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NanoBio, at the interface of nanotechnology and life sciences

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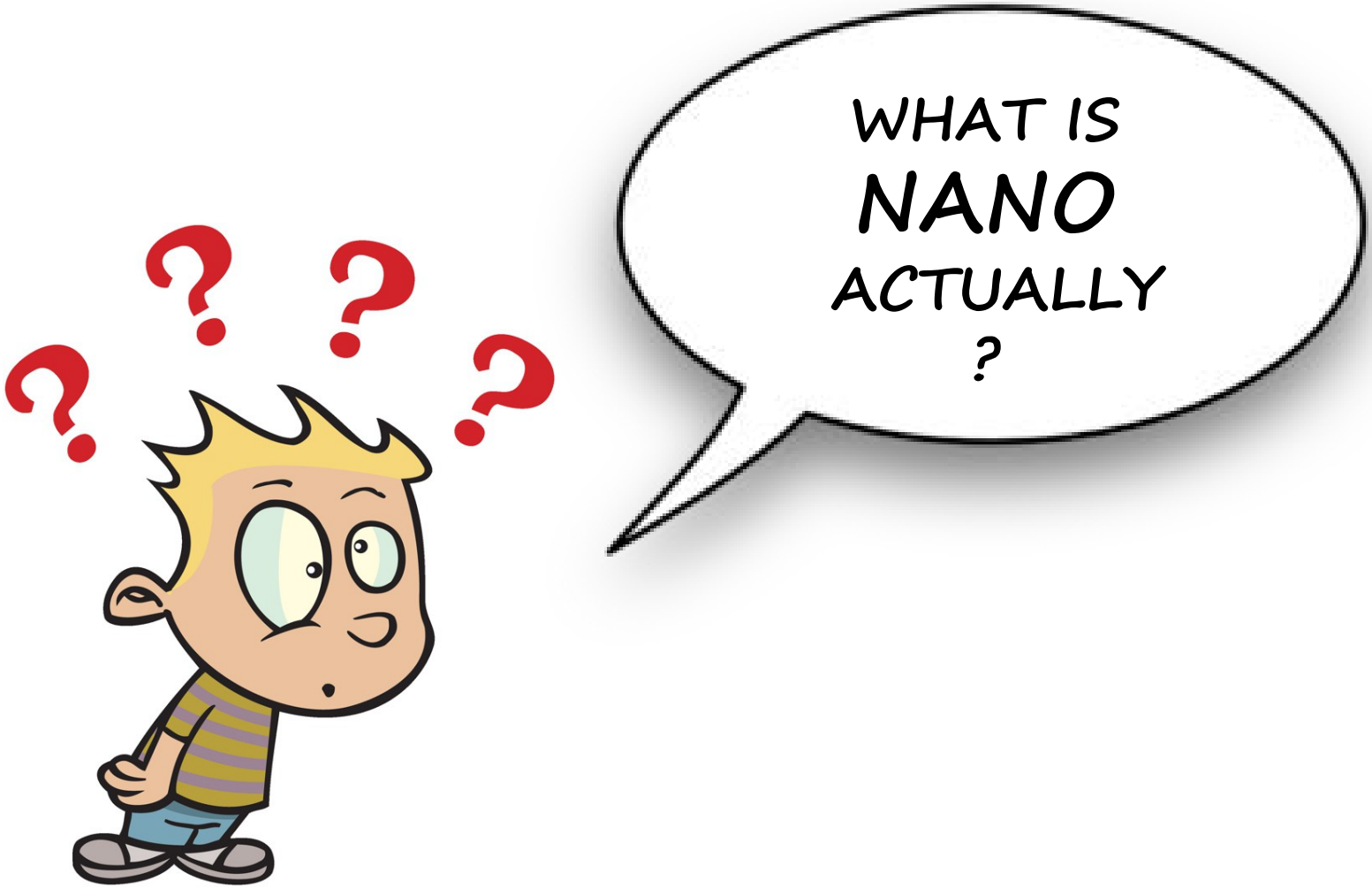

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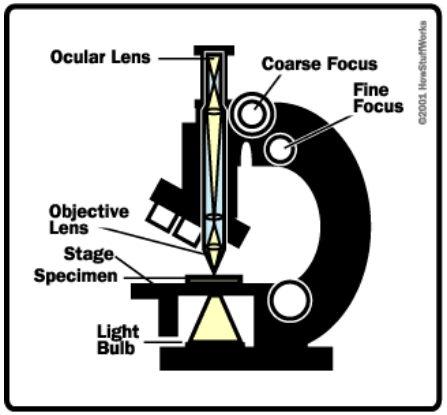

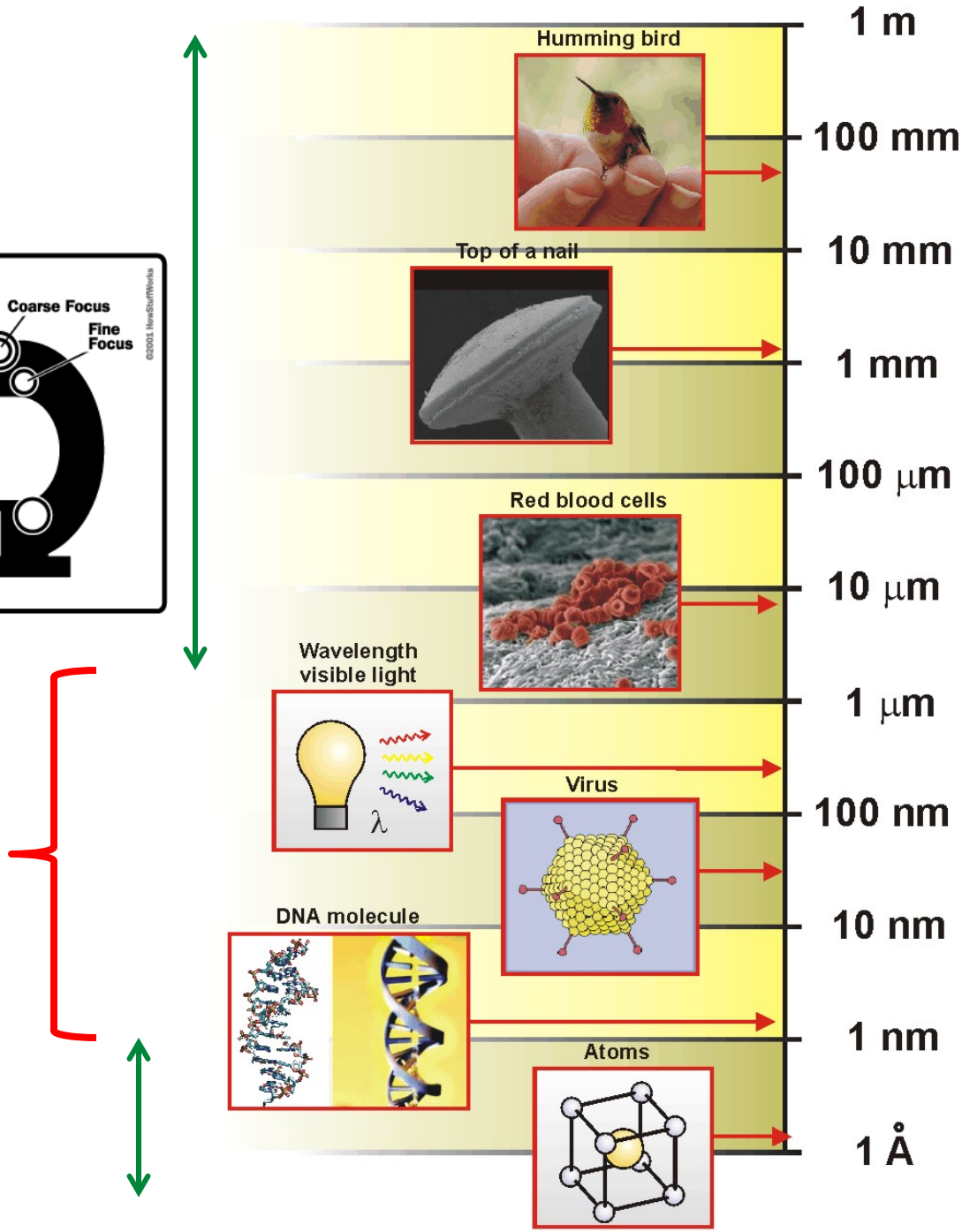

'Hidden' nano-domain

Structure of molecules, crystals (chemistry)

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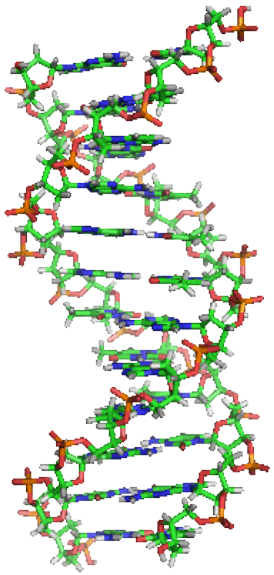
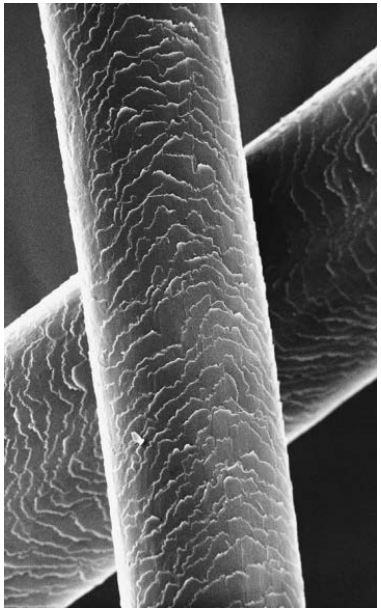


