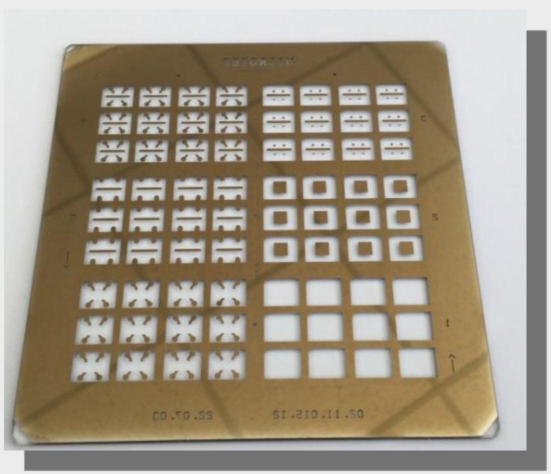
RMPD mask, additive manufacturing of microstructures in parallel

RMPD© -mask since 1998

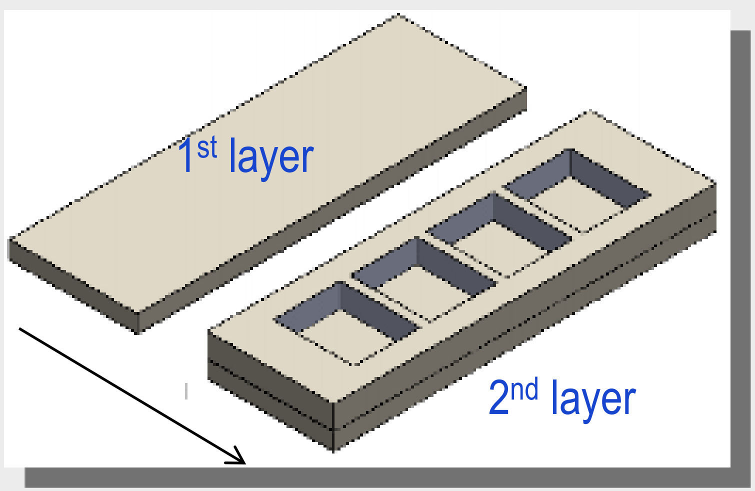


RMPD mask by microTEC since 1998:

- Additive manufacturing for mass production
- Parallel production by arrays of layers
- Layer by layer approach
- Resolution down to 1µm lateral
- Mask size scalable according to volume from 5” – 14”
- 2.5D design (limited number of layers of different geometry)



5“ photo mask

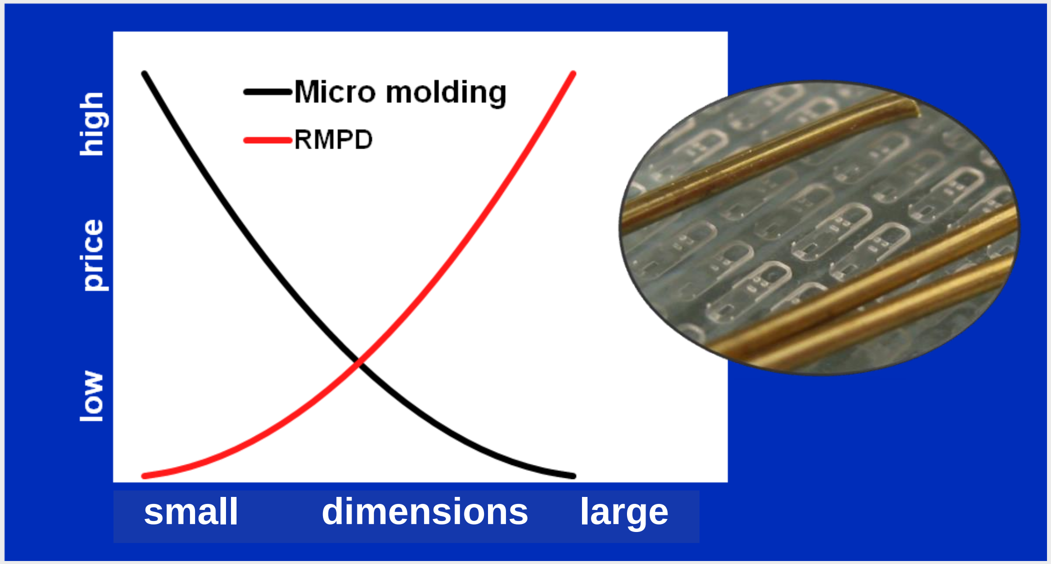


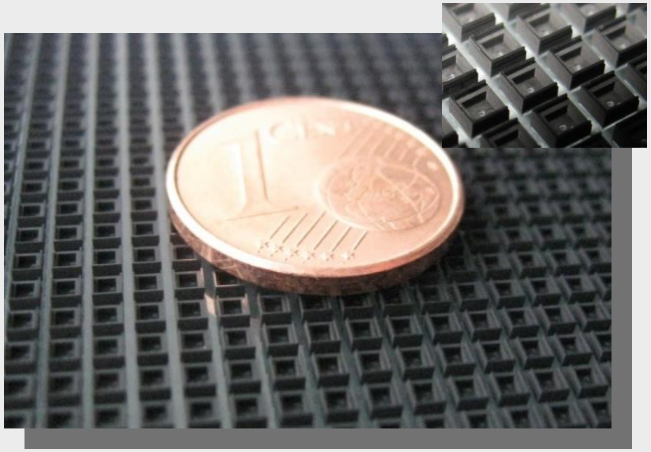
Time and cost of RMPD mask

Low costs for high volume productions:

- small dimensions
  - ⇒ more parts per batch
- low complexity in z-direction
  - ⇒ 3D model sliced into layers of different geometries
  - ⇒ typically 2-6 different layers per mask

Timeline	RMPD® - mask
mask design and production	5“ mask 6” mask 9“ mask 14“ mask
mask design and production	1 week
process set-up	1- 2 days
cycle time per part 1x1x1mm³	1 µsec. (parallel process)





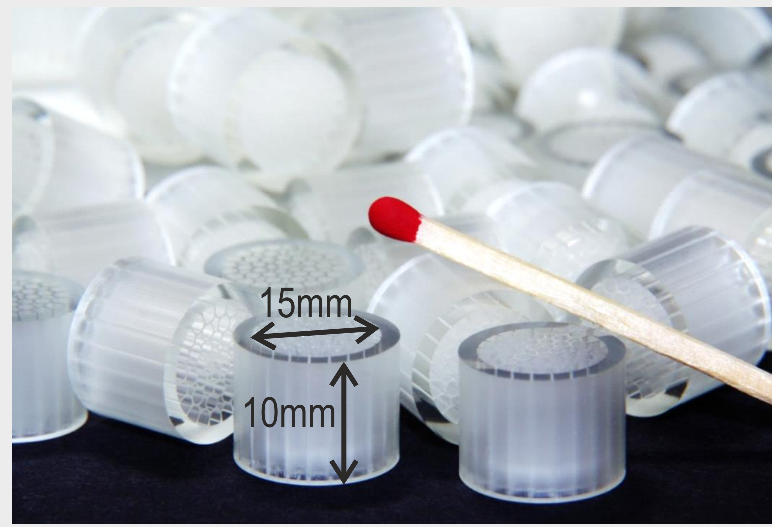
microTEC

RMPD mask with one geometry in growth direction

bürkert
FLUID CONTROL SYSTEMS

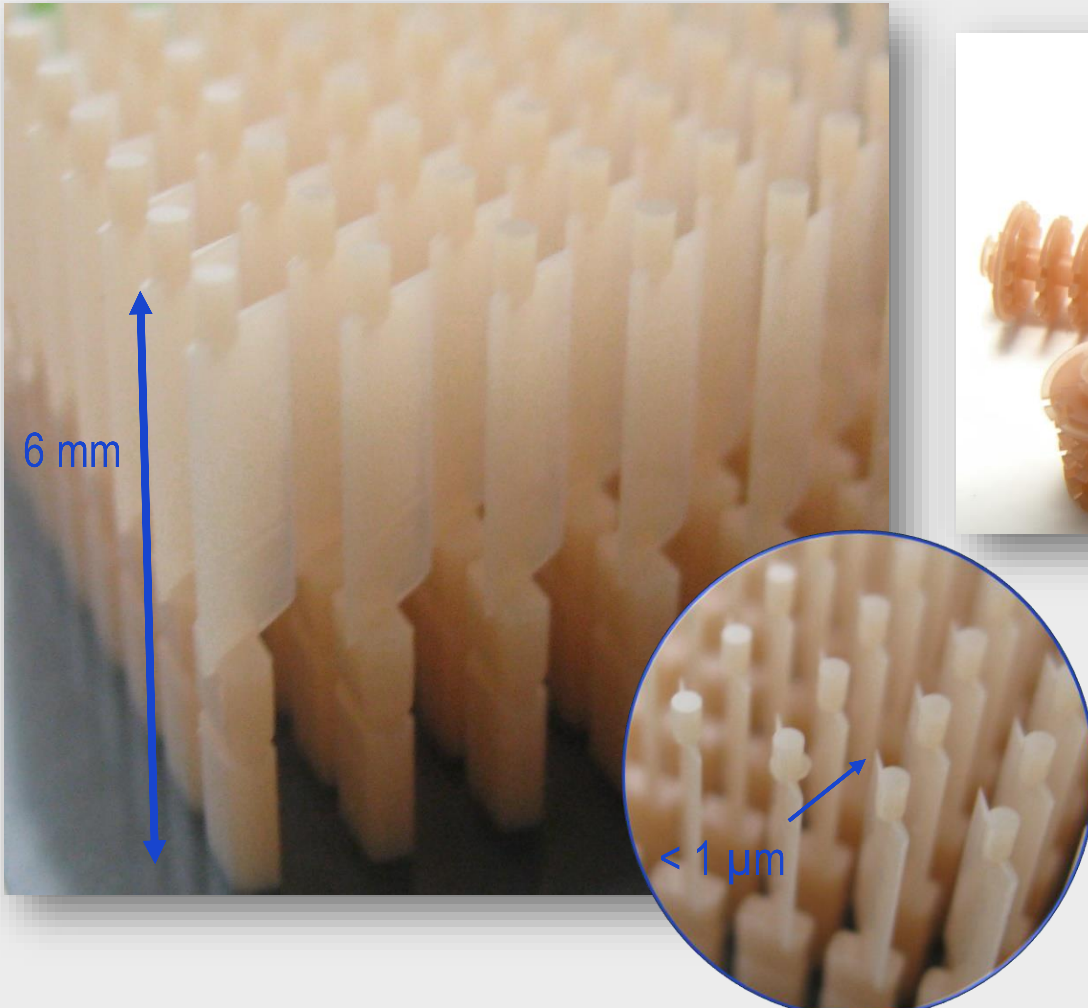
High aspect ratio structures for mass flow meters

- Various geometries for different flow rates
- 100 layers of 100µm thickness
- >120 high precision structures per batch
- 3 batches in 8h
- Annual production ~50.000 parts



