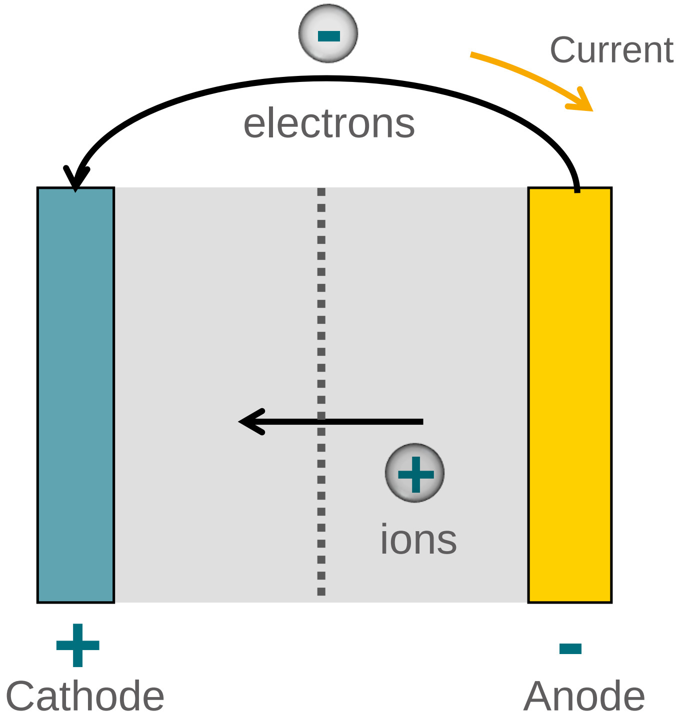
Sprayable water-based compositions for Li-ion battery electrodes

Battery - discharging mode



BiR&D

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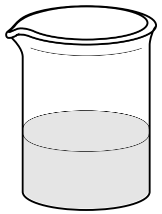
LiEU
LIAISON ENTREPRISES-UNIVERSITÉS

Sprayable water-based compositions for Li-ion battery electrodes

Electrode manufacturing



Liquid electrode formulation

= Active Material, Binder, Solvent, Additives

Coating
(Roller coating)

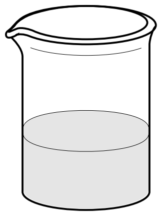
Liquid formulation
Current Collector

Solvent

Solid composition
Current Collector

- Binder = poly vinylidene fluoride (PVDF)
- Solvent = N-methyl-pyrrolidone (NMP)
- 2D plane shapes

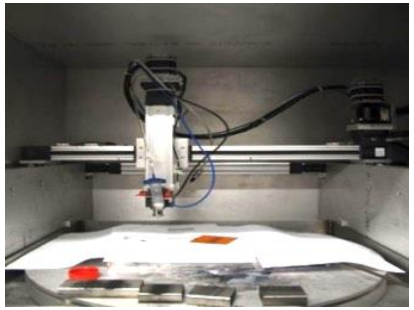
Our approach



Liquid electrode formulation

= Active Material, Binder → Xanthan gum, Solvent → Water, Additives

Coating
(Spray coating)



Liquid formulation
Current Collector

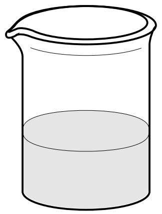
Solvent

Solid composition
Current Collector

- Binder = polysaccharide
- Solvent = water
- Advantages of spray coating

Sprayable water-based compositions for Li-ion battery electrodes

Tests in coin cells



=

- LTO ($Li_4Ti_5O_{12}$) – Anode or LFP ($LiFePO_4$) - Cathode
- Xanthan gum
- Water
- Carbon

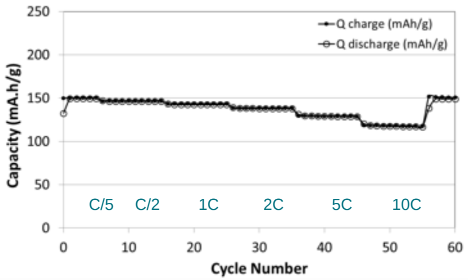
Source: http://www.batterie-bms.com

Properties

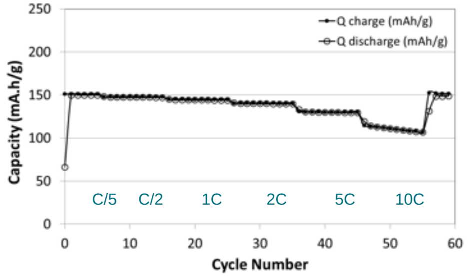
- Good specific capacity and cycling properties
- Similar electrochemical performance compared to PVDF/NMP based coatings
- Improved adhesion on the metal electrode base (no need of surface treatment)

LFP / AL – half cell

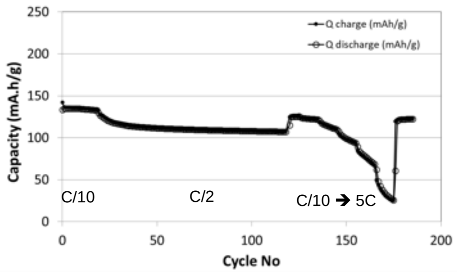
Xanthan gum
Water
Spray



PVDF
NMP
bar-coater



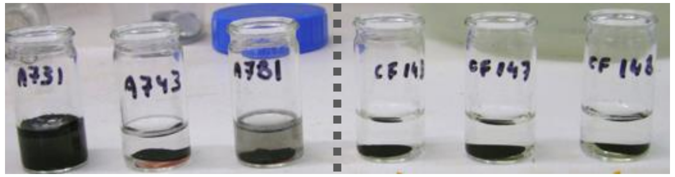
LTO/Cu + LFP/AL full cell



Source: www.pexels.com

Easy recycling of current collectors

LTO | LFP

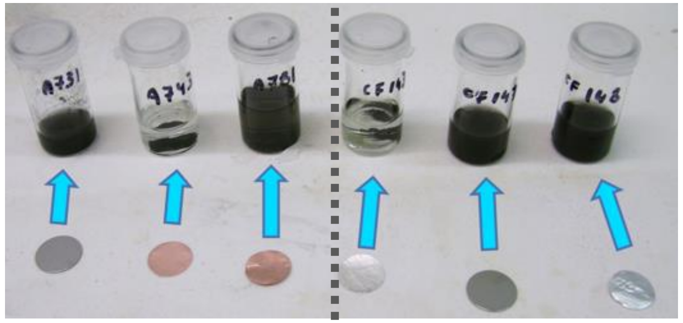


stainless steel, Cu, Cu | Al, stainless steel, Al

Water

Hand-shaking or sonication

LTO | LFP



Sprayable water-based compositions for Li-ion battery electrodes

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Technology maturity & Advantages