2 nanometer

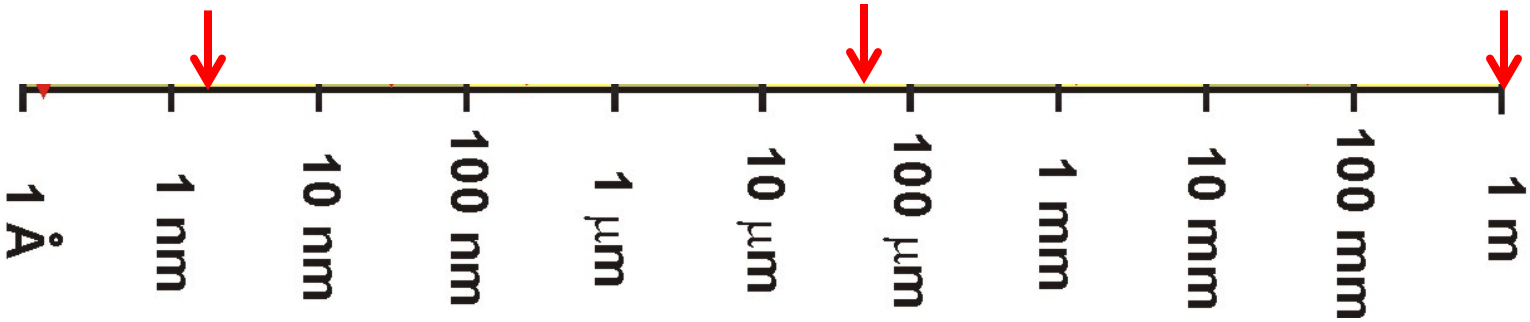
25.000 x



50 micrometer

25.000 x

1 meter



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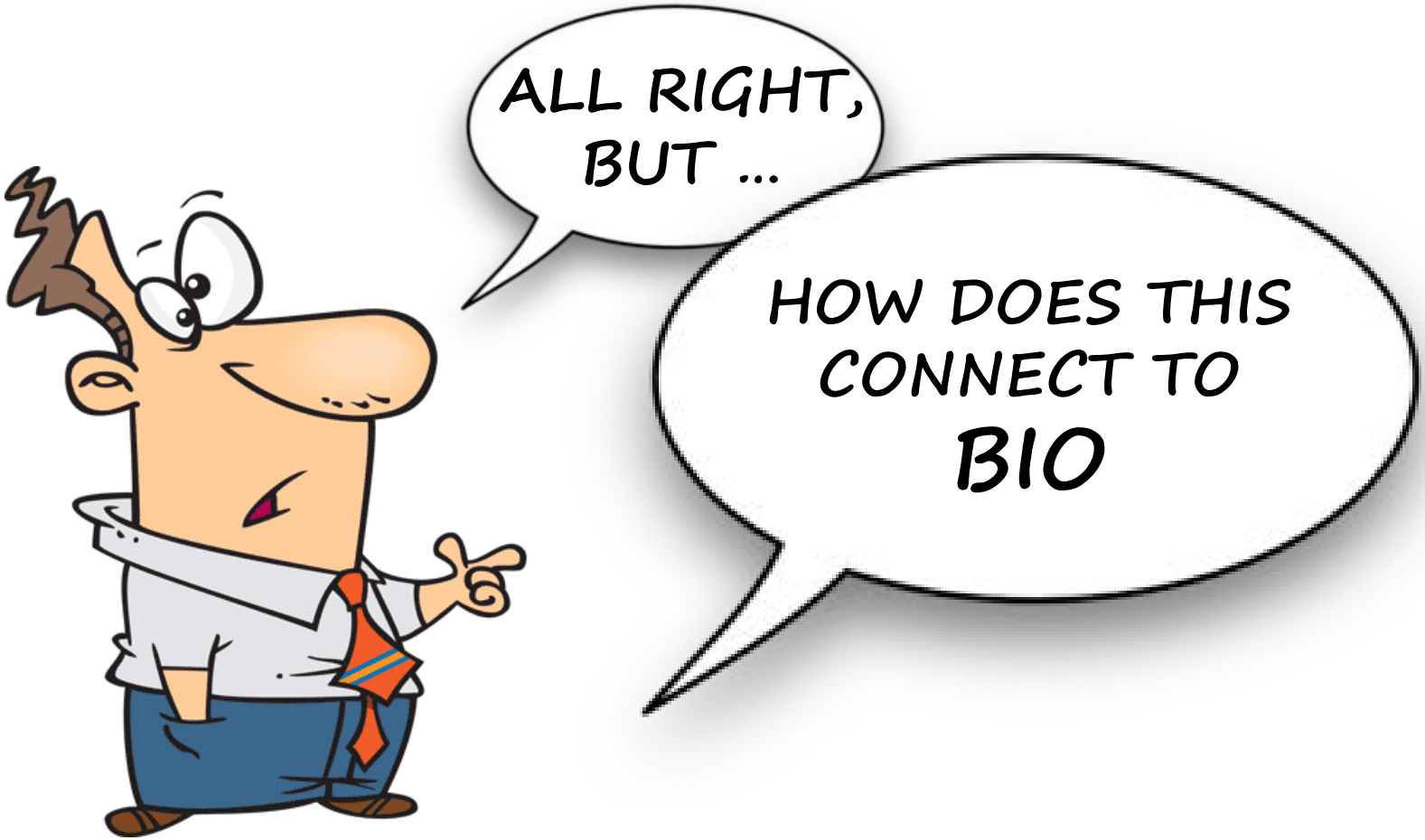
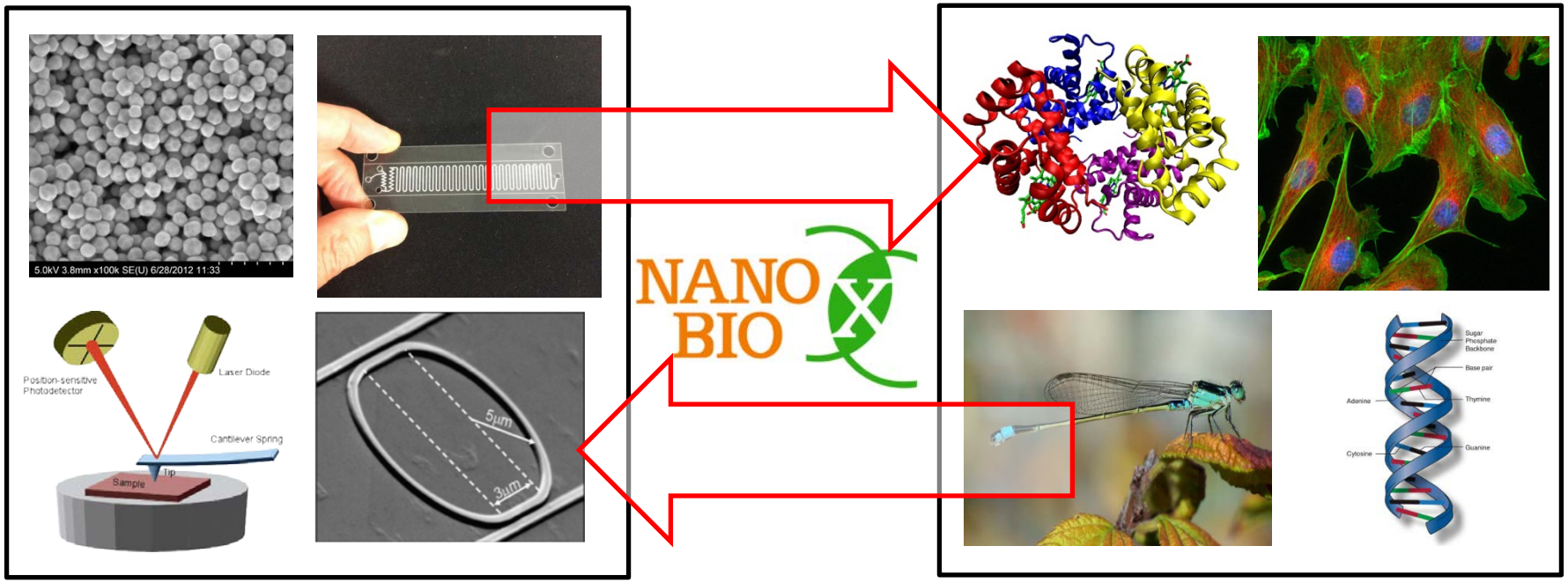


NanoBio

Nanotechnology

The living world (Bio)



Application of technologies to study the living world (on the nano scale)

Exploiting and using principles observed in Nature to create new devices, materials, …