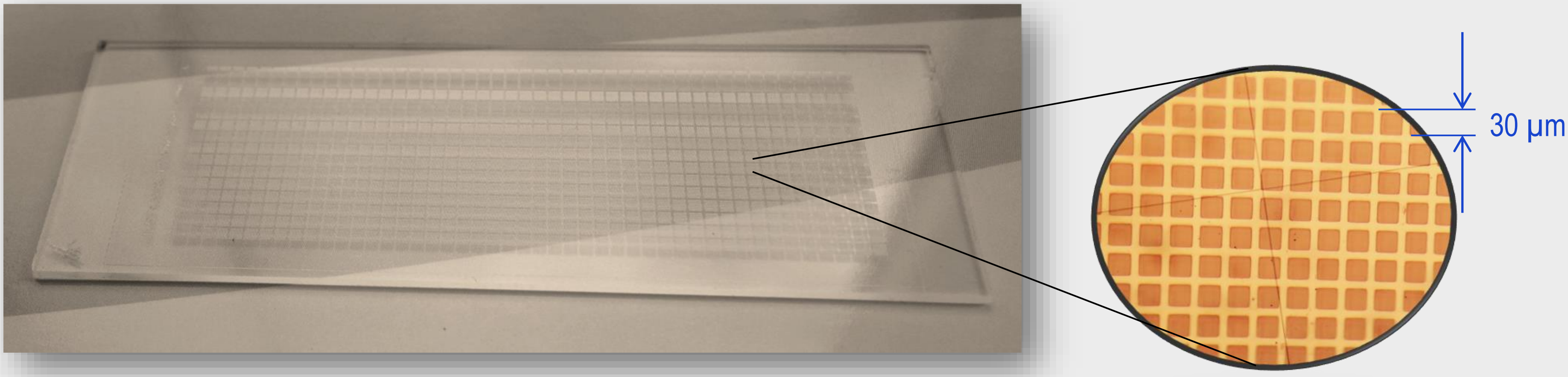
microTEC

Parallel production of high aspect ratio structures : 10 part or 1 Million parts within 10 days



microTEC

Single-cell RNA sequencing, Polymer nano well plates on glass

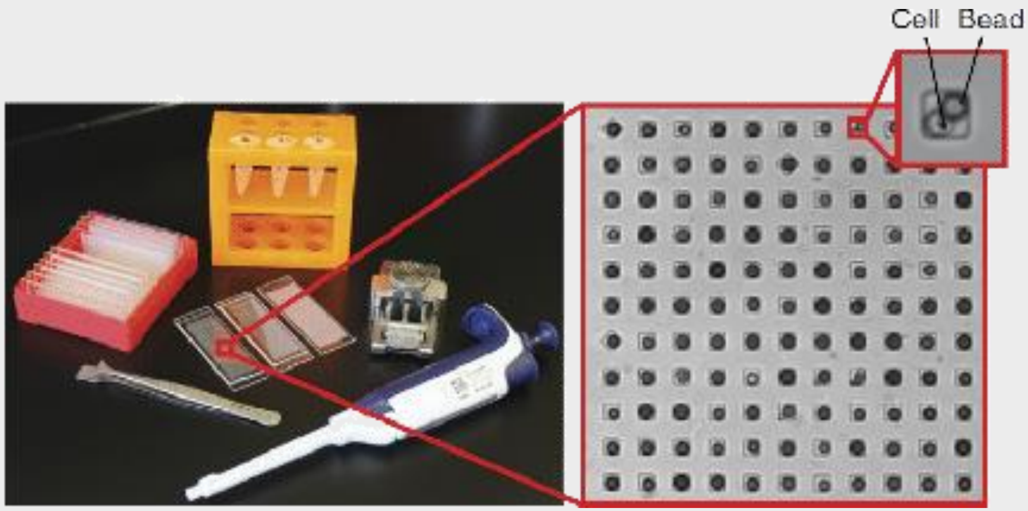


RMPD-mask, polymer structure on glass

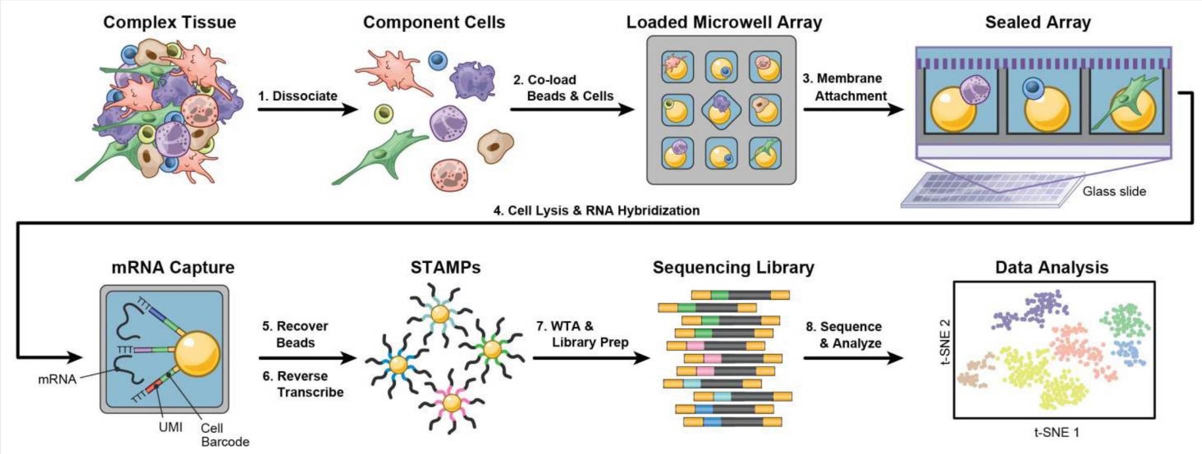
- Thickness 50-120µm
- Up to 2 million subnanoliter wells on one slide
- Functionalized materials to anchor cells
- PCR capabilities
- Low fluorescent materials

Customer: Massachusetts Institute of Technology, Ragon Institute, Massachusetts General Hospital

Single-cell RNA sequencing, Polymer nano well plates on glass



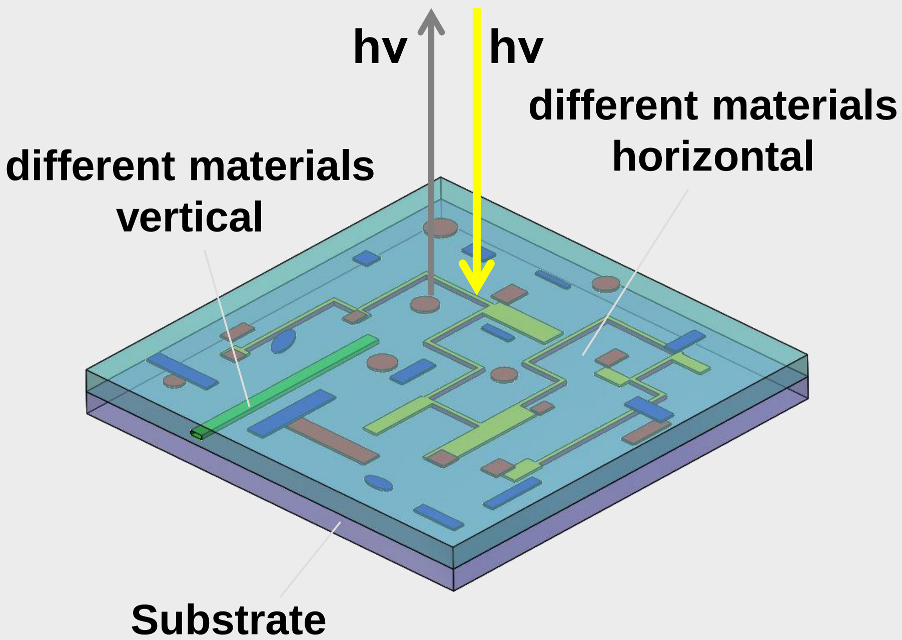
Seq-Well, a portable, low-cost platform for massively parallel single-cell RNA-seq



doi:10.1038/nmeth.4179

Customer: Massachusetts Institute of Technology, Ragon Institute, Massachusetts General Hospital

RMPD®-multimat technologies



Flexibility of choice to grow UV curing materials

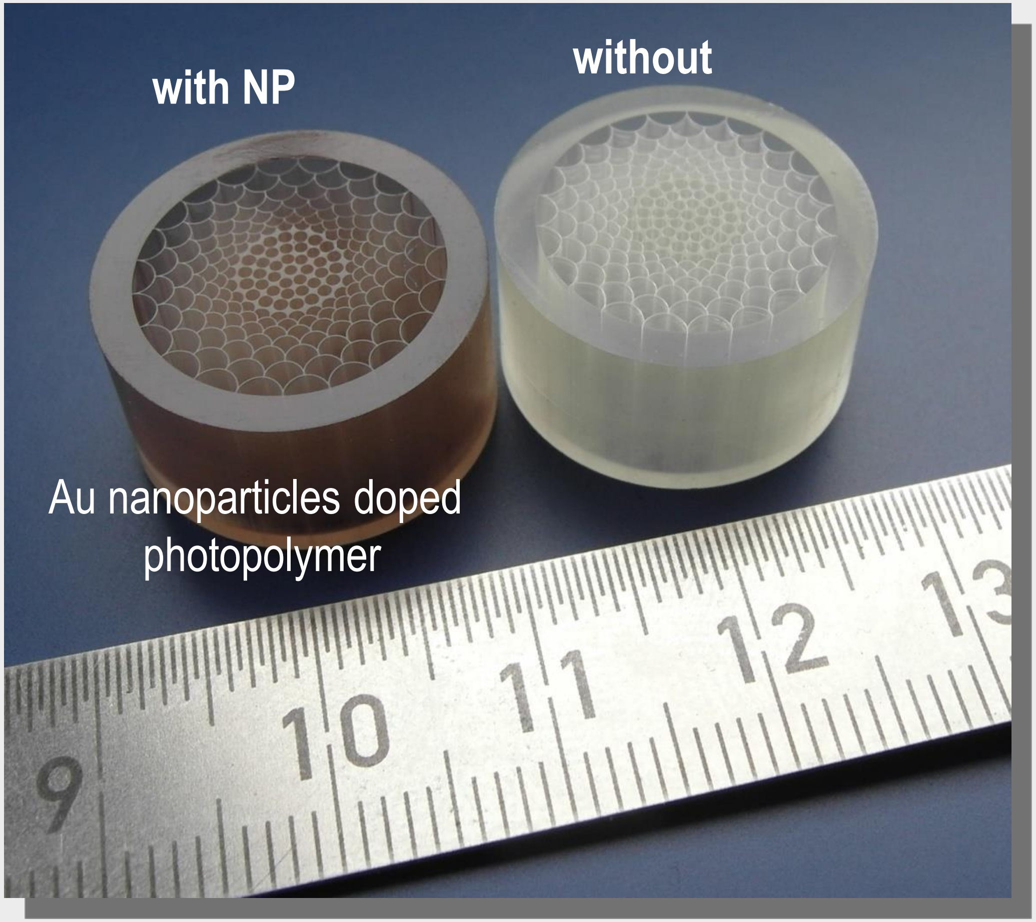
- Substitute materials vertically or horizontally, Resolution 1-2µm
- Layer thickness from 1µm to 200 µm (depending on the polymer)

- Examples:
  - waveguides with two refractive indices
  - dispenser systems with different chemical properties depending on tip height
  - different mechanical properties