TRL/IRL 4

- Fluorine-free binder
- Aqueous formulation
- No need of costly solvent recovery system
- No need of dispersant
- Applicable by spray
- Easy recycling of electrode bases

IP - Status

International patent application
WO2017/211555 A1 (PCT)
EP, US, CN, JP, KR - Pending

Research Team

LGC CHEMICAL ENGINEERING
NANOMATERIALS, CATALYSIS, ELECTROCHEMISTRY

- Pr. N. Job
- www.nce.ulg.ac.be

Opportunities

- Research collaborations
- License agreement

Acknowledgement

www.enmieux.be
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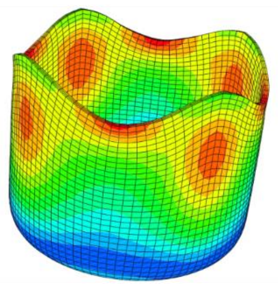
Virtual experiments and multiscale simulation for metal components and metal forming processes

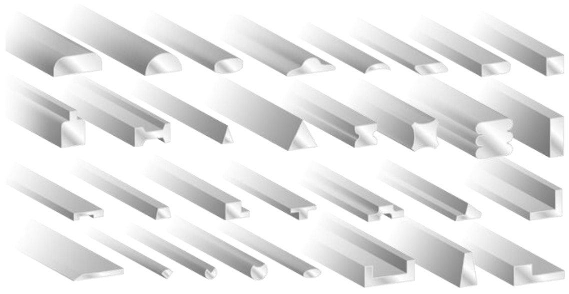
D. Roose, A. Van Bael

- Joint work:
  - MTM – Materials Engineering department, KU Leuven
  - NUMA – Applied Mathematics research group, KU Leuven

- Applications:



www.turbosquid.com



www.alloywire.com

www.3dmetalforming.com

- Collaborations:

At NUMA and MTM, we developed a simulation package that targets two industrial painpoints in metal forming industry

KU LEUVEN

D. Roose, A. Van Bael

Painpoint 1

Availability of material data is limited

- Material databases do not include all materials nor their variability
- Mechanical testing is expensive & time-consuming

Solution: Replace advanced mechanical experiments with virtual tests

Painpoint 2

Simulation results of forming process are not accurate enough

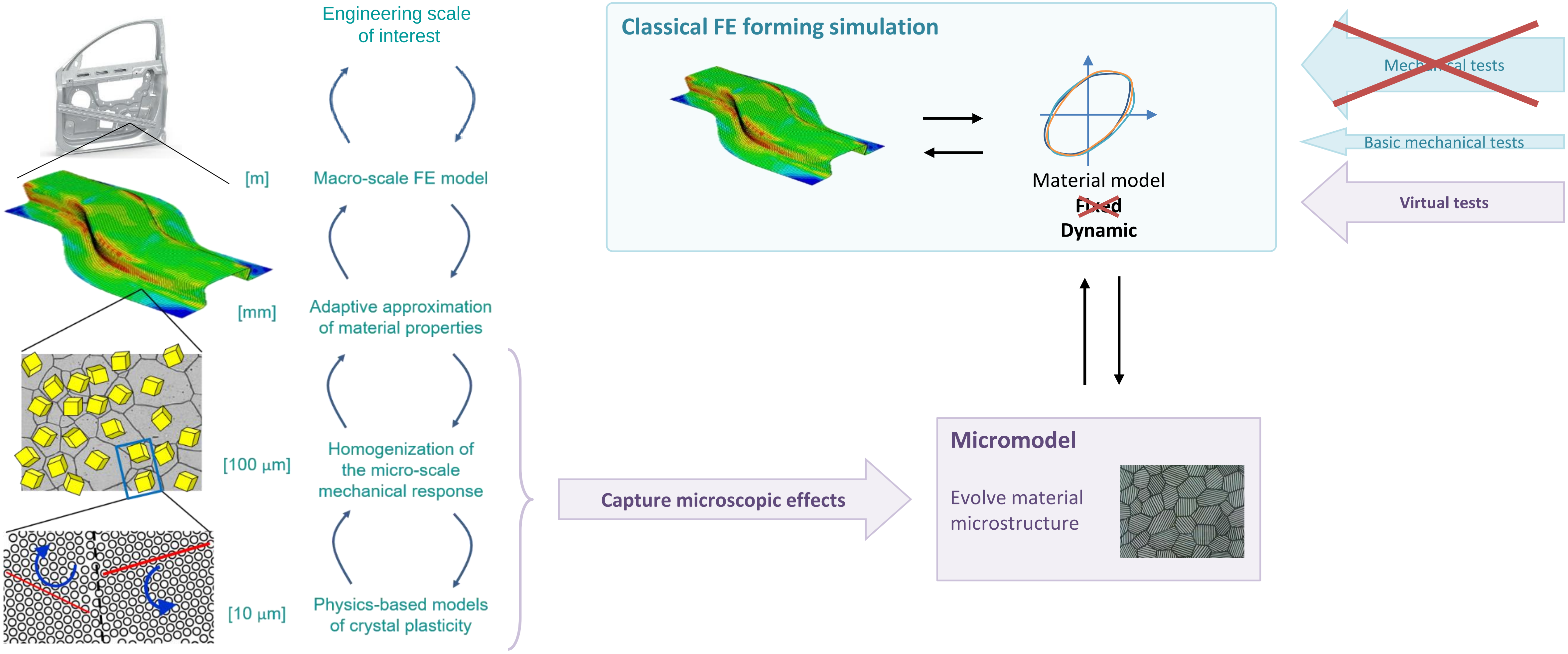
- Properties evolve during processing from base material to formed part
- Simpler material models lead to inaccurate mechanical properties of simulated part