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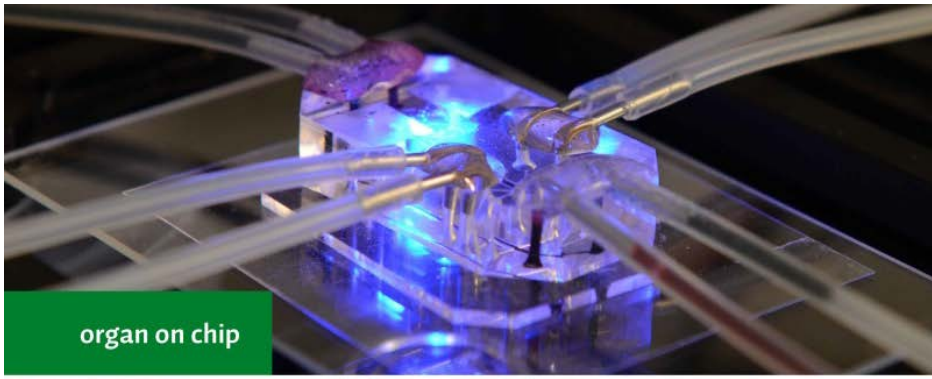
Research group NanoBio

where nanotechnology and life sciences meet

labelfree sensors for biomedical applications



organ on chip

bio-inspired nanostructured functional coatings

characterization of nanomaterials

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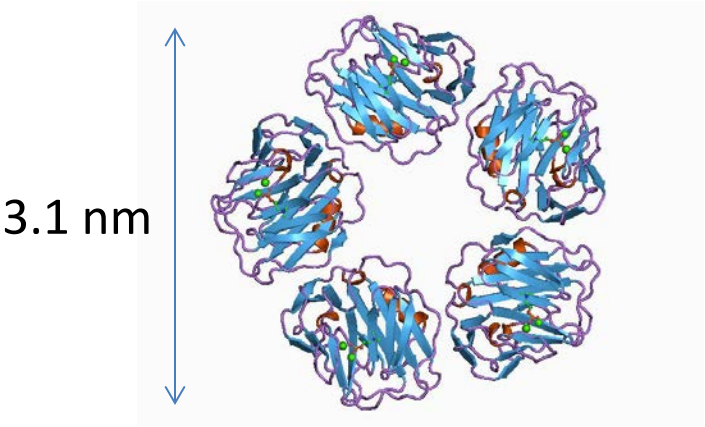
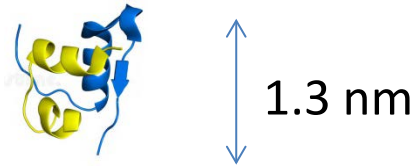
Labelfree sensing of proteins

Developing a point-of-care device that can detect low concentrations of proteins in the human blood, specifically for diabetes patients

Label-free = without adding a label to the protein



CRP



Insulin

Funded by:

biovolt

TECH FOR FUTURE

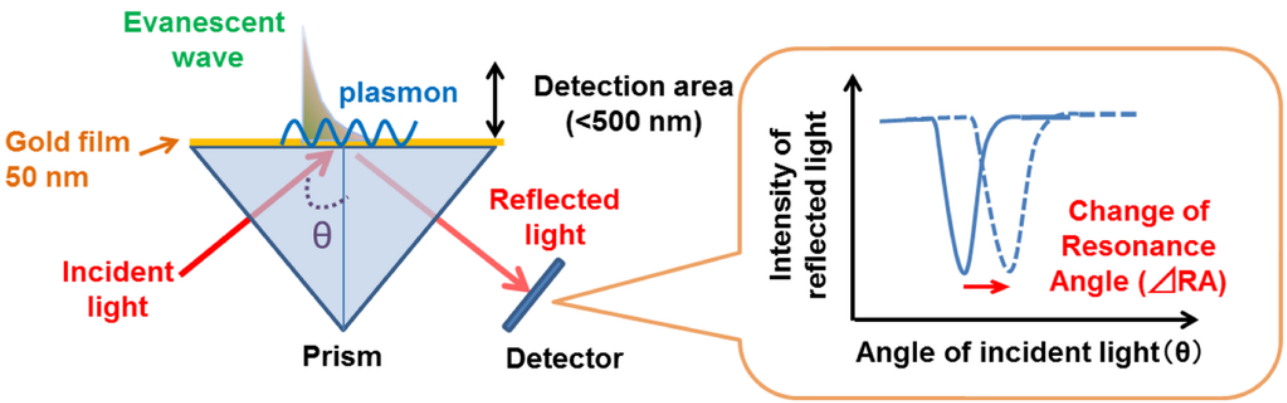
Centre of Expertise HTSM Oost

Een initiatief van Saxion en Windesheim

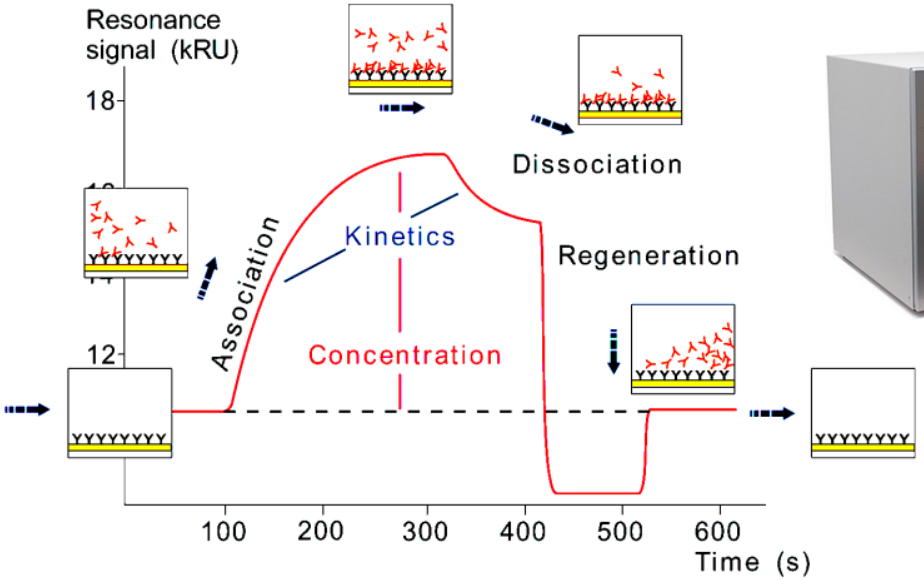
mede mogelijk gemaakt door provincie Overijssel

Testing existing platforms

Cellmic



Vedalab



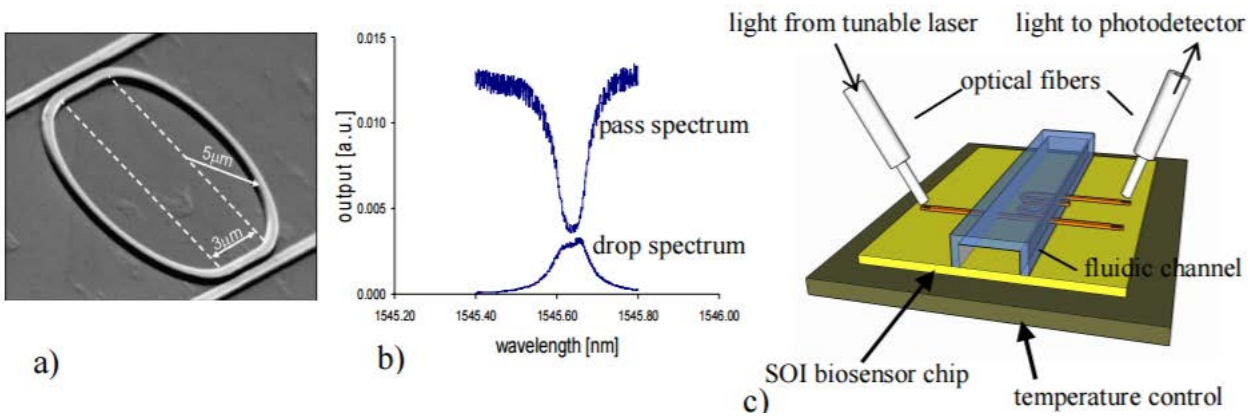
Surface plasmon resonance (SPR)

Integrated optical sensor

Optimizing the protocol to enable detection of low concentrations of proteins:

→ Optimizing the sensor surface

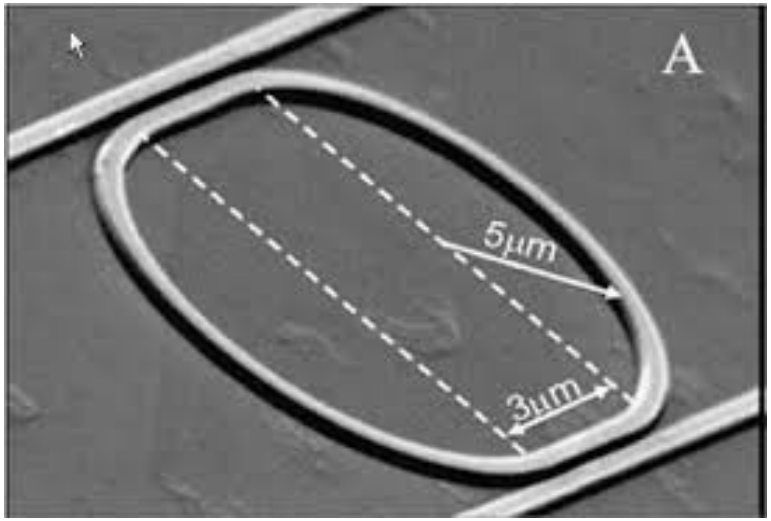
→ Integration of the chip with fluidics



→ Testing in buffer solution, serum and full blood

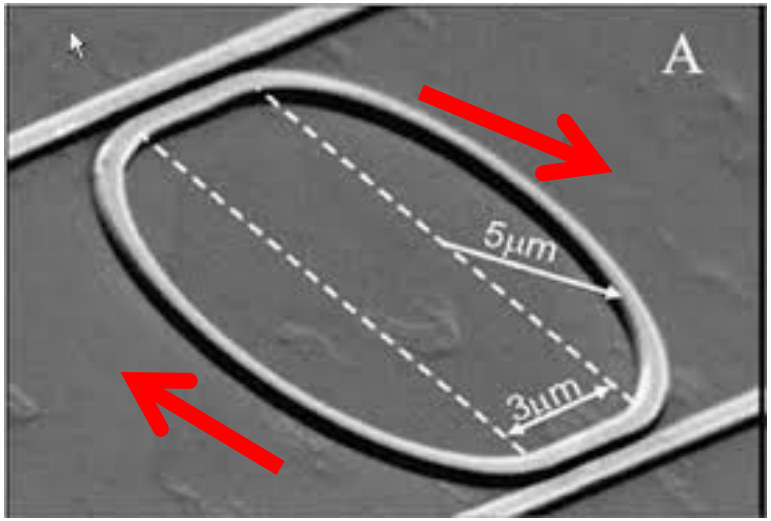
Labelfree sensing

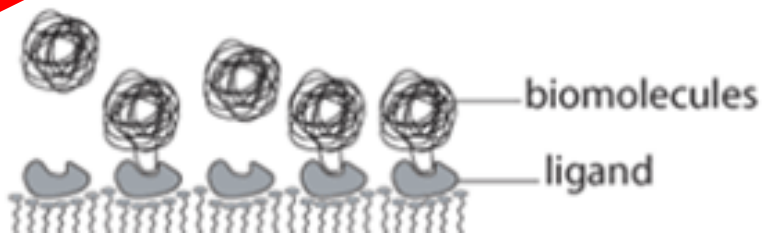
Kan ook toegepast worden op een microring-resonator.