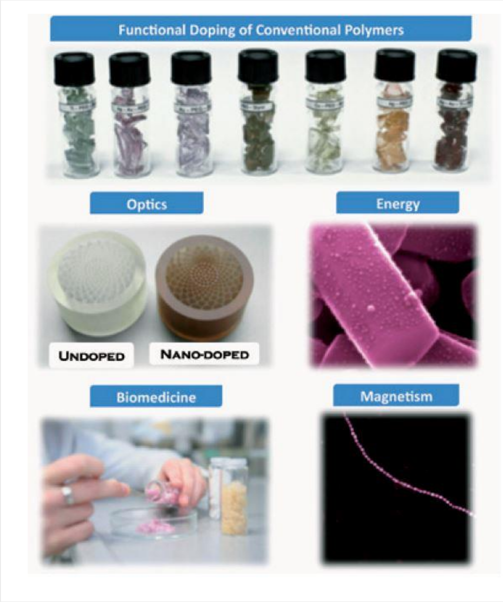
- possible Solutions:
  - p and n doped monomer, polytronic
  - photon collecting, PV cell
  - photon radiation, TV screen

microTEC

Functional doped photopolymer



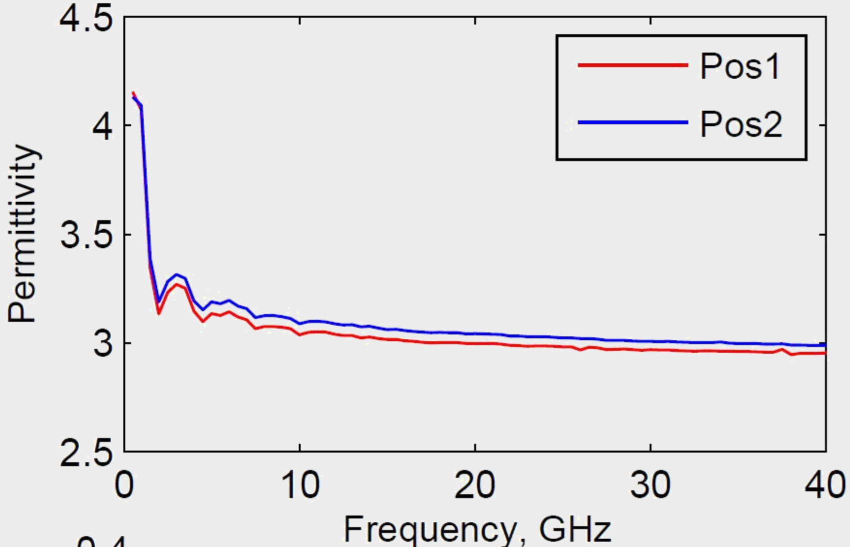
- Direct generated optical filters
- no assembling
- holography
- optical storage materials
- volume gratings
- nano materials

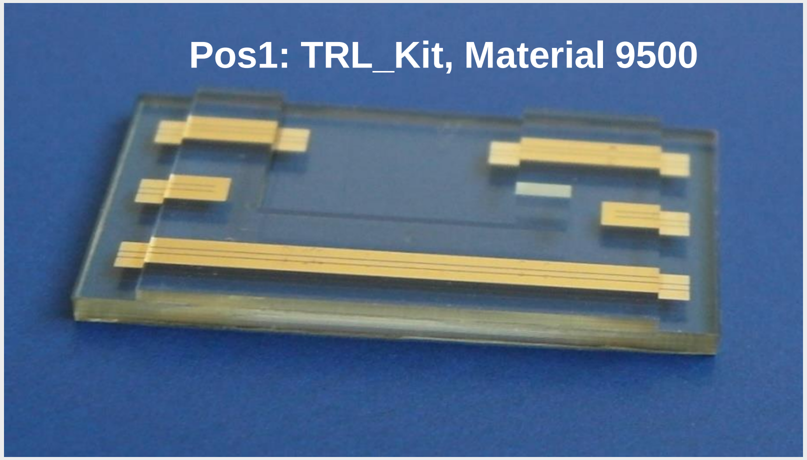


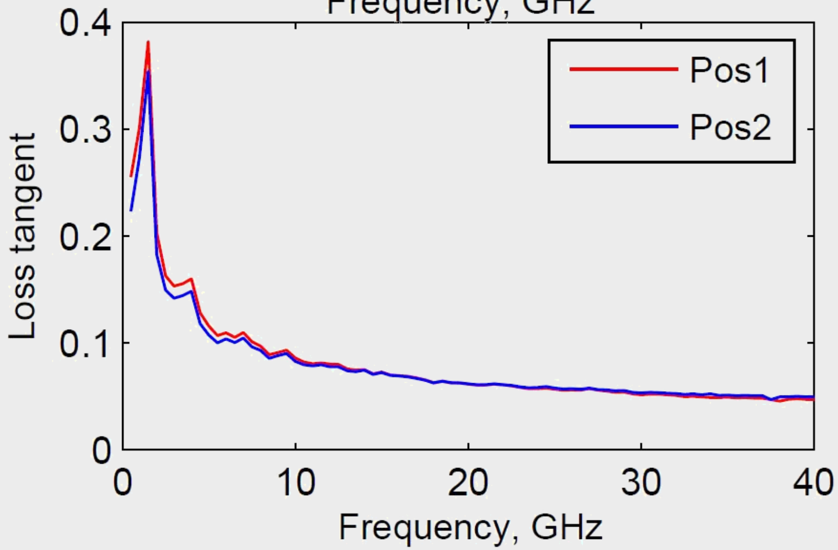
CENIDE
CENTER FOR NANO INTEGRATION DUISBURG ESSEN

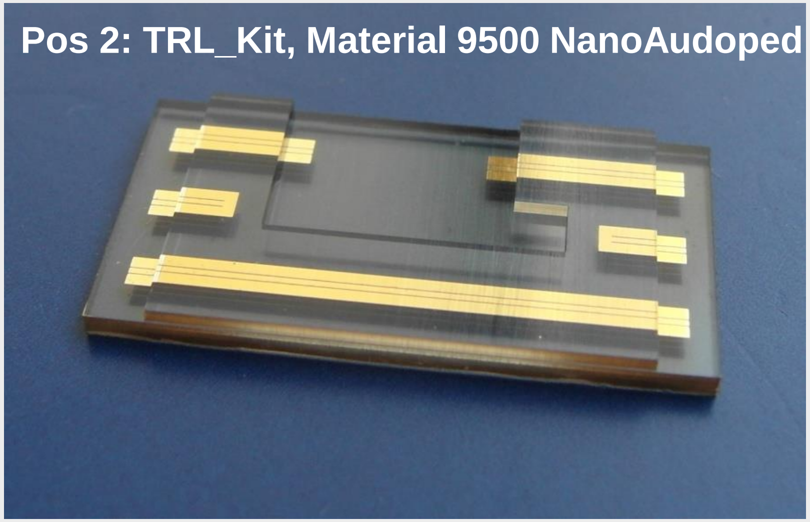
microTEC

RF test, RMPD-Mask with metallization layer and Au nano particle doped photopolymer