Solution: Couple microstructure evolutions to FE forming simulations on component scale

Our software simulates advanced mechanical tests and adds microstructure evolutions in FE simulations to improve accuracy

D. Roose, A. Van Bael

KU LEUVEN



Projected benefits of using our software package

D. Roose, A. Van Bael

KU LEUVEN

- **Cost-efficient alternative** for mechanical testing
  - Expensive, time-consuming mechanical testing is replaced by cheap virtual tests
- **Time and cost saving** in the product design phase
  - Less trial-and-error steps are needed
- **Higher predictive simulation power**
  - Virtual tests enable use of more complex material models
- **Improved knowledge** on all stages of the forming process and final product
  - Access to evolved material microstructure and properties

Contact info

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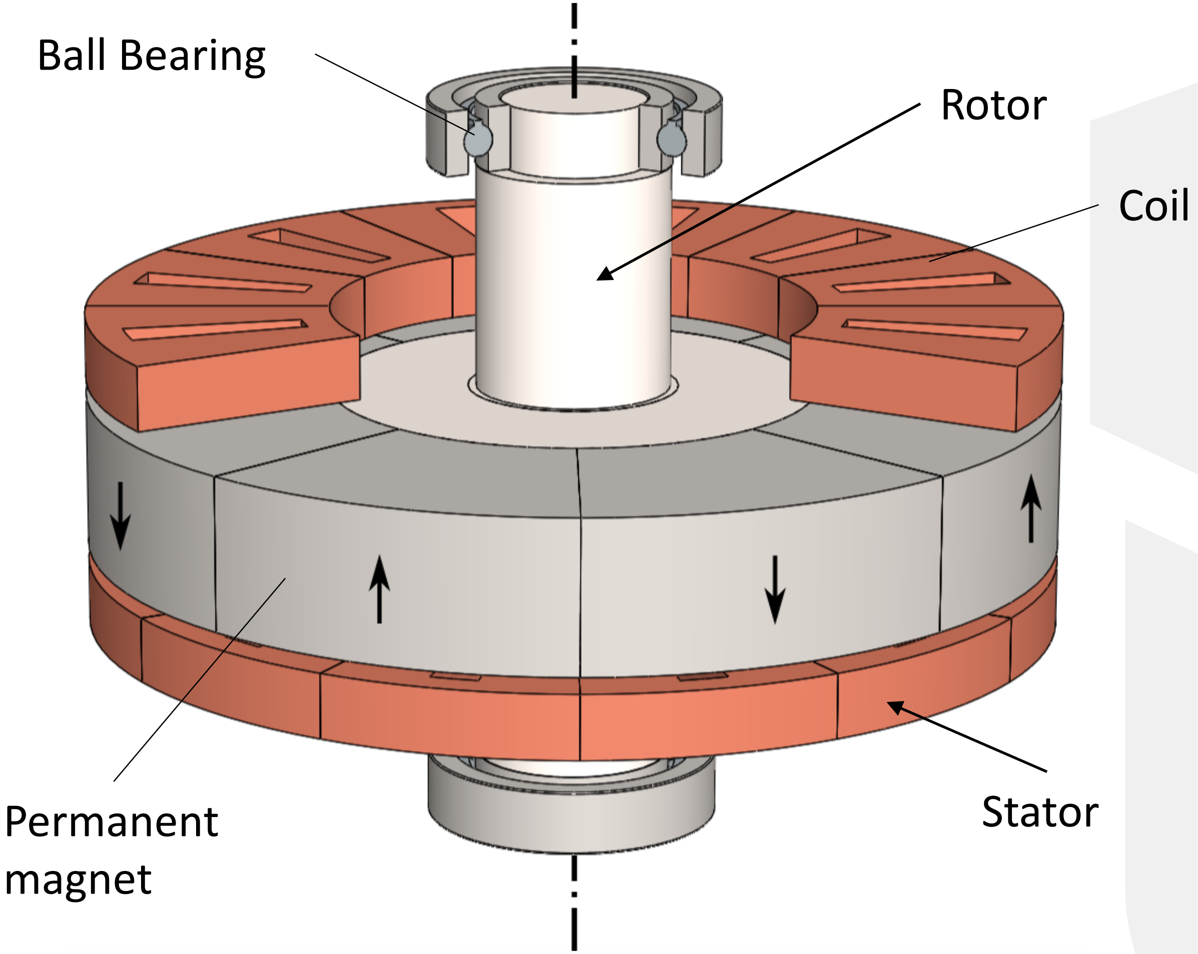
Valorization manager, NUMA
ward.melis@kuleuven.be

https://set.kuleuven.be/m2form

Electric machine having a passive axial electrodynamic bearing

Self-bearing motor, High spin speed, Low losses, Passive

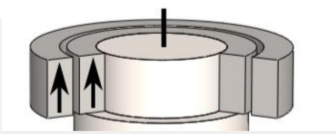


Limitations – Mechanical bearings

- Risks of contamination (lubricants, microparticles)
- Speed limit
- Moderate reliability