Labelfree sensing

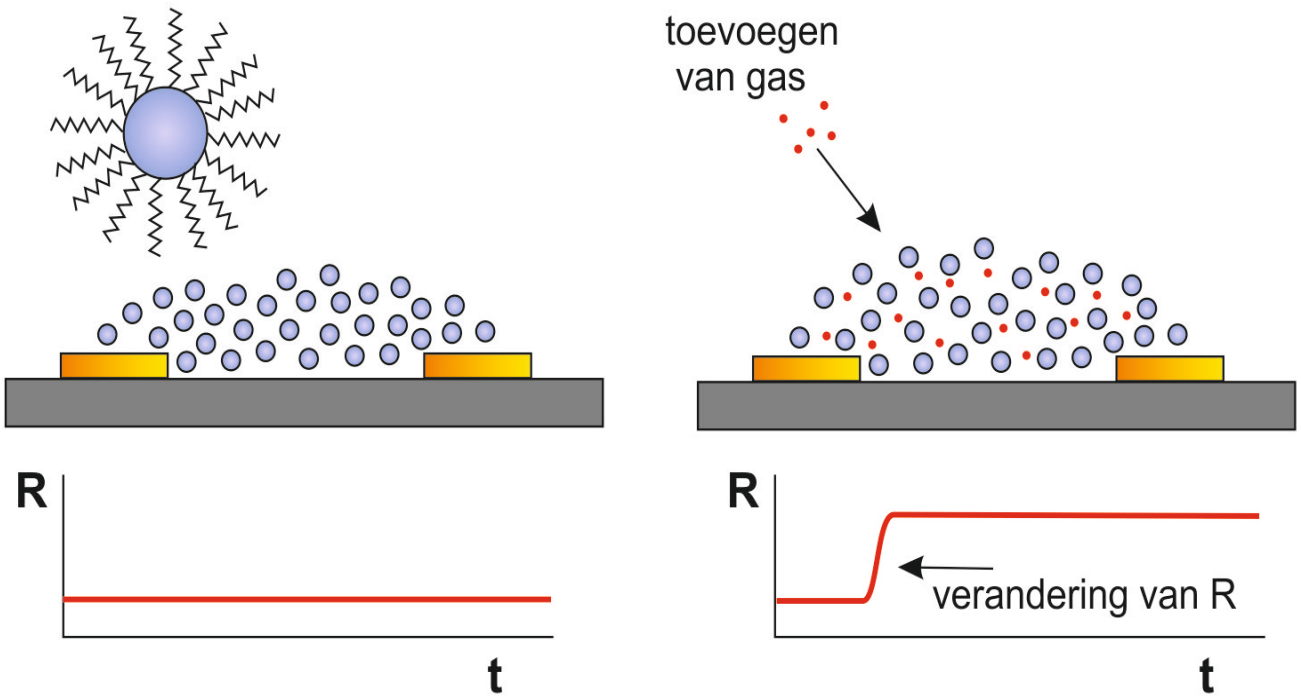
Kan ook toegepast worden op een microring-resonator.





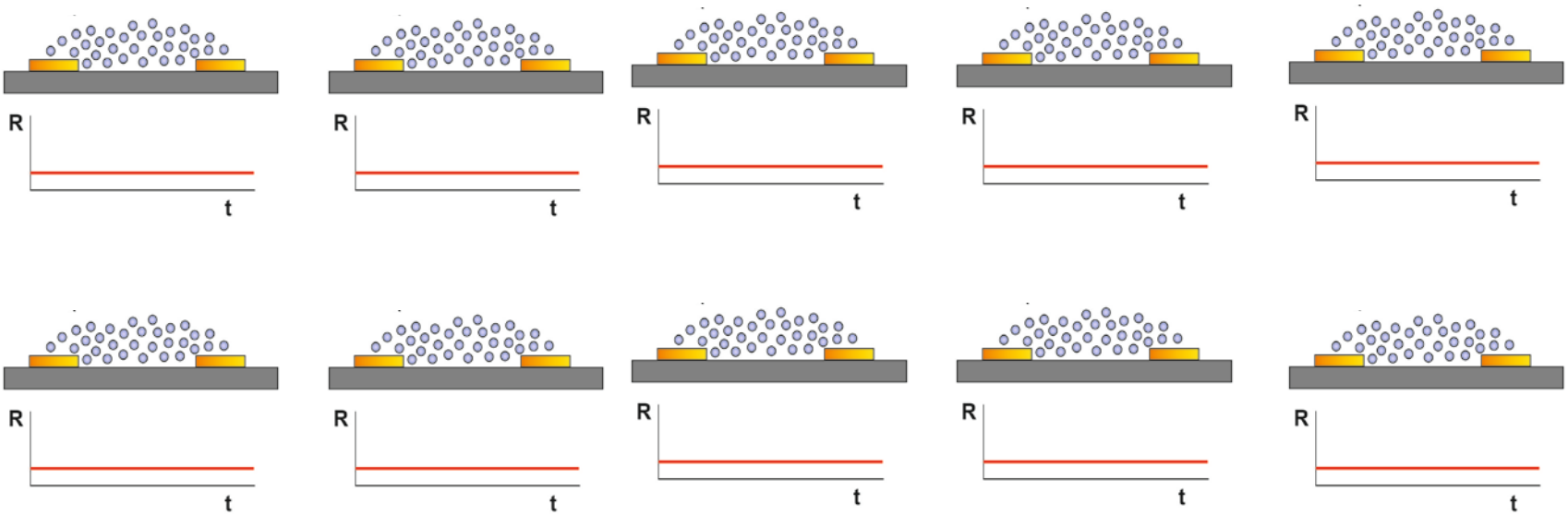
Nanoparticle-based sensors

Volatile organic compounds interact with the nanoparticles (or the molecules on their surface, and this affects the interaction between the nanoparticles, which affects the impedance.



Specificity ?

Specificity is realized by using multiple sensors at the same time, Each sensor reacts differently but reproducibly.



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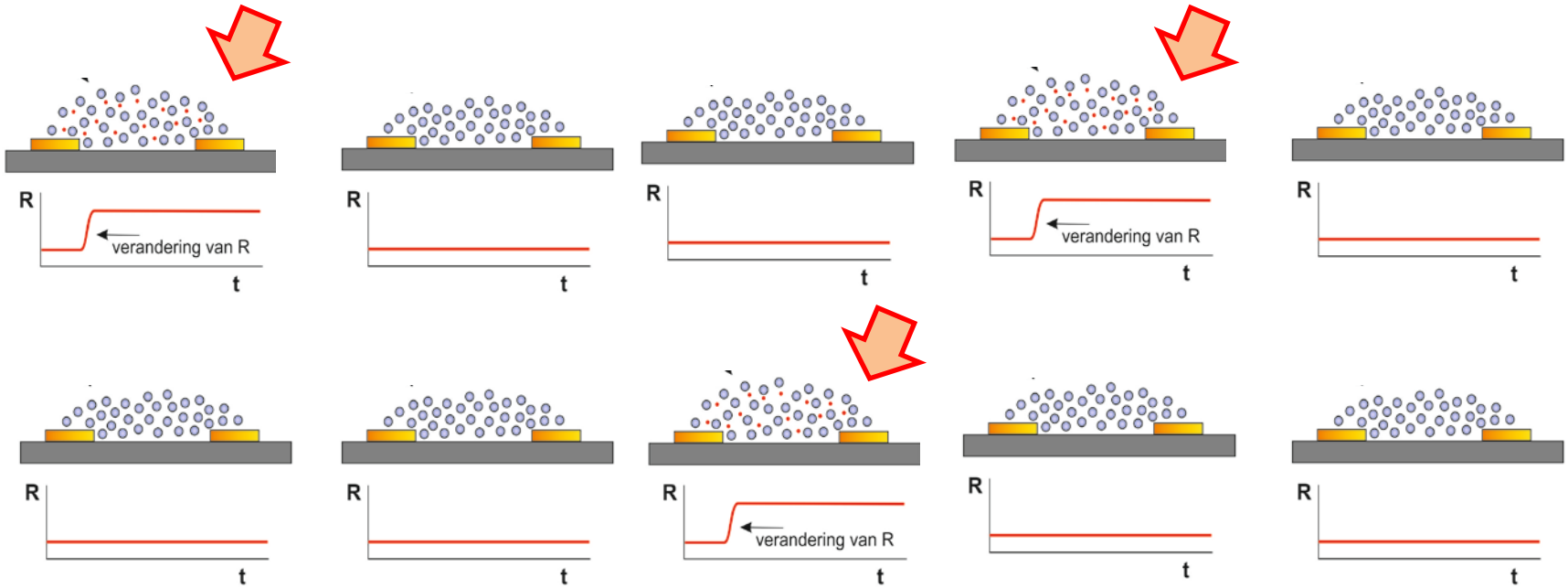

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Nanoparticle-based sensors

Table 1. Summary of the current data on disease detection using breath analysis as a function of the different capping ligand used with the gold nanoparticles.