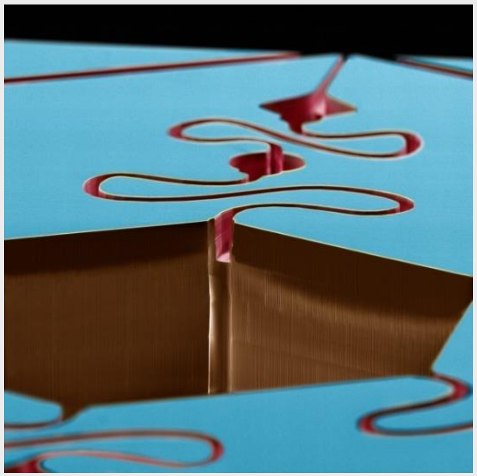


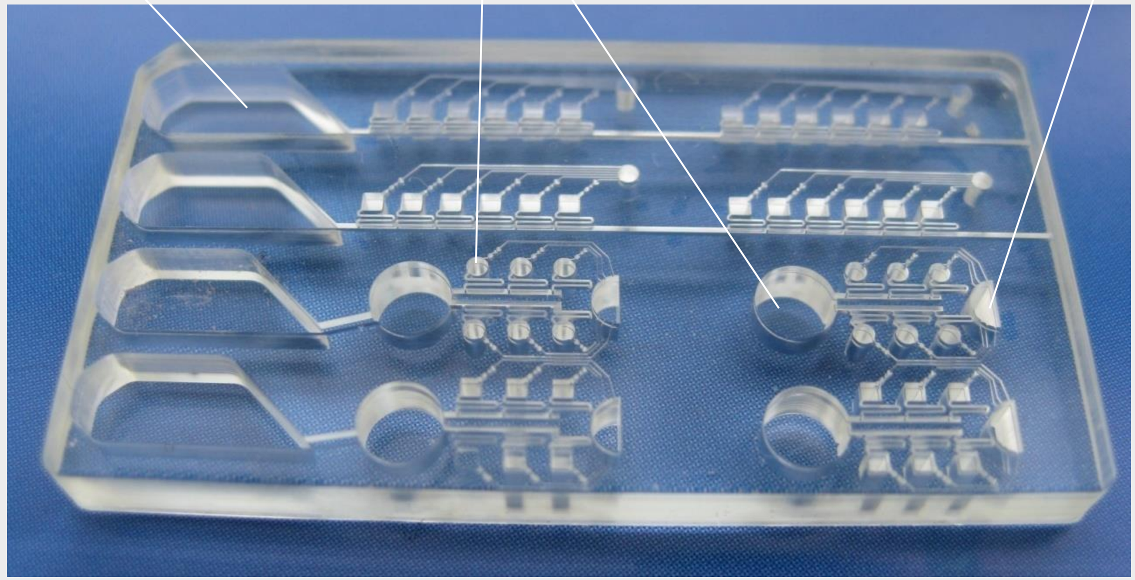


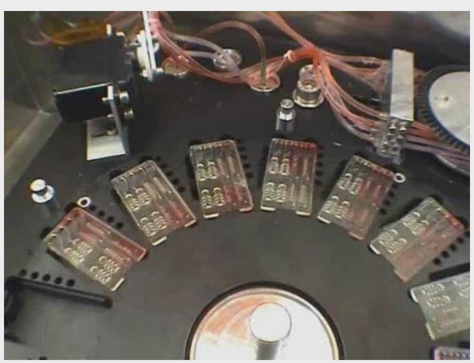


microTEC

Fluidic cartridge successfully tested at zero-g



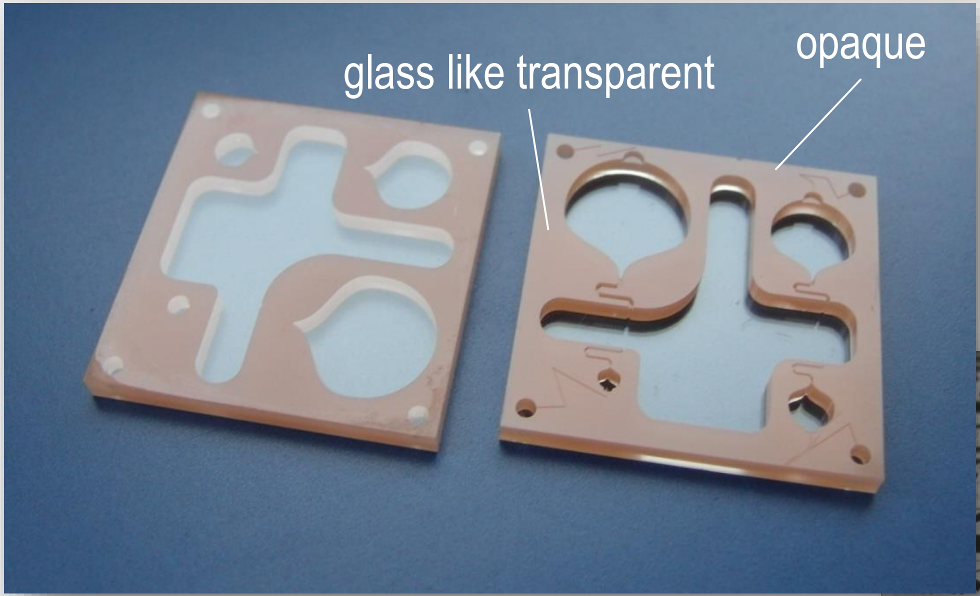




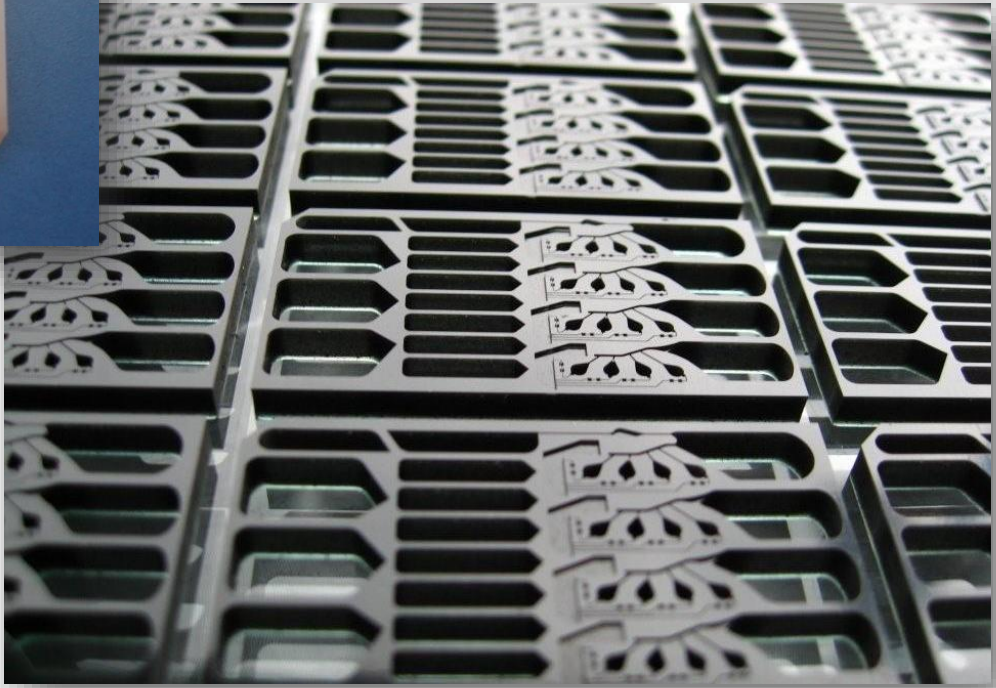
- Two different materials in vertical direction
- Intrinsic hydrophilic and hydrophobic materials