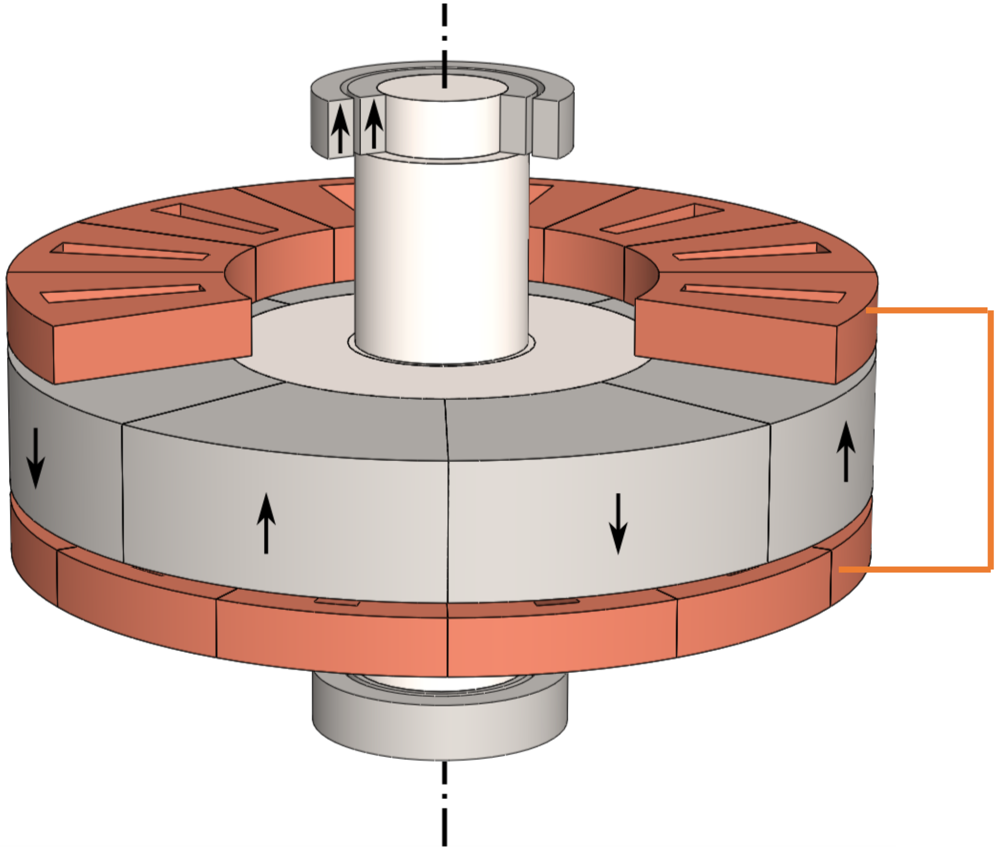
Limitations – Active electrodynamic bearing

- Power electronics
- Controllers and sensors
- Reduced reliability
- High cost and complexity



LE FONDS SOCIAL EUROPÉEN ET LA WALLONIE INVESTISSENT DANS VOTRE AVENIR

Electric machine having a passive axial electrodynamic bearing



Passively self-levitated axial flux permanent magnet motor

- Permanent magnets & windings → produce driving torque
- Connection of windings in short-circuited path

→ currents are passively induced when axial out-centering of rotor

→ Restoring thrust force & no control

Advantages

- Compactness
- Reliability
- High-speed operation
- Passive thrust force
- No additional control electronic for bearing

Electric machine having a passive axial electrodynamic bearing

Applications: critical applications: high speed, low contamination, …
Examples: Medical and Healthcare, Chemistry, High speed applications, (µ-)Pumps, Compressors

Key Factors	Ball Bearings (reference)	Active Magnetic Bearings	Invention
Risks of contamination (lubricants, microparticles)	😐	😊😊	😊
Costs (investment and maintenance)	😐	☹	😊
Reliability	😐	😊	😊😊
Compactness	😐	😊	😊😊

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www.enmieux.be

Electric machine having a passive axial electrodynamic bearing

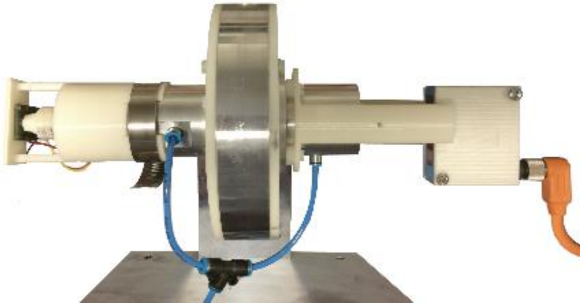
Self-bearing motor, High spin speed, Low losses, Passive

Intellectual Property

Patent pending: PCT patent application filed on the 18th of May 2018 (WO2018211101A1)