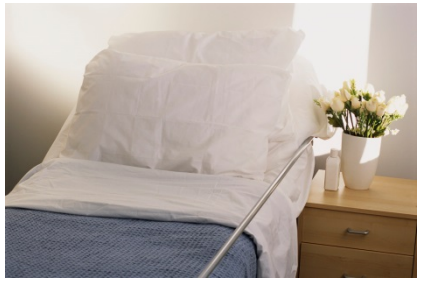
Disease	11-mercapto-1-undecanol	1,6-hexanedithiol	1-butanethiol	1-decanethiol	2-mercaptobenzimidazole	2-amino-4-chlorobenzenethiol	2-ethylhexanethiol	2-mercaptobenzimidazole	2-mercaptobenzoxazole	2-nitro-4-(trifluoromethyl)benzenethiol	2-nitro-4-trifluoro-methylbenzenethiol	3-ethoxythiophenol	3-mercapto-propionate	3-methyl-1-butanethiol	4-chlorobenzene methanethiol	4-methoxy-toluenethiol	Decanethiol	Dibutyl disulfide	Dodecanethiol	Hexanethiol	Octadecanethiol	Octadecylamine	*Tert*-dodecanethiol
Neurology																							
Alzheimer's and Parkinson's disease					x								x										
Idiopathic and atypical Parkinsonism		x		x			x												x				
Nephrology																							
Chronic kidney disease and disease staging							x											x		x			x
Before vs after hemodialysis																			x				x
Acute kidney injury				x											x						x		
Respiratory																							
Pulmonary hypertension				x															x		x		x
tuberculosis																			x				
Cancer																							
Head and neck cancer			x						x					x						x			x
Gastric cancer						x	x	x			x	x					x				x		x
Breast cancer																						x	
Lung cancer	X		x				x		x							x	x		x	x			x
Subtypes of lung cancer							x	x	x	x	x					x			x	x			x
Lung cancer follow-up											x						x						

Antibacterial coatings

Develop and apply a coating with nanomaterials on the textile that reduces the growth of bacteria.

Focus is on:

- Doctor's uniform
- Separation curtains
- Surgery jacket



Bed and cushion sheets

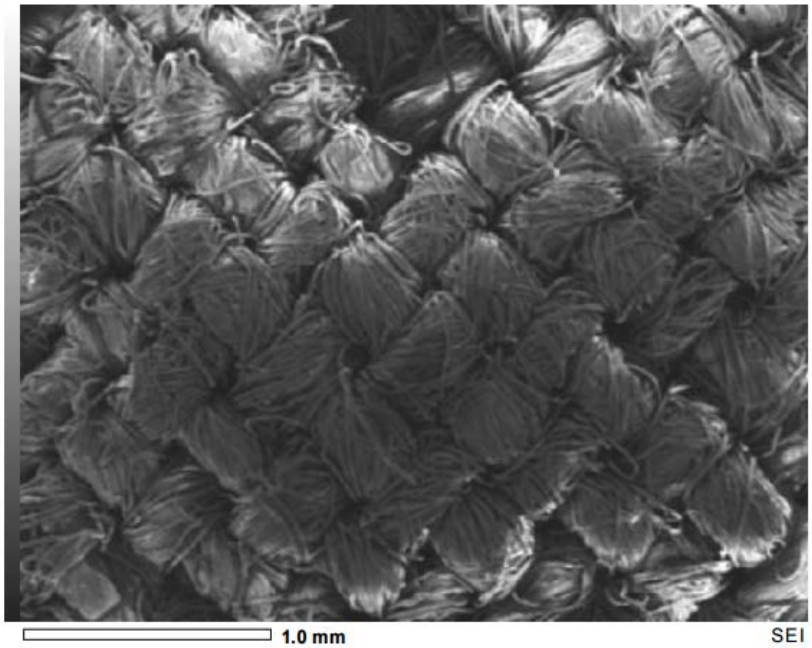
Doctor's uniform

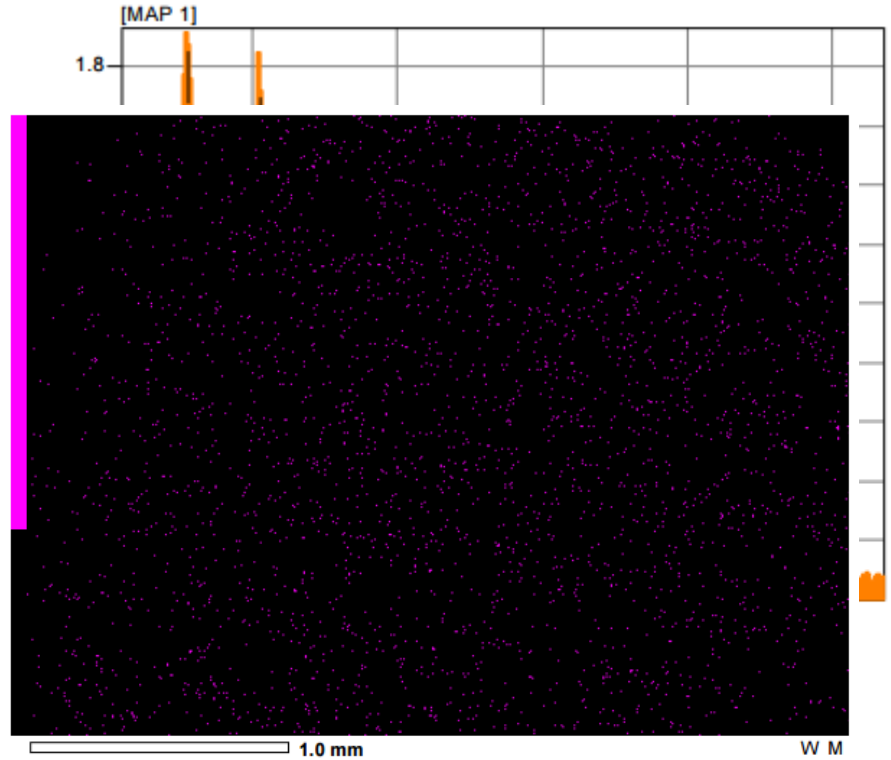
Washing cloth

Separation curtains

Quantifying amount of nano-material on textile (SEM/EDS)

EDS = energy-dispersive X-ray spectroscopy



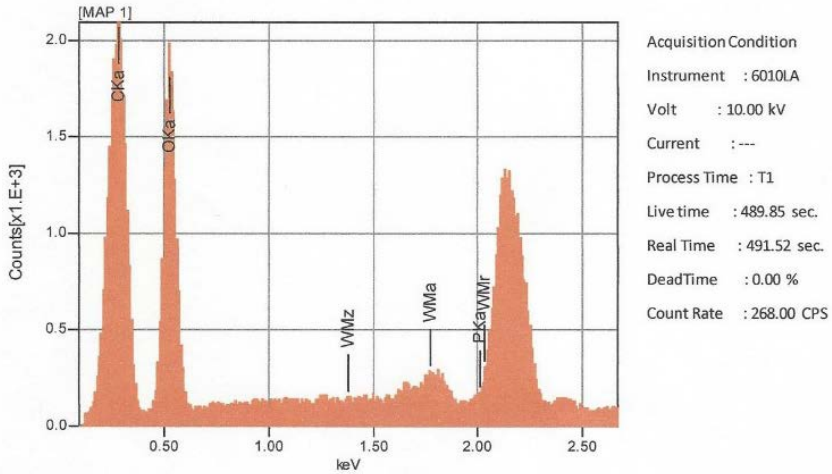


C*	88.02	99.30	0.00	0.16	33589	0.0011674	K
O*							
Si	nd	nd					K
WO3*	11.98	0.70	8.00	1.23	4047	0.0005189	M
Total	100.00	100.00	8.00				

Cotton treated with 2% Silicotungstic acid (padding with Foulard)

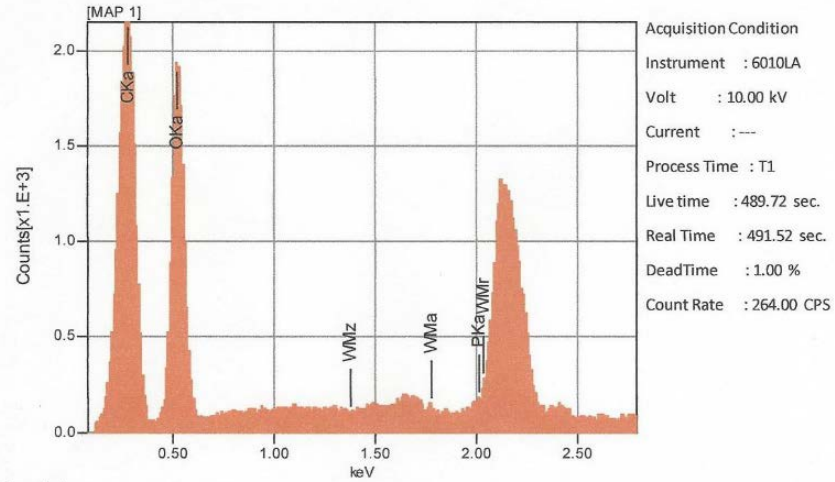
Abrasion by washing

Textiles in healthcare are washed very often and therefore the abrasion by washing is investigated (95° C)