microTEC

micro fluidic cartridges for life science applications

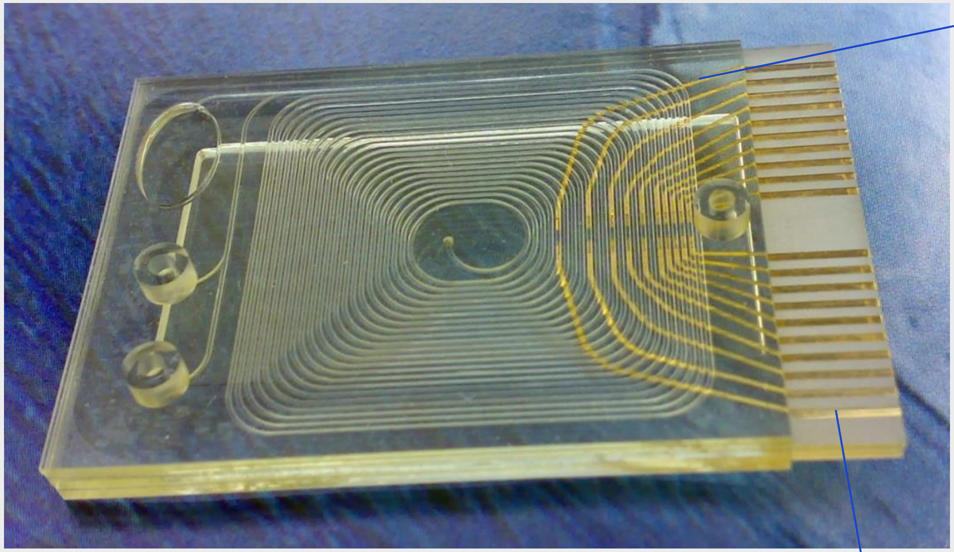


micro fluidic cartridges in black polymer, with glass bottom



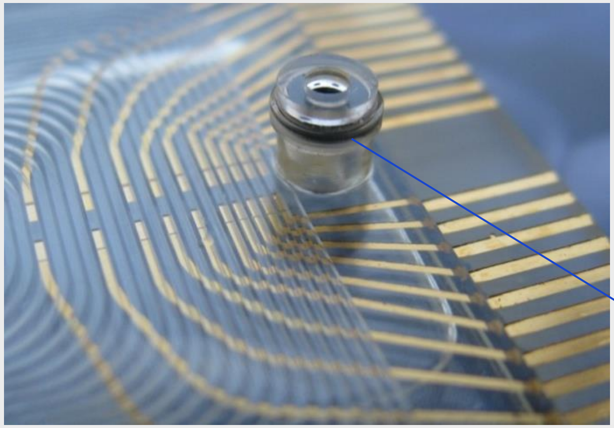
microTEC

Fluidic, fluidic connectors, electrodes, electronic board interface



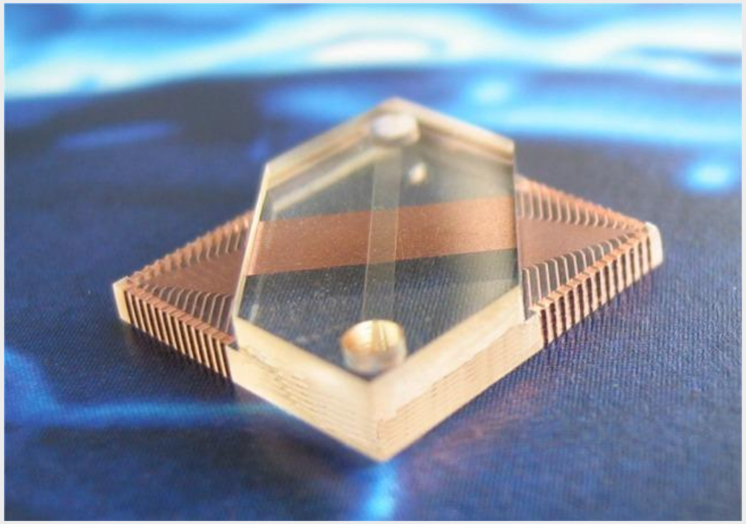
Au electrodes

connector



integrated o-ring as sealing

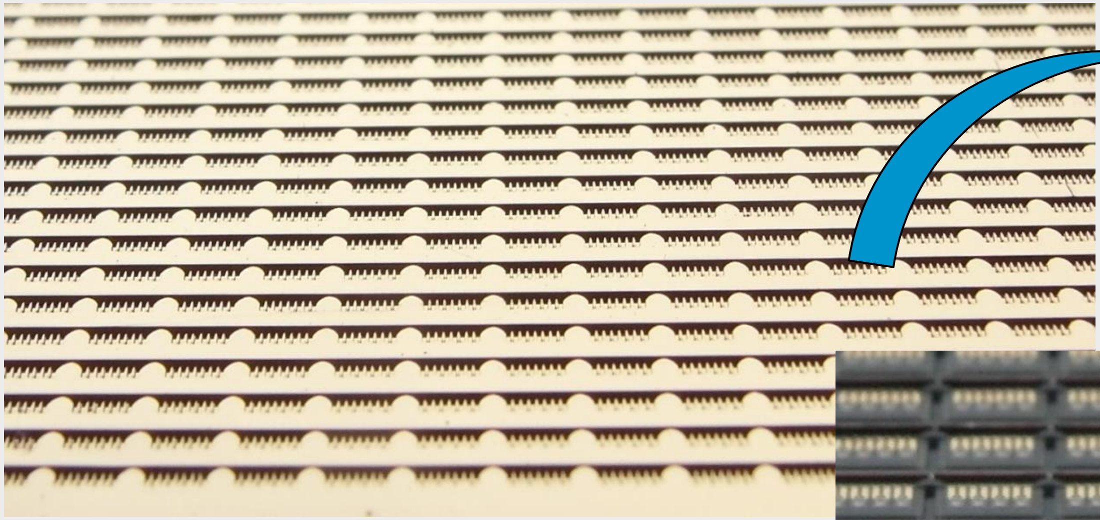
Electrohydrodynamic (EHD) pump



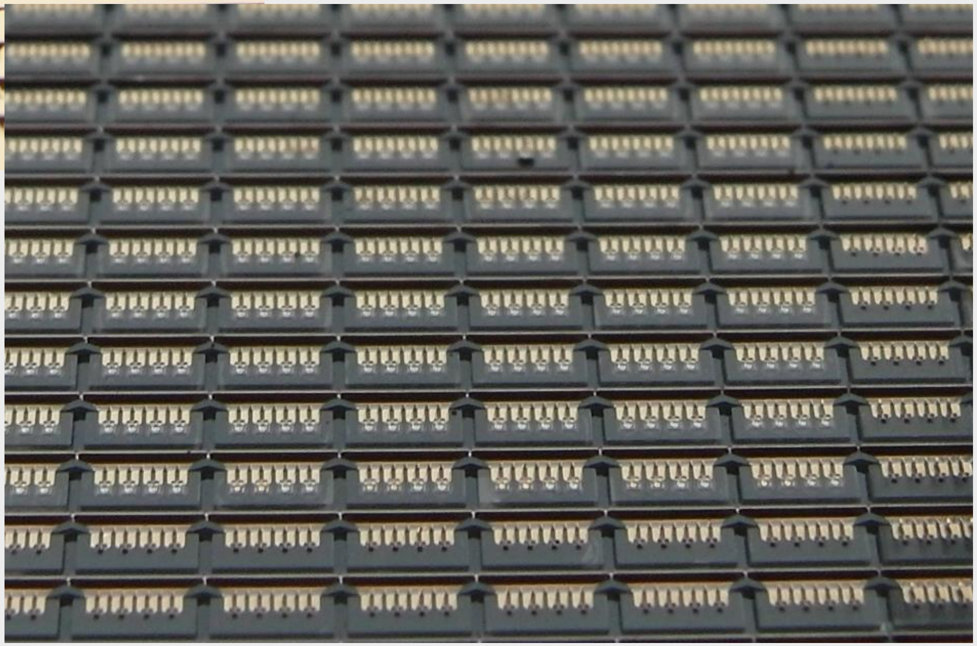
Pitch 50 µm

3D-CSP Batch process to build MEMS

metallization layer via PVD



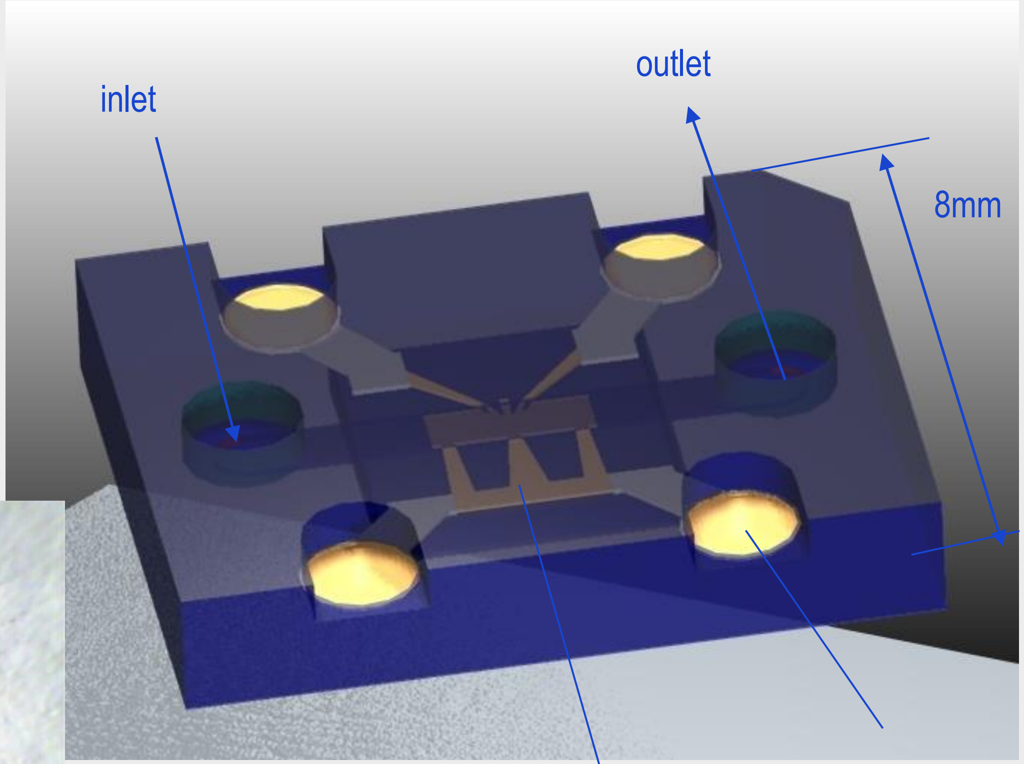
remove lift off mask

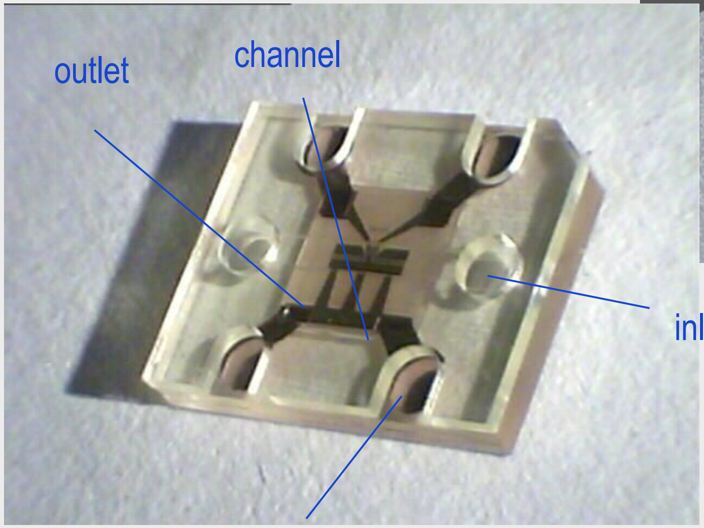


Packaging of Surface Acoustic Wave sensor (SAW): Fluidic structure and RF Electronics in one device

$$\Delta f \sim (k_1 \Delta \eta_s - k_2 \Delta m) \cdot f_0^2$$

$$f_0 > 100\ \mathrm{MHz}$$



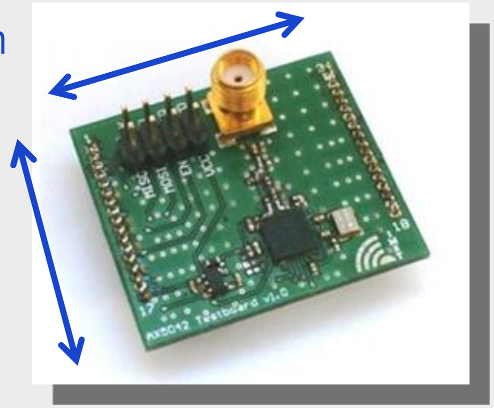


Cost efficient disposable MEMS via batch packaging processing

Wireless communication module

50 mm

50 mm

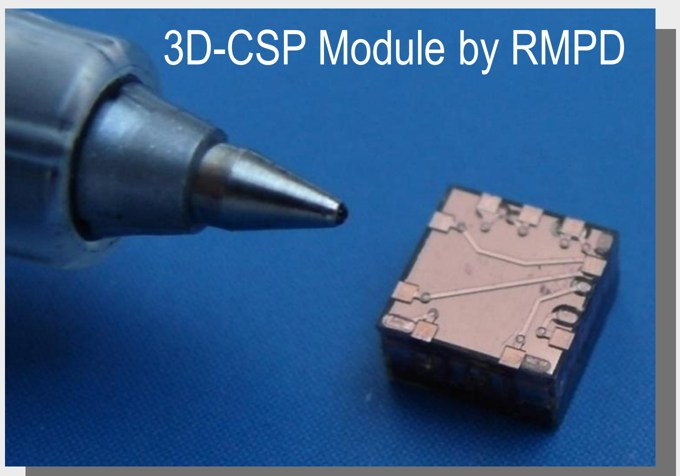


3D-CSP Module by RMPD:

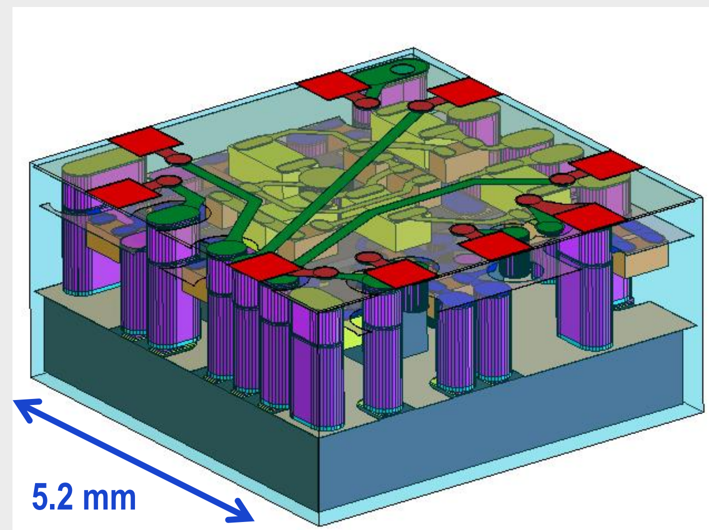
- Advanced multi-channel single chip UHF transceiver
- 200-mA RF Low-Dropout Regulator

Conventional Transceiver

- 433 MHz narrow band radio module
- AX 5042: Advanced multi-channel single chip UHF transceiver
- About 30 parts



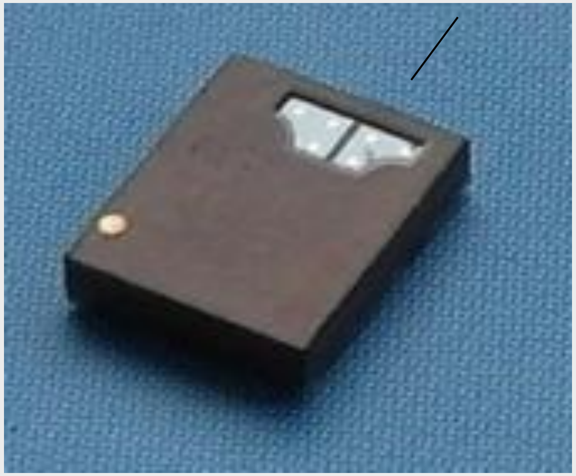
3D CAD model



Customer: IMST

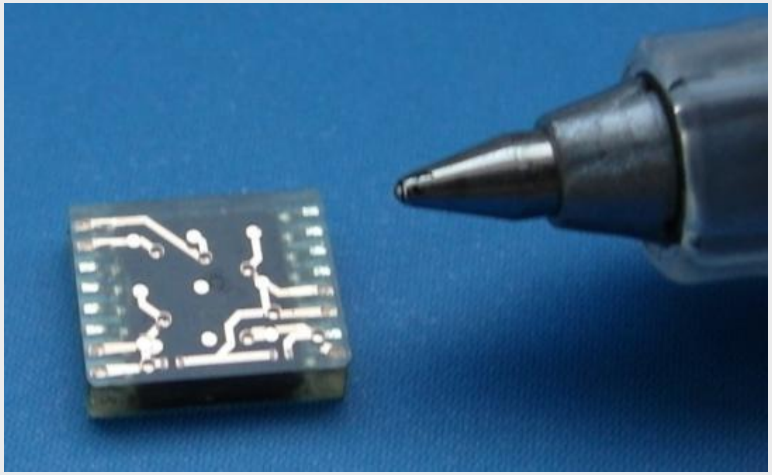
Low-Power sensor module for pressure, temperature

Interface to medium



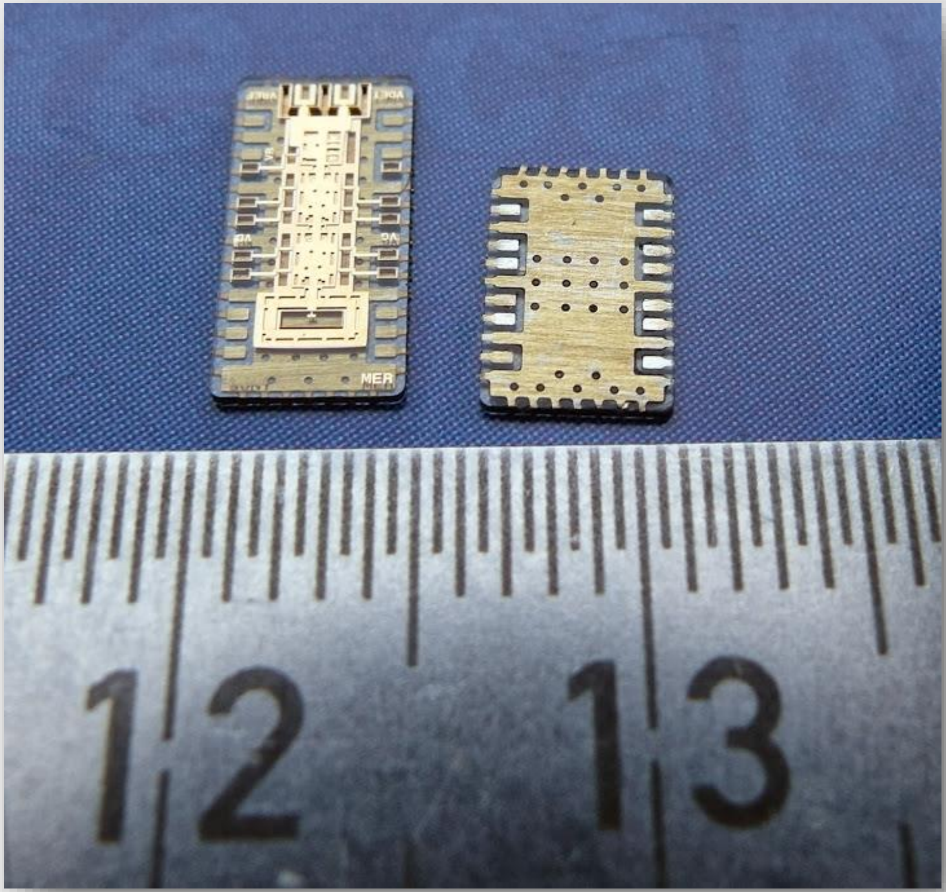
3D-CSP Module

- Temperature sensor Pt 30.000
- measurement precision ± 0,1 ° C
- measuring current < 10 µA
- high resolution
- 5 x 2,5 mm^2