TRL 4

A second improved prototype under construction



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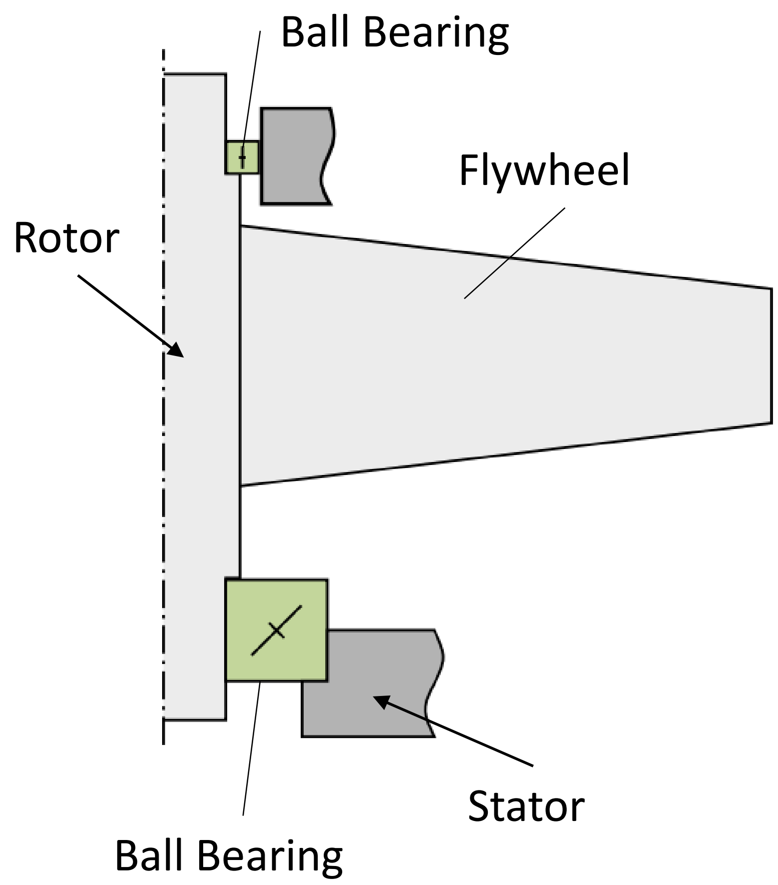
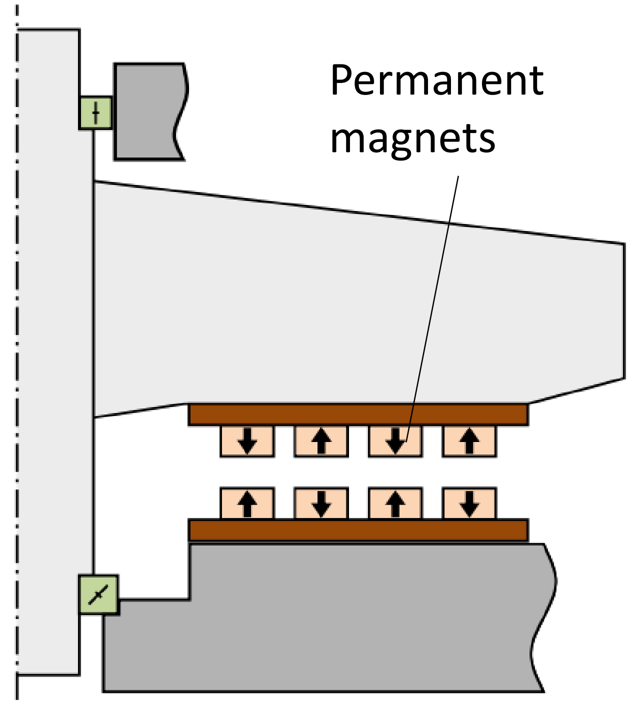
Self-compensating permanent magnet bearing

Permanent Magnet Bearing, Temperature compensation, Ageing compensation, Passive

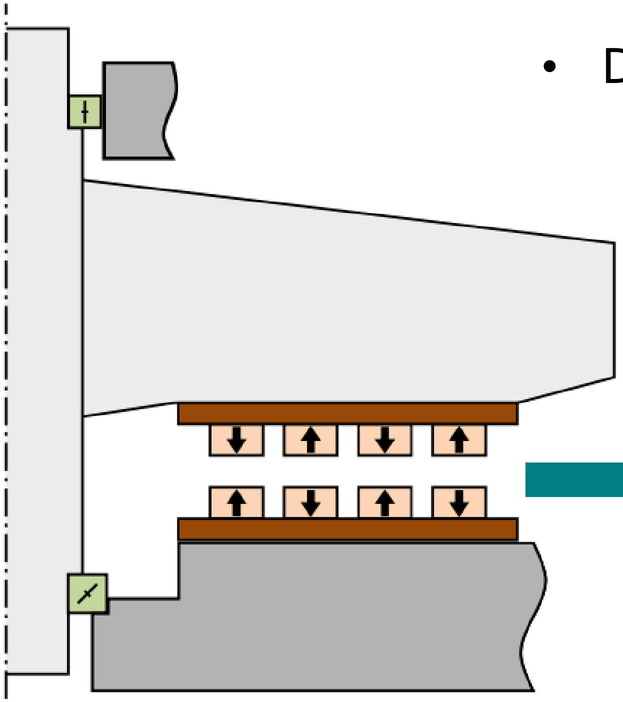


Limitations – Mechanical bearings

- Loss
- Friction
- Lifetime $\sim \left(\frac{1}{load}\right)^3$
- Low reliability