Chemical

formula	mass%	mol%	Cation	Sigma	Net	K ratio	Line
C*	85.03	99.10	0.00	0.16	34946	0.0012144	K
O*							
P	nd	nd					K
WO3*	14.97	0.90	8.00	1.17	5705	0.0007315	M
Total	100.00	100.00	8.00				

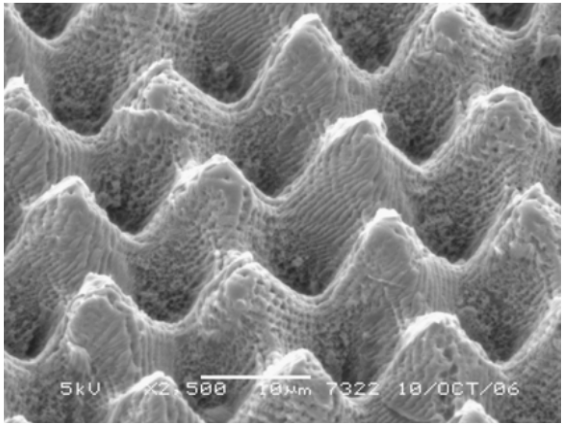


Chemical

formula	mass%	mol%	Cation	Sigma	Net	K ratio	Line
C*	100.00	100.00	0.00	0.17	39160	0.0013612	K
O*							
P	nd	nd					K
W	nd	nd					M

Most of the nanomaterial appears to be removed from the textile !

Nanostructured surfaces

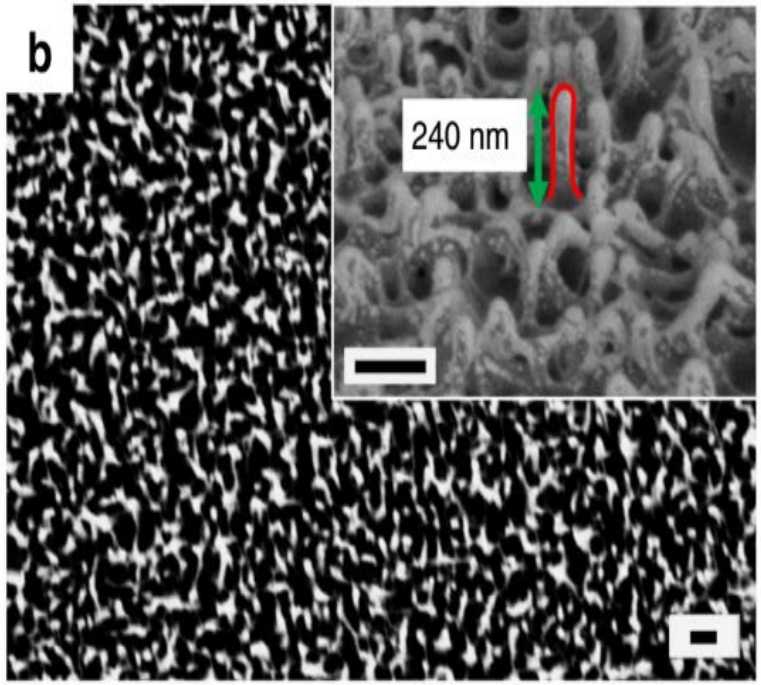


Bio-inspired surfaces → Superhydrophobic surfaces (water-repelling)

Nanostructured surfaces

Bio-inspired surfaces → Antibacterial properties

Dragonfly

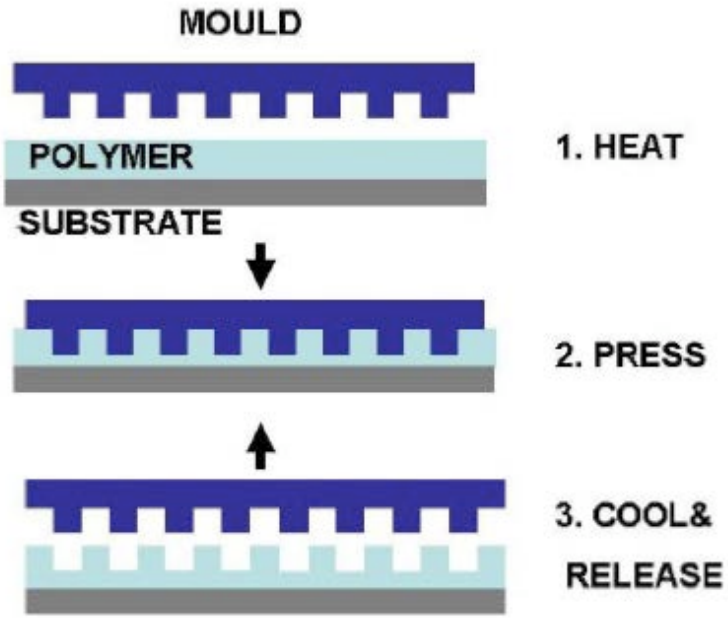


EM image of the forewing
(scale bar = 200 nm)

Ivanova et al., Nature Communications 4: 2838 (2013)

Fabrication nanostructured surfaces on larger scale

Nano-imprint lithography



- What feature size can we transfer in PVC?
- Can we use additives to improve this ?
- Other materials
- Can we make this a continuous roll process?

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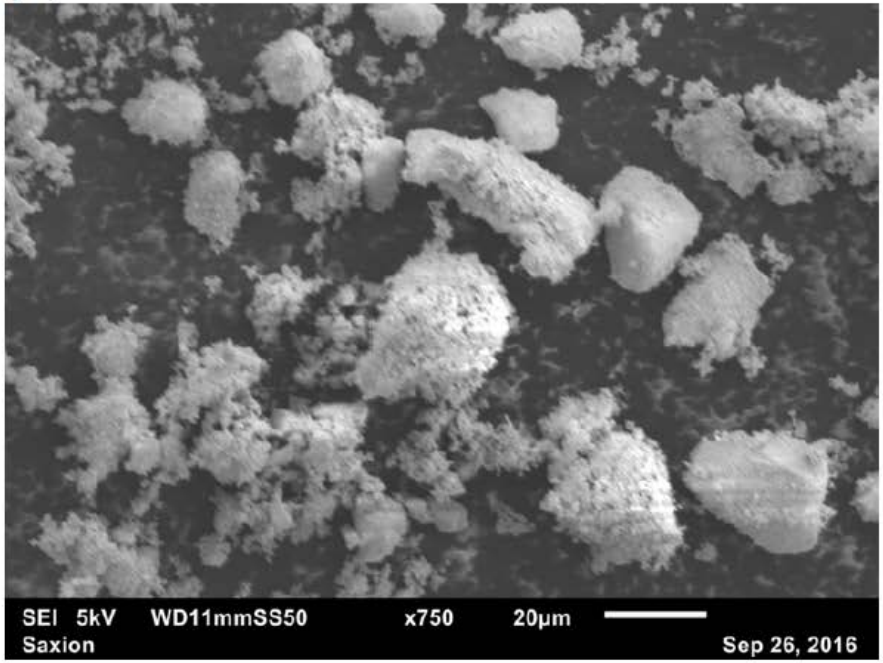
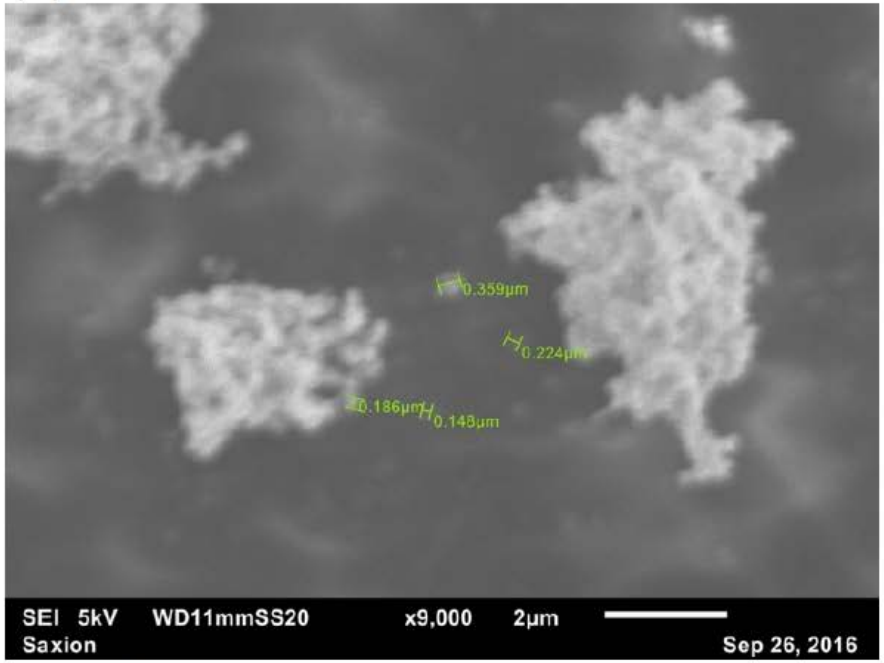
Characterization of nanoparticles

(A)



(B)