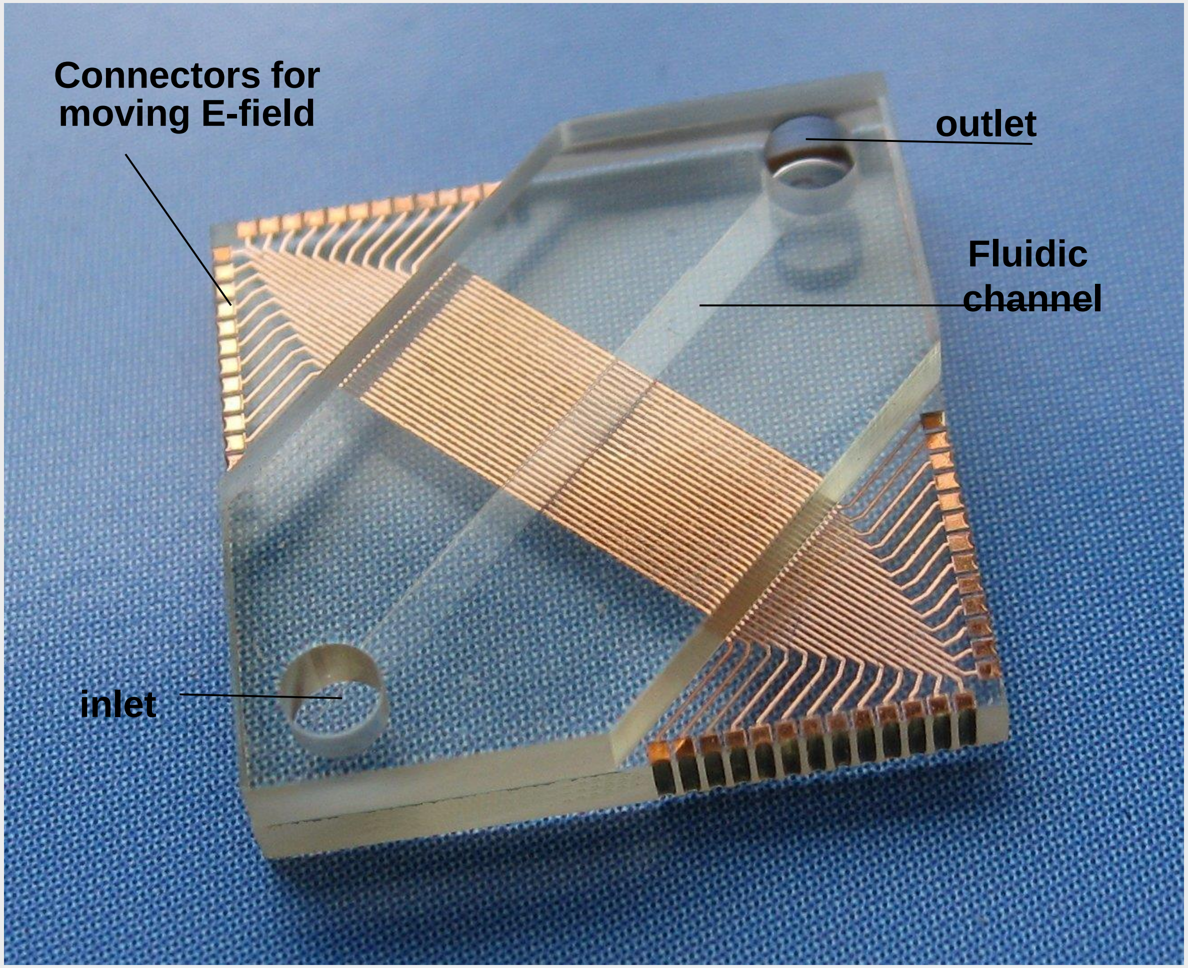
RF modules from 100 to 500 GHz

distance radar and motion sensor



Customer: Sony

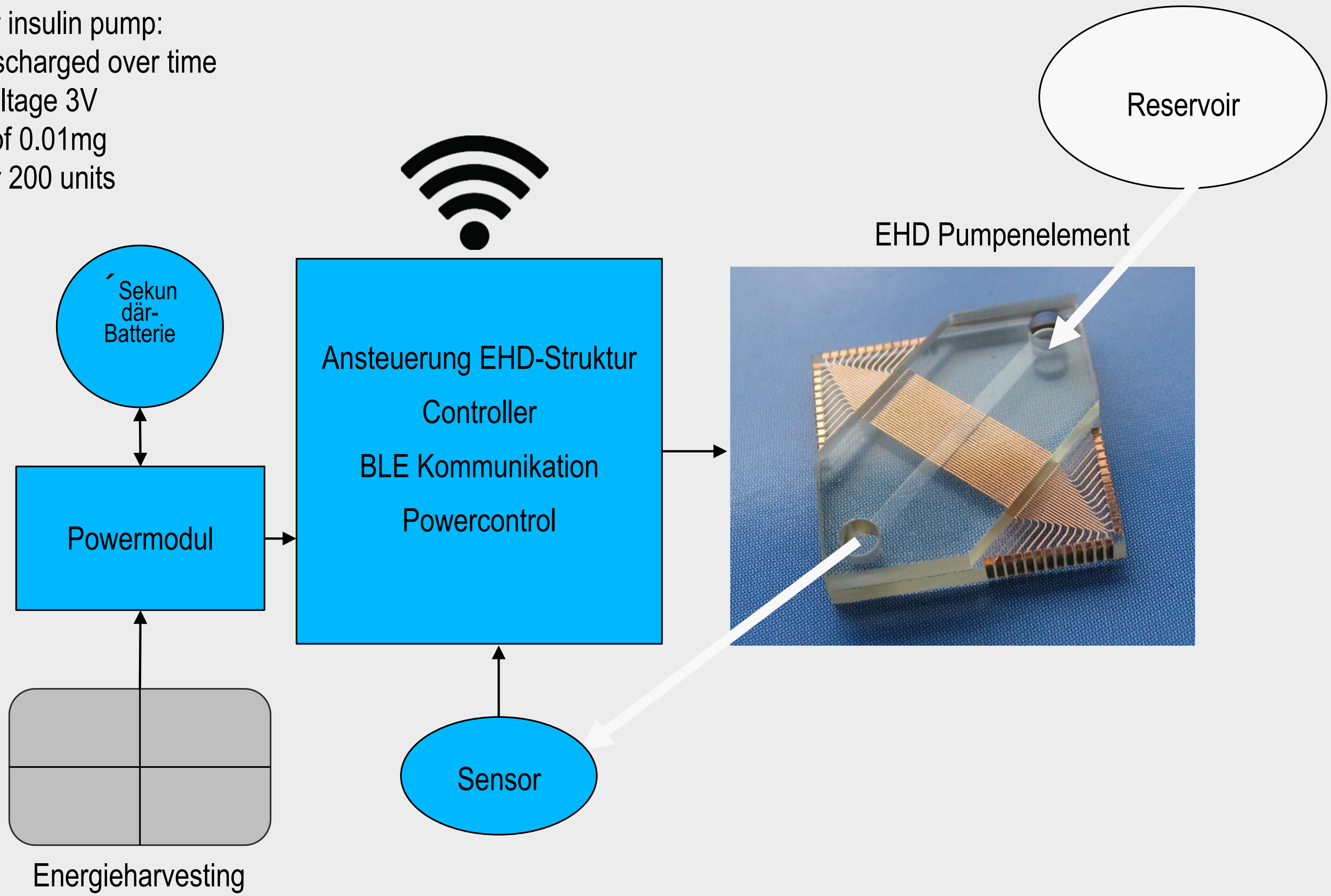
EHD pump, without moving parts, driven by electrical fields



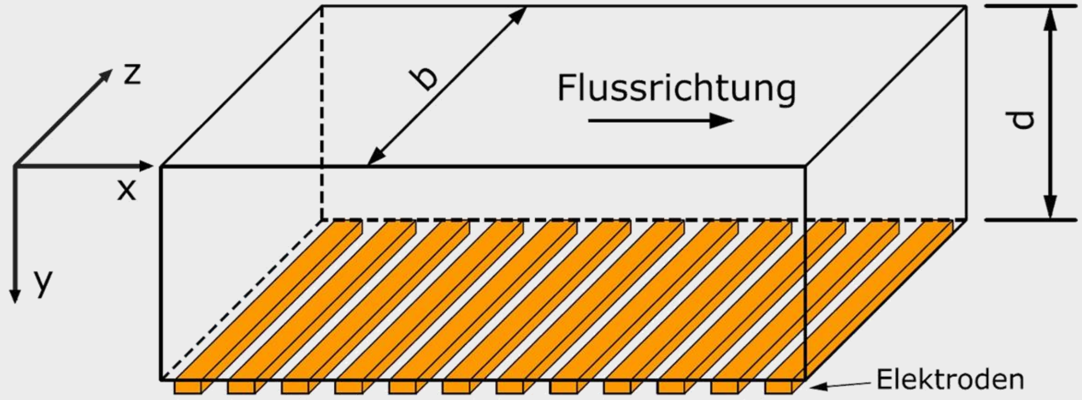
Kontroll- und Dosiersystem

Requirements for insulin pump:

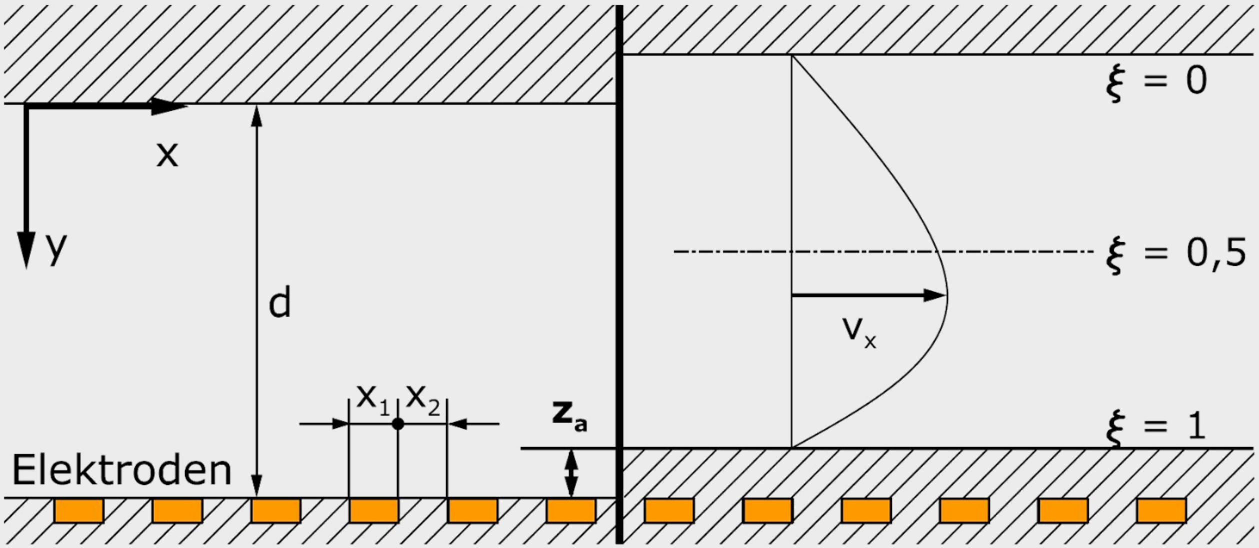
- Volume is discharged over time
- Operating voltage 3V
- Pump units of 0.01mg
- Reservoir for 200 units