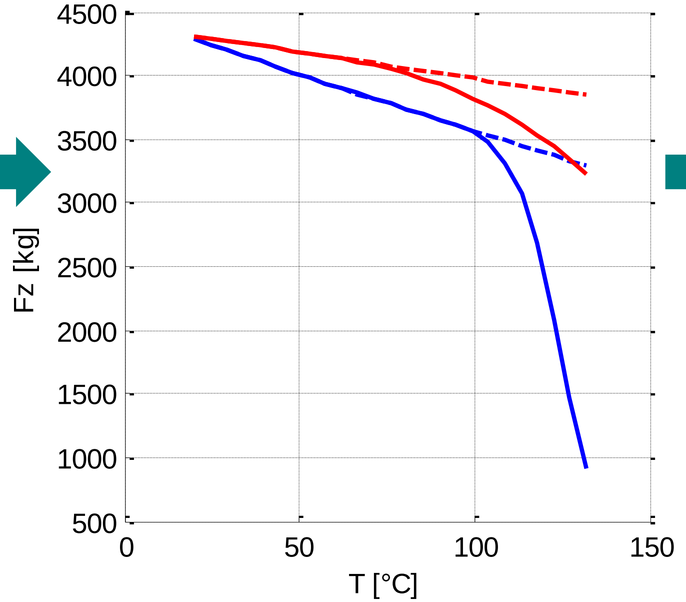


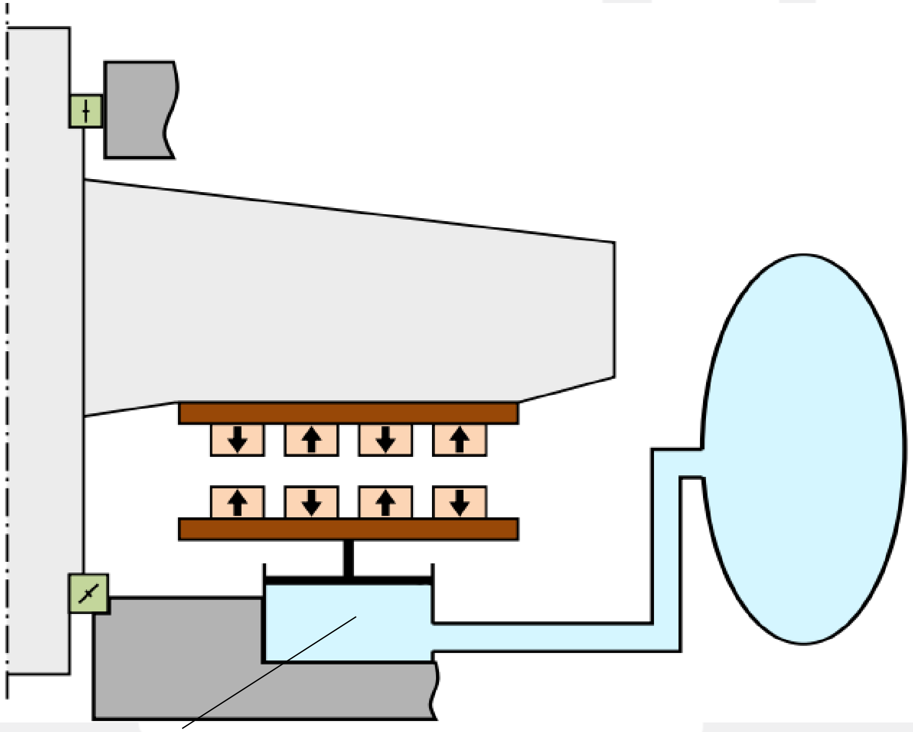
Self-compensating permanent magnet bearing



Limitations – Permanent magnets

- Demagnetization:
  - Ageing
  - Temperature





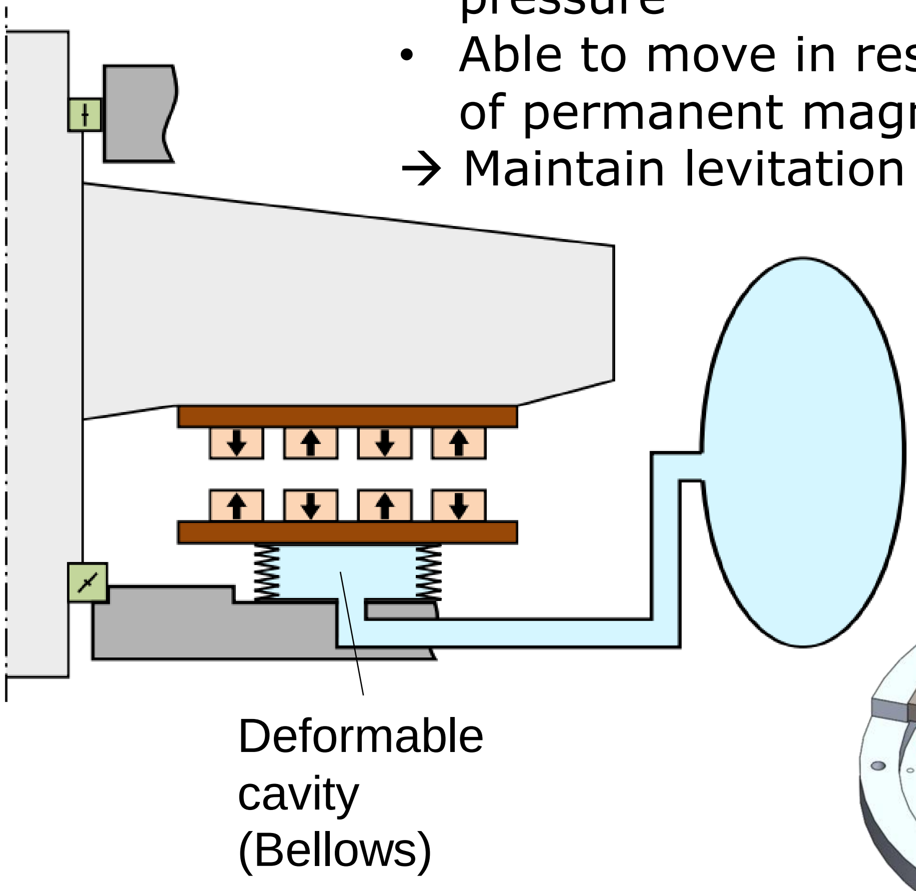
Compensating mechanism

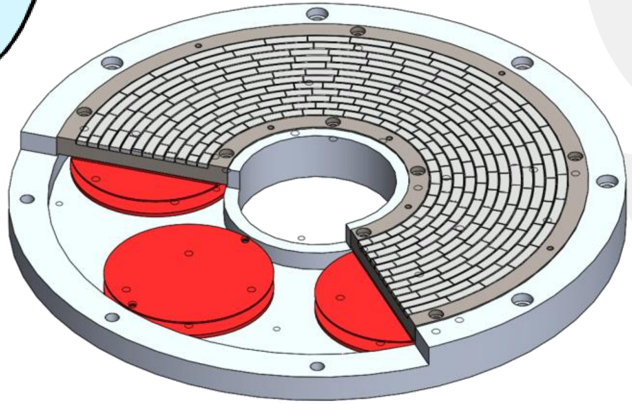
Self-compensating permanent magnet bearing

Deformable cavity:

- Containing a fluid under constant pressure
- Able to move in response to a change of permanent magnets properties

→ Maintain levitation force constant





Advantages:

- Demagnetization self- compensation
- Lower Loss
- No Friction
- Increased Lifetime
- High reliability
- Fine tuning of the gap between magnets

Self-compensating permanent magnet bearing

Permanent Magnet Bearing, Temperature compensation, Ageing compensation, Passive

Intellectual Property

Patent pending: EP patent application filed on the 10th of August 2018 (EP18188404)

TRL 5

Prototype has been tested and functionality have been demonstrated over a limited range of operating conditions (Flywheel application)

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EnergyVille

Research on sustainable energy and intelligent energy systems

Industry meets University
March 19, 2019

KU LEUVEN

The energy transition: EnergyVille’s vision

Distributed renewable energy

Information- and communication-technology

Technological innovation

\+

Cost reduction

Sustainable energysystem

- COP21 targets
- RES => Intermittency
- Consumers -> “prosumers”
- Elektricity as dominant vector
- Coupling with heat, gas, …
- Key role of cities
- Security of supply
- Economical

EnergyVille - Mission

EnergyVille is a **top research institute** to reach a **market-based, sustainable energy system for large urban areas**.