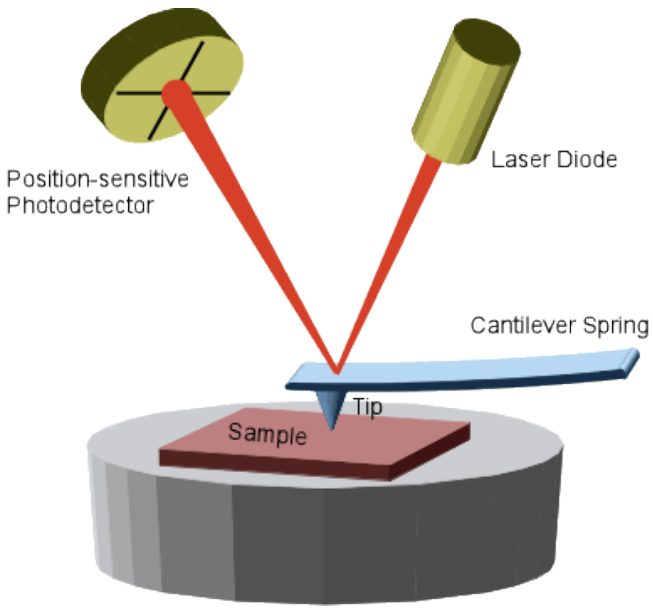
Figuur 3: SEM van onbehandeld barium ferrit. (A) geeft een indicatie over de verdeling van de deeltjesgrootte en (B) laat de afmetingen van de kleinste gedetecteerde deeltjes zien.

peak

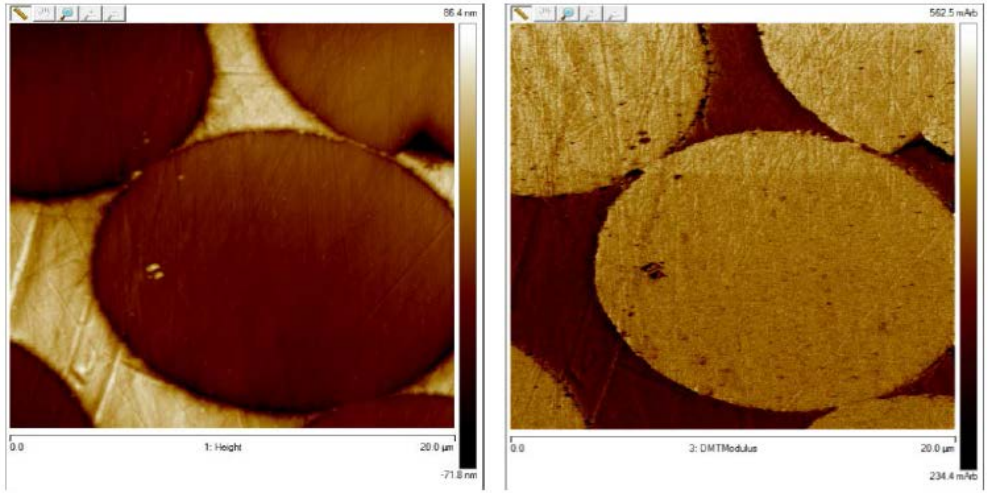
Rijksinstituut voor Volksgezondheid en Milieu
Ministerie van Volksgezondheid, Welzijn en Sport

Characterization of nanoparticles

Other characterization techniques:



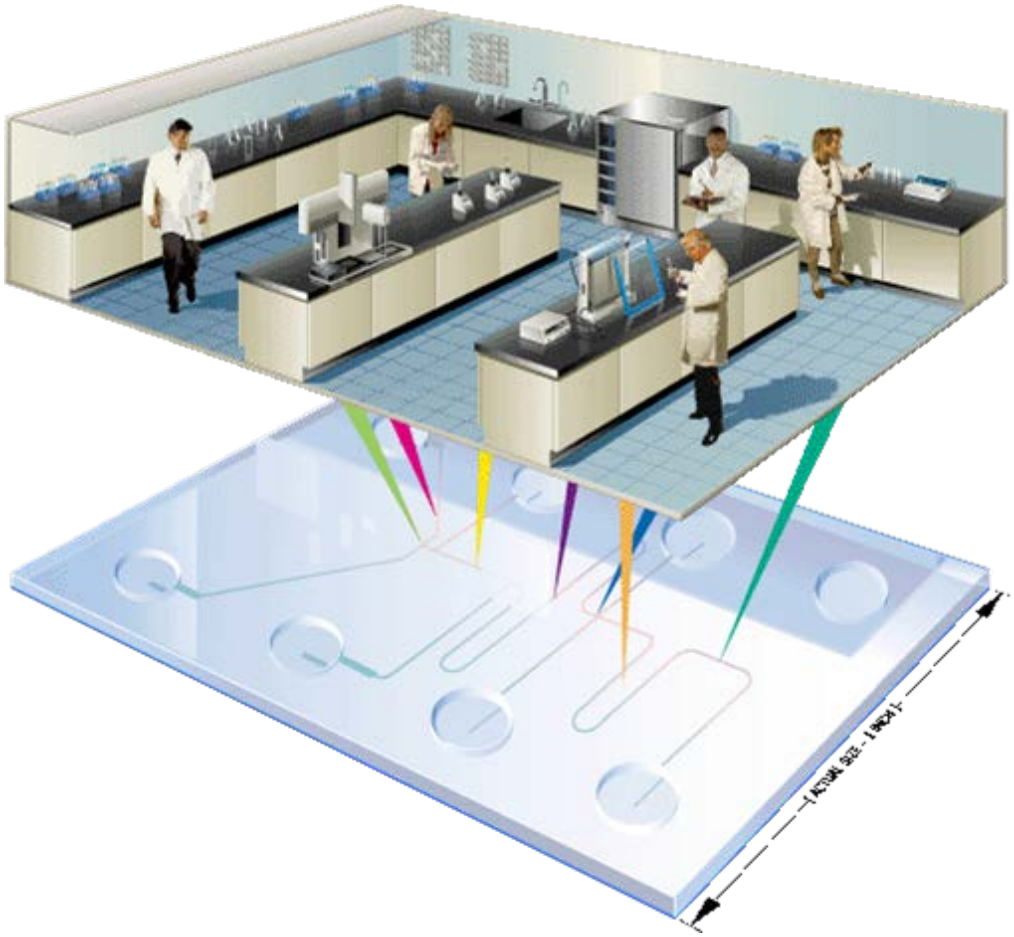
Atomic force microscopy



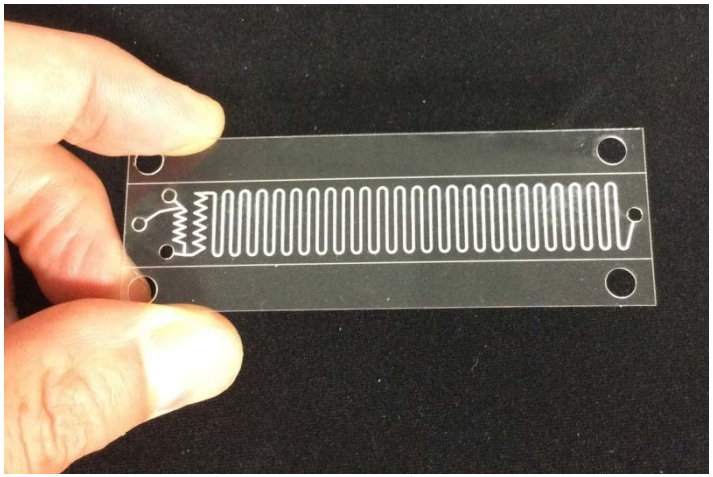
Cross-section of glass fibers (d=17 um) in epoxy resin (is composite material used in pipes)

FUTURE PIPE INDUSTRIES

Lab-on-a-chip



- Smaller (thus portable)
- Faster analysis
- Cheaper (fewer reagents)
- More reliable
- No extensive training needed (everyone can use it)



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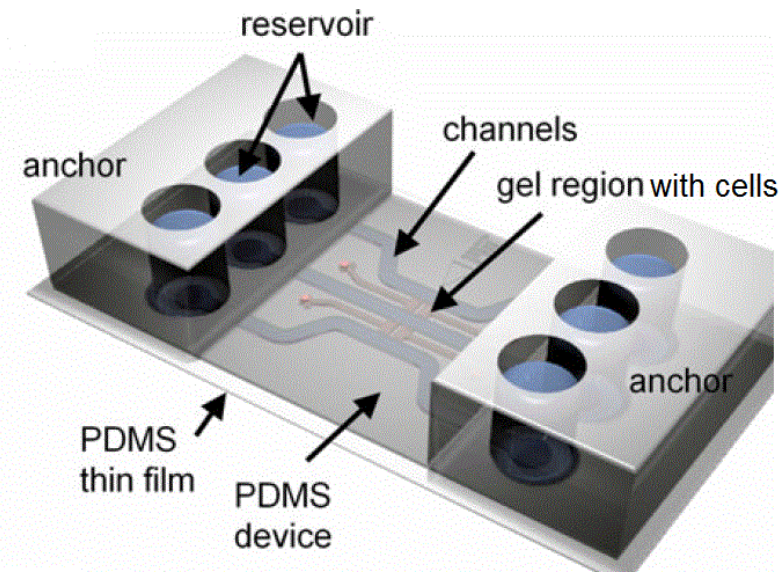
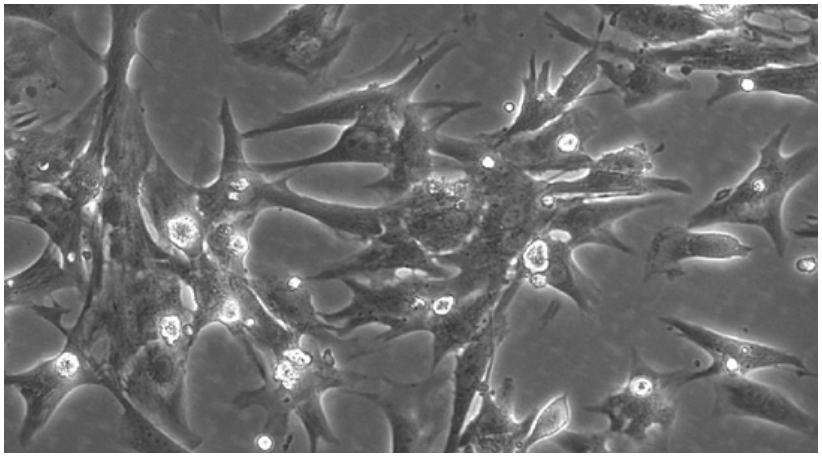
Heart-on-a-chip.