Kanalgeometrie und Elektroden



Strömungsverteilung im Kanal und Formel zur Strömungsgeschwindigkeit



$$v_x = -\frac{\gamma\,\epsilon\,k\,U^2}{12\,\eta} \cdot \frac{S}{(1+S^2)} \cdot \left(\xi - \xi^3\right)$$

Beispielberechnung

Definitionen:

Dielektrizitätskonstante für Wasser (bei $20°C$):	$\epsilon_{rW} = 80,1$
Dielektrizitätskonstante im Vakuum:	$\epsilon_0 = 8,8542 \cdot 10^{-12} \frac{As}{Vm}$
Dynamische Viskosität von Wasser (bei $20°C$):	$\eta = 1,003 \cdot 10^{-3}\, Pa\, s$
Elektrodenbreite:	$x_1 = 0,05\, mm$
Elektrodenabstand:	$x_2 = 0,05\, mm$
Kanalbreite:	$b = 1\, mm$
Kanalhöhe:	$d = 0,1\, mm$
Angelegte Spannung:	$U = 40\, V$
Mittlere Leitfähigkeit:	$\bar{\sigma} = 0,0004\, S/m$
Leitfähigkeitsgradient:	$\sigma_T - \sigma_B = 0,02 \cdot \bar{\sigma}$
Frequenz:	$f = 400\, kHz$

Berechnung Fördermenge

Berechnung der Relaxationszeit:

$$\tau_R = \frac{\epsilon_{rW} \cdot \epsilon_0}{\bar{\sigma}} = 1,773 \cdot 10^{-6} s.$$

Berechnung der Wellenzahl:

$$k = \frac{\pi}{2(x_1 + x_2)} = 15708 \frac{1}{m}.$$

Berechnung der Kreisfrequenz der Welle:

$$\omega = 2\pi \cdot f = 2,51 \cdot 10^6 \frac{1}{s}.$$

$$\begin{aligned} \bar{v_x} \quad = \quad & \frac{15708 \cdot 8,8542 \cdot 10^{-12} \cdot 80,1 \cdot 40^2 \cdot 0,02 \cdot 0,0004}{12 \cdot 1,003 \cdot 10^{-3} \cdot 0,0004} \cdot \\ & \frac{2,513 \cdot 10^6 \cdot 1,773 \cdot 10^{-6}}{1 + (2,513 \cdot 10^6 \cdot 1,773 \cdot 10^{-6})^2} \cdot 0,25 = 0,001582 \frac{m}{s} = 1,582 \frac{mm}{s} \end{aligned}$$

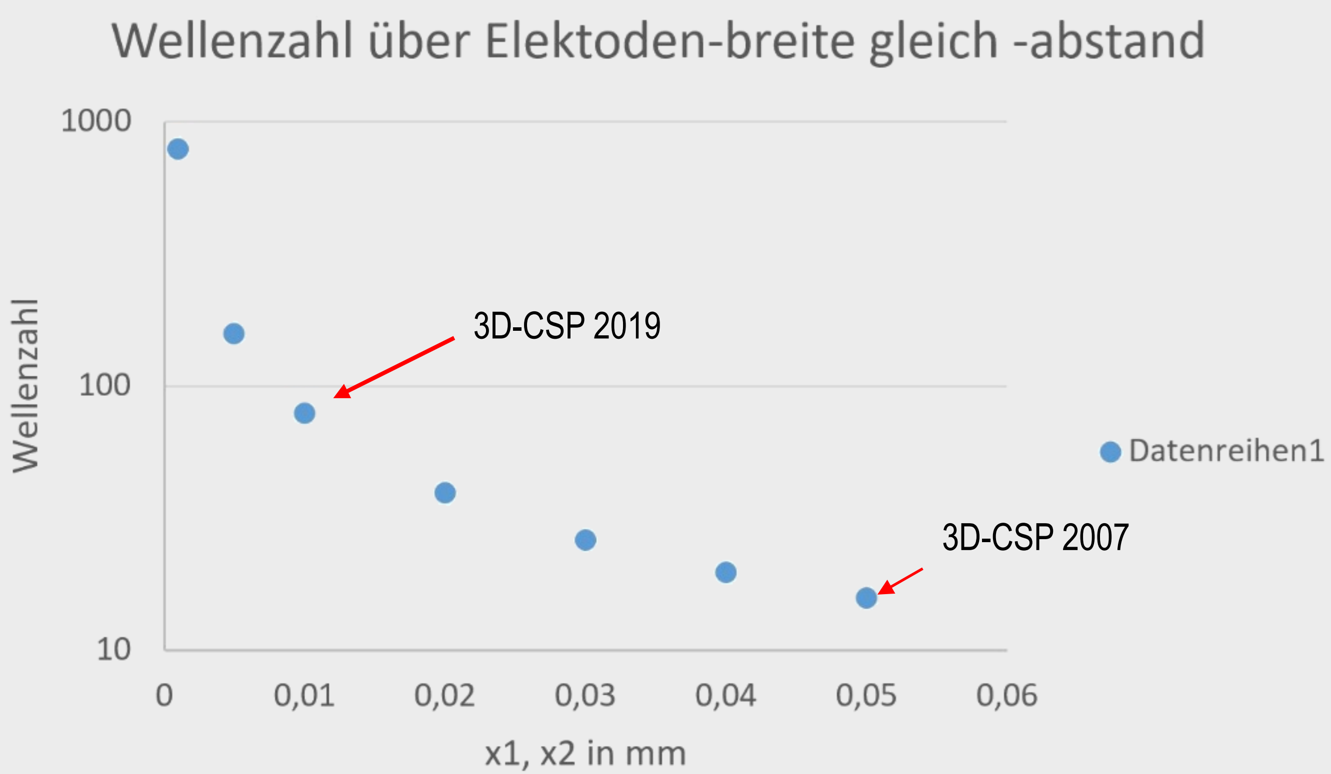
Die Einheitenrechnung:

$$[\bar{v_x}] = \frac{As \cdot V^2 \cdot m^2 \cdot S \cdot m \cdot}{m \cdot Vm \cdot N \cdot s \cdot m \cdot S} \cdot \frac{\frac{1}{s} \cdot s}{1 + (\frac{1}{s} \cdot s)^2} = \frac{m}{s}$$

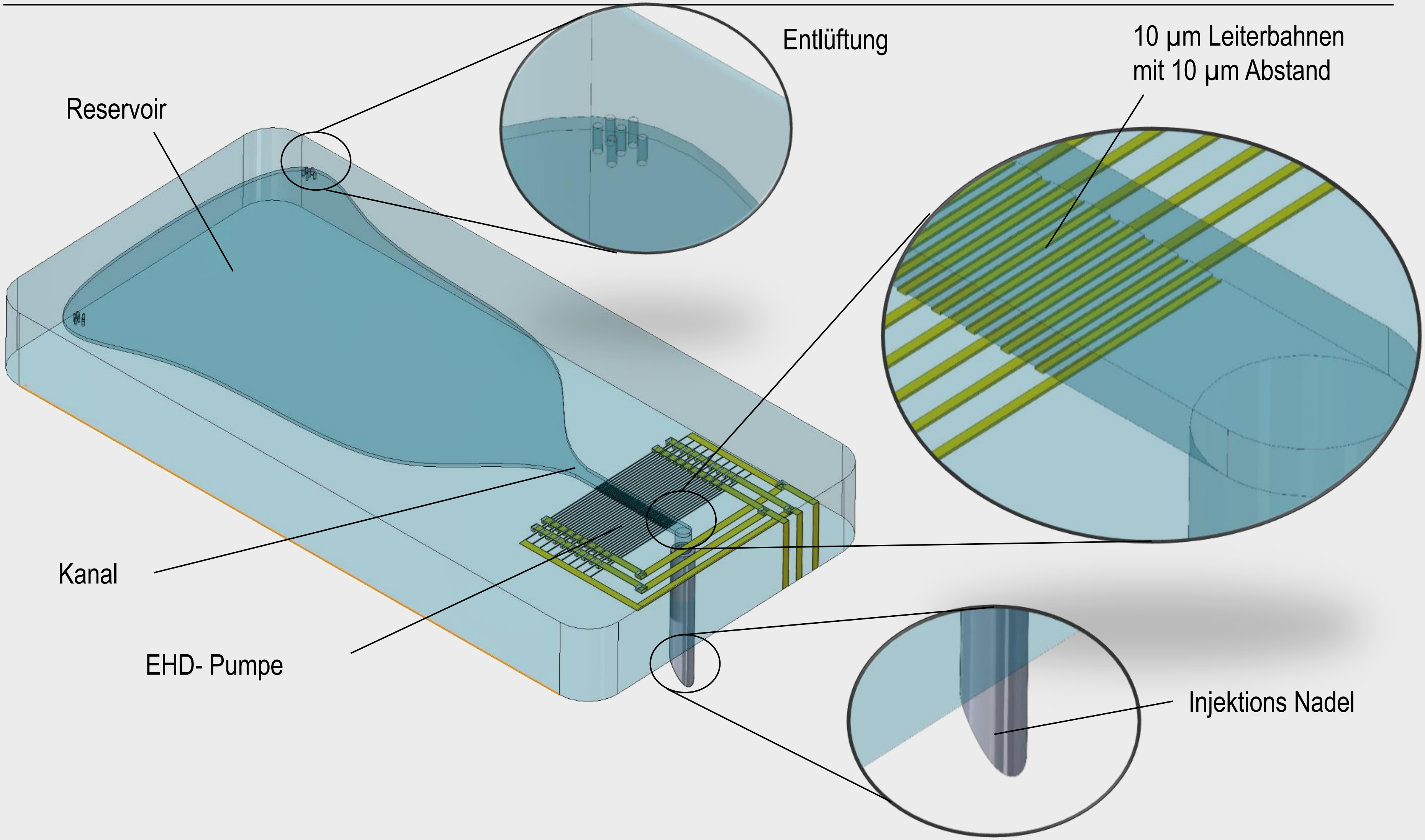
Die Durchflussmenge Q wird berechnet:

$$Q = A_{Pumpe} \cdot \bar{v_x} = 0,1 mm^2 \cdot 1,582 \frac{mm}{s} = 0,1582 \frac{\mu l}{s} = 9,492 \frac{\mu l}{min}$$