This comprises **Basic, Applied and Industry-driven research**, both theoretical and experimental.

EnergyVille serves the community by

- **developing generic technologies and methodologies** resulting in **new products and services**
- **assisting in human capital development**
- giving **science-based policy input** from local to global level.

Flemish energy research partnership by:

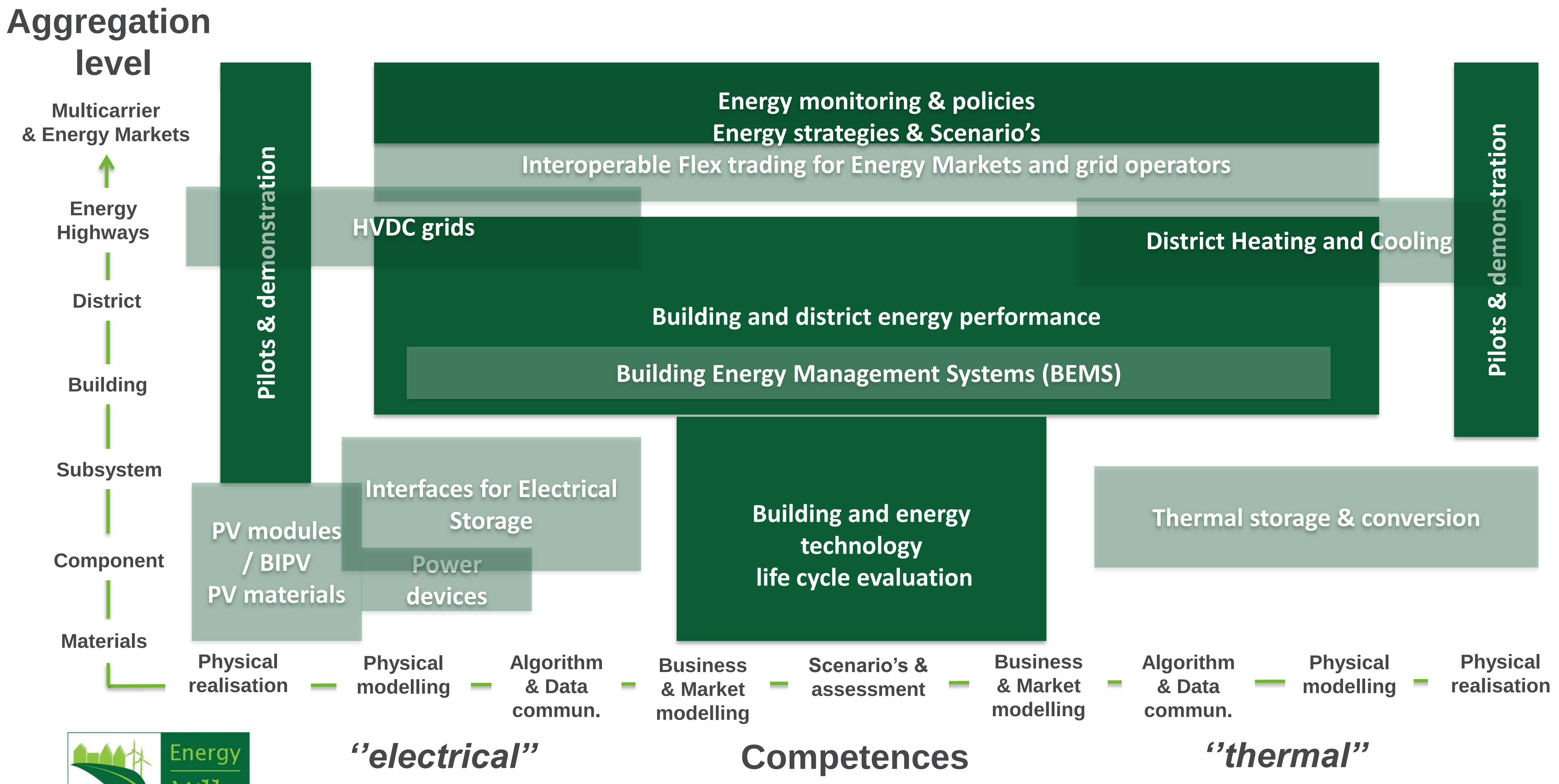
VITO **KU Leuven** **imec** **UHasselt**

Flemish research collaboration

EnergyVille

In 2018 : ~350 collaborators ; ~ 35 MEuro external project income

HOTSPOT FOR TECHNOLOGY, ENERGY AND INNOVATION
93 HA - 5 ZONES:
① WHAT? (high)tech, innovative, knowledge intensive companies & international R&D-intensive companies, knowledge institutes & research centers DEVELOPERS KU Leuven, City of Genk, LRM, Vito, Imec, POM Limburg in cooperation with university associations KULeuven-KHLim and UHasselt-XIOS-PXL
② WHAT? Knowledge-, service- & production companies in technology, energy, ICT, engineering, systems, living lab, smart city applications, & space for individual companies in case of sufficient building volume DEVELOPERS MoTher Ltd. (City of Genk, LRM, DMI Vastgoed, Vanhout Projects & Van Roey) and City of Genk
③ WHAT? Beating heart of the Thor site with o.a. food court, meeting rooms, flex offices, auditorium, food general services, reception, eventing, community, building, ... DEVELOPER City of Genk
④ WHAT? Innovative technological education cluster that matches the actual and future needs of companies w.r.t. technology competencies DEVELOPERS City of Genk, VDAB and Syntra
⑤ WHAT? Unique mine park with terrils, picnic spots, cycle tracks and footpaths. Beautiful scenery for touristic-artistic projects DEVELOPER City of Genk
URBAN PARK
Nature and recreation area — 30,0ha
TECHNOLOGY & TALENTCAMPUS
• START SCHOOLYEAR 2017
T2 CAMPUS
Technology and talent education — 4,3ha
ENERGYVILLE 1&2
• ENERGYVILLE 1: MID2015
FOR SALE FOR RENT
MOTHOR
• 2016
BUSINESS & ACTIVITY CENTRE
• Q4 2014
INCUBATHOR
• AVAILABLE NOW
MAIN BUILDING
Business — 2,2 ha
SCIENCE PARK
Research & development and business — 20ha
HIGH-QUALITY BUSINESS PARK
Business — 36,3 ha



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Integrating photovoltaics into real facades of buildings

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The case for integration of PV in facades of high-rise buildings

2020 NZEB directives => enhanced use of PV on buildings

- rooftop area for PV often scarce
- aesthetics suited for office-buildings
- high facade engineering capacity
- benign to the local grid (congestion !)
  - generation close to consumption
  - in sync with airco load
  - East – South – West facades => flatter day profile
  - seasonal profile
- façade cost Euro/m^2 marginally increased and compensated by enhanced "greening"


Heron Tower London

Energy Ville

The case for PV in "curtain walls"

North Galaxy, Brussels

- Industrially pre-fabricated
- Semi-standardized dimensions
- Millions of m^2 / year of facades installed

- **multi-GW /yr. production opportunities for PV for facade-integration**

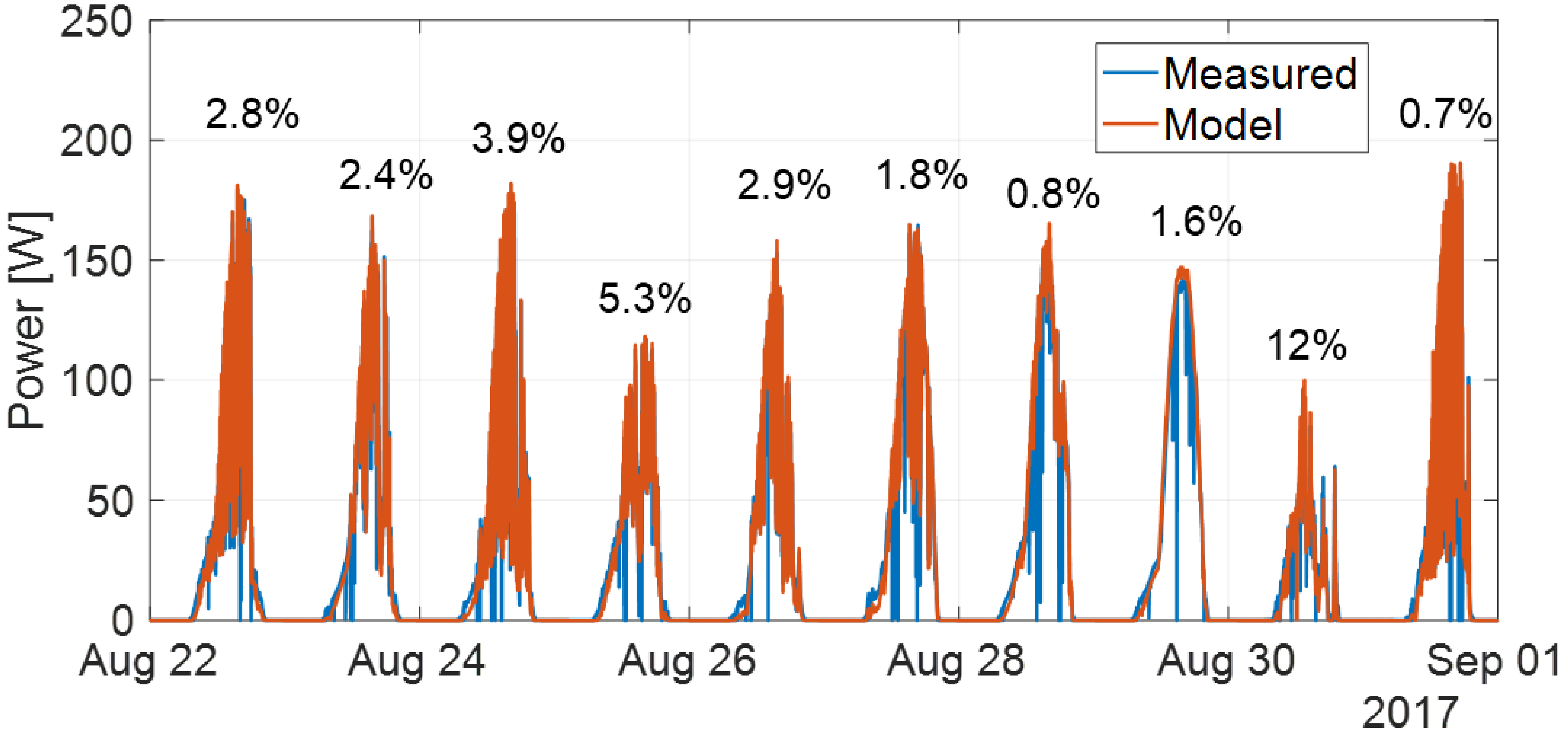
Prototype: PV in curtain wall

Ventilation holes

PV in opaque part

Glass in transparent part

+ 1 year operation proven – accurate BIPV models available



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Edison vs Tesla :

Low Voltage bipolar DC grids

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THE CURRENT WAR

THE TALE OF AN EARLY TECH RIVALRY

DC

DIRECT CURRENT