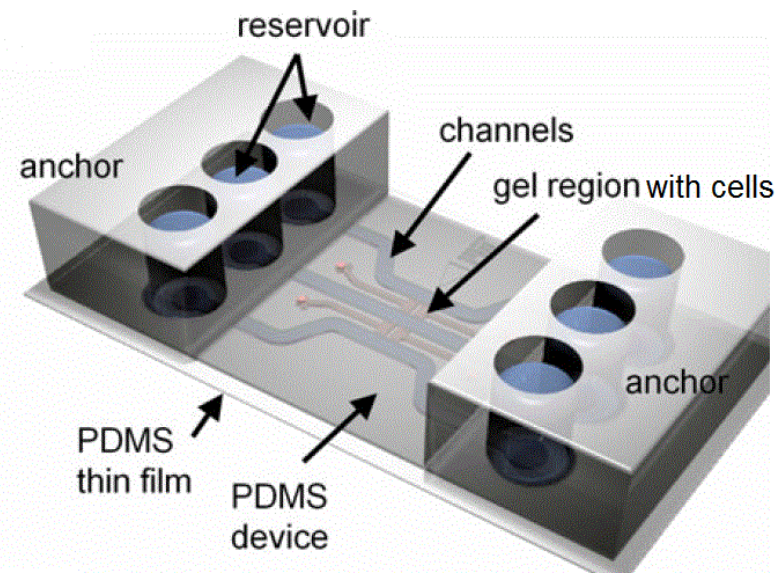


The main goal of this project is to fabricate standardized, robust generic heart-on-a-chip demonstrator devices that will be validated and further optimized to generate new physiologically relevant models to study cardiotoxicity in vitro.

- 3D printing of these devices
- Development of interface to grow cells
- Integrate sensors (electrodes, optical sensors)
- Standardization

Funded by: SiA Nationaal Regieorgaan Praktijkgericht Onderzoek

Motivation



- Heart-on-a-chip uses human cells, which is more relevant
- Can pre-screen new drugs or chemicals to avoid animal tests
- (Future) Might replace animal testing altogether.

- Allows personalized medicine: when your own cells are cultured in the chip, you can use use the chip to find out which drug is most effective for you.

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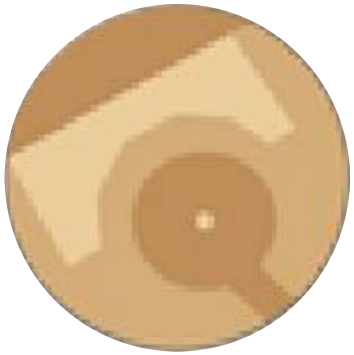
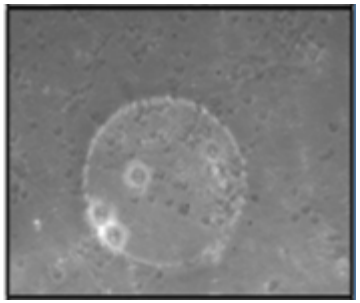
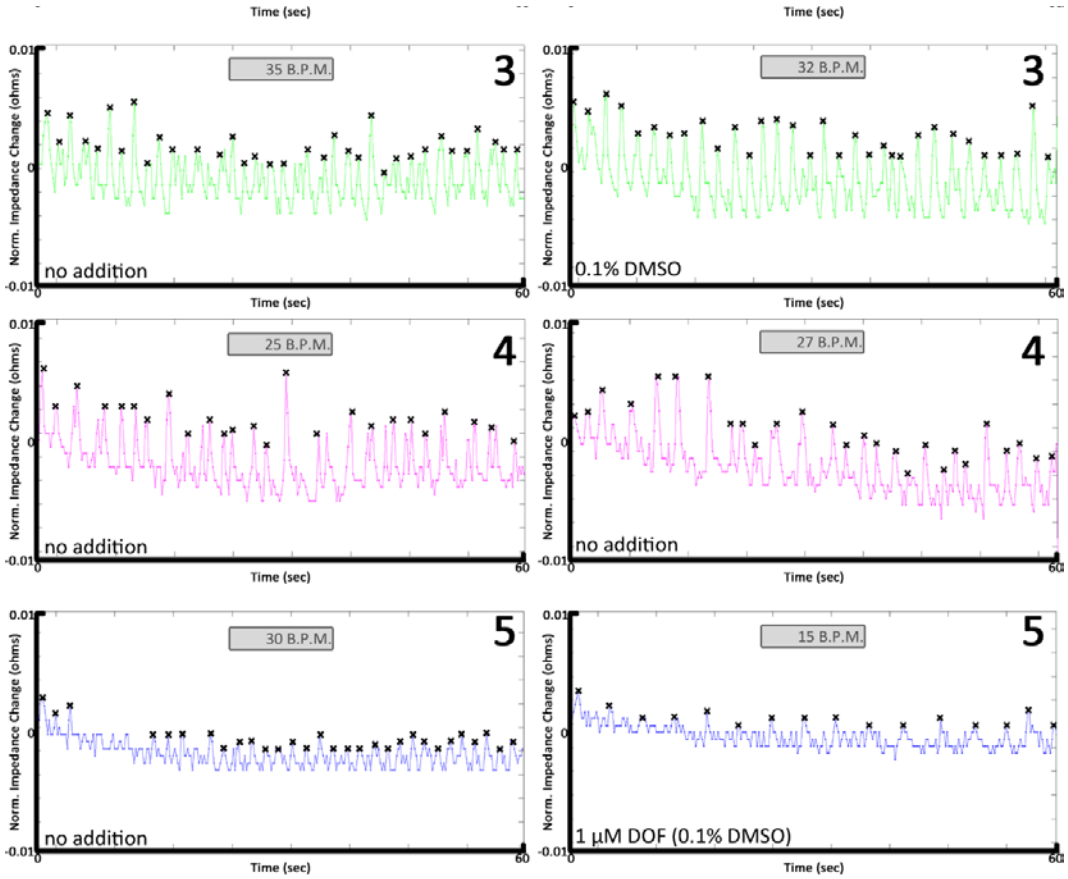
Beating heart cells in culture

Impedance measurements







1 hour after adding 1 µM dofetilide.

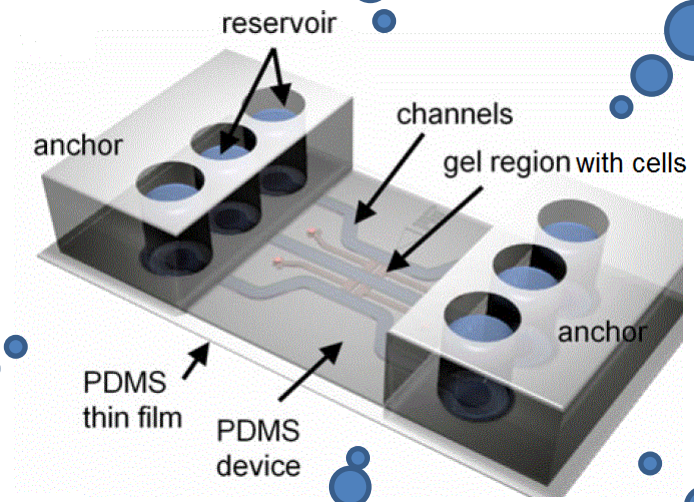
Well 3 (DMSO): 35 bpm → 32 bpm
Well 4 (controle): 25 bpm → 27 bp
Well 5 (dofetilide): 30 bpm → 15 bpm

In of multiple

Nurse practitioners (GZW)

Electrical Engineers (EL or TI)

Biologists (BML)



Chemists (CT or CE)

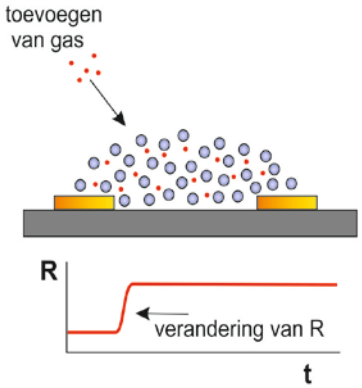
Physicists (TN)

Business developers

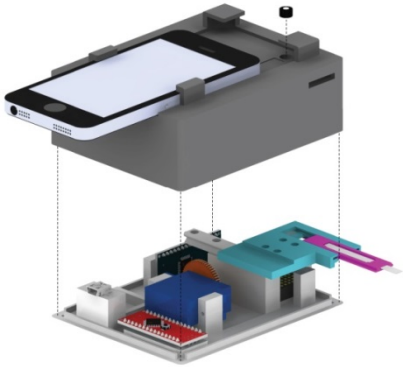
Designers (ID)

Other activities

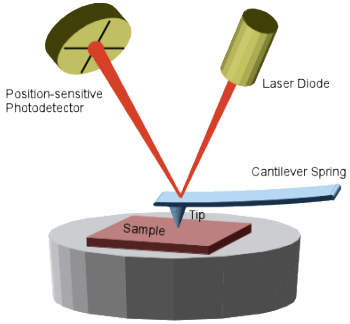
Antibacterial nanostructured surfaces



Nanoparticle-based sensing



Early detection and identification of bacteria



Characterization nanomaterials and nanocomposites

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Erwin Nijhuis
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Thanxx

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