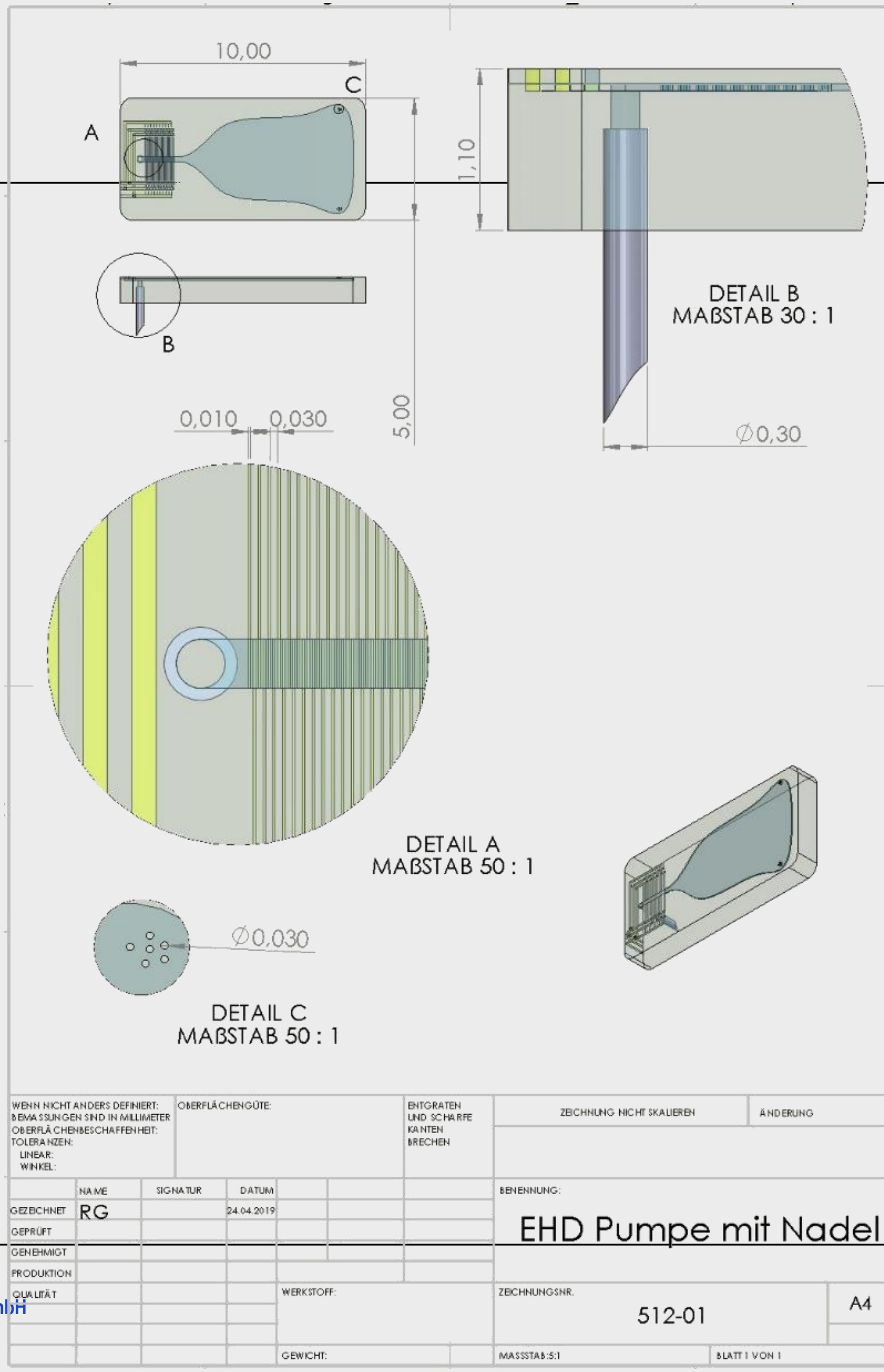
Wellenzahl und Elektodenbreite und Elektrodenabstand



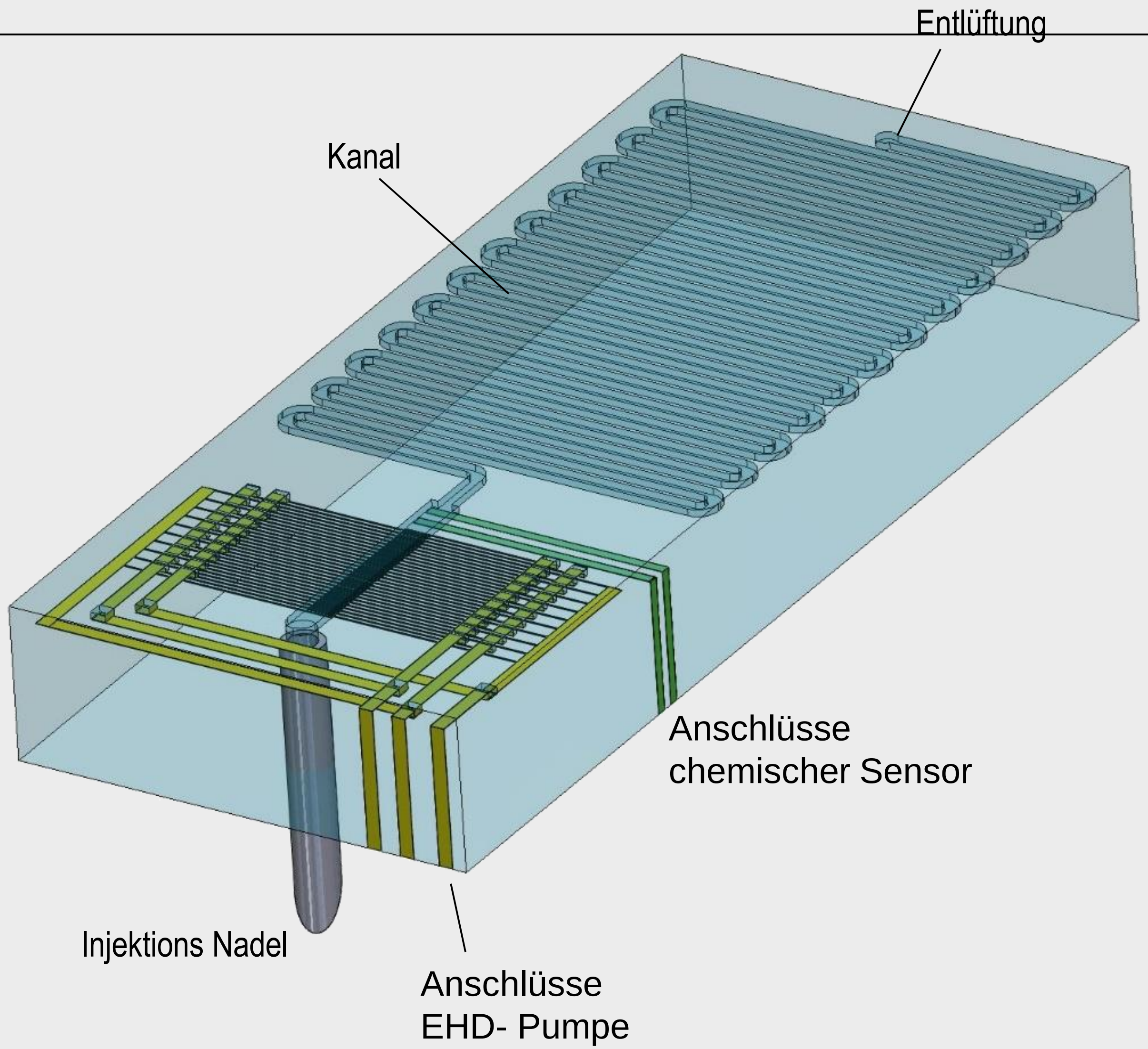
Design EHD Pumpe für feine Dosierung



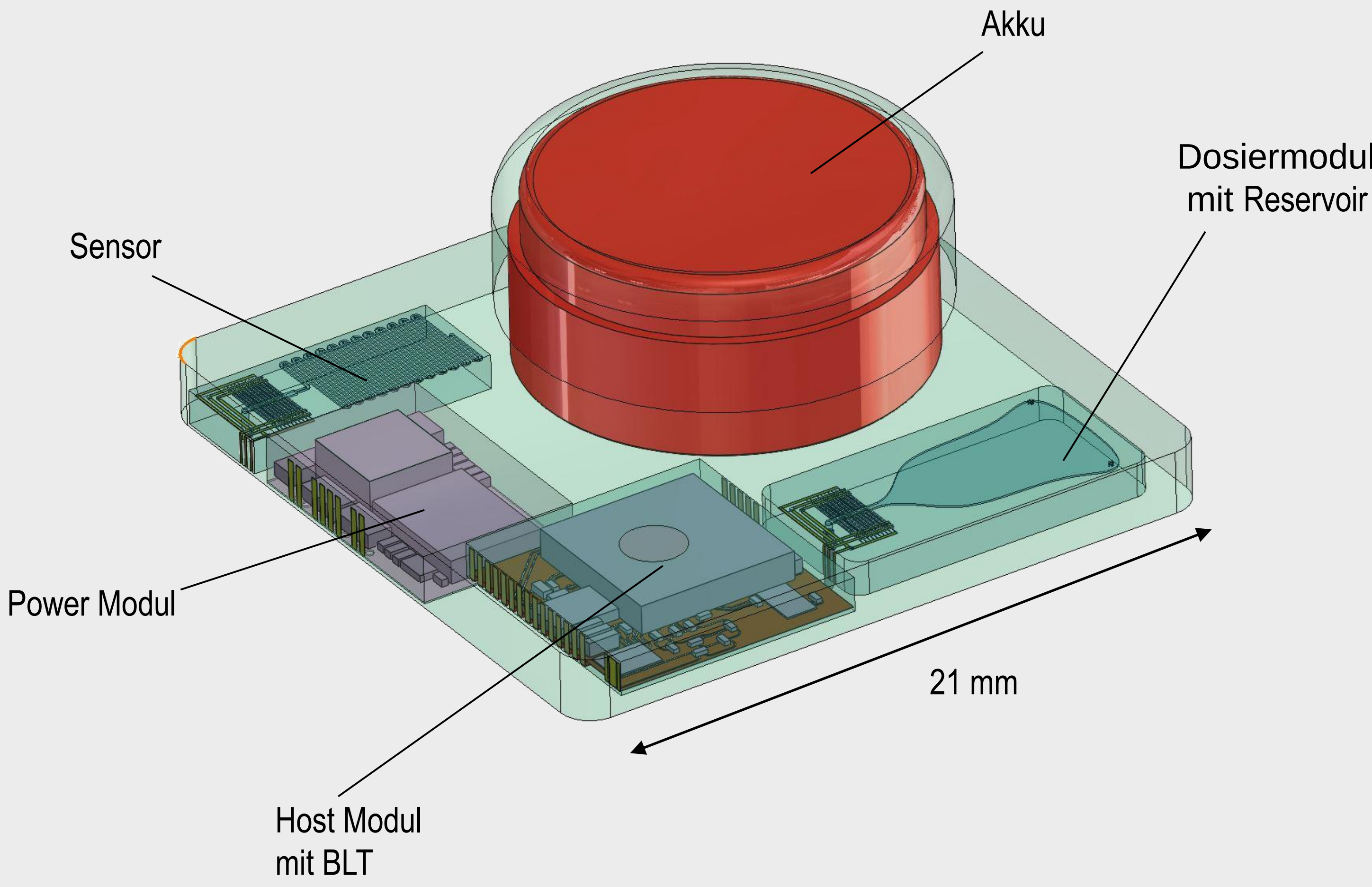
Zeichnung EHD-Pumpe für feine Dosierung



Designstudie EHD Pumpe für chemischen Sensor



Designstudie für Kontroll- und Dosierungssystem



microTEC

Gesellschaft für
Mikrotechnologie mbH

Bismarckstraße 142b
47057 Duisburg
Tel: +49 203 306 2050
Fax: +49 203 306 2069

http://www.microTEC-D.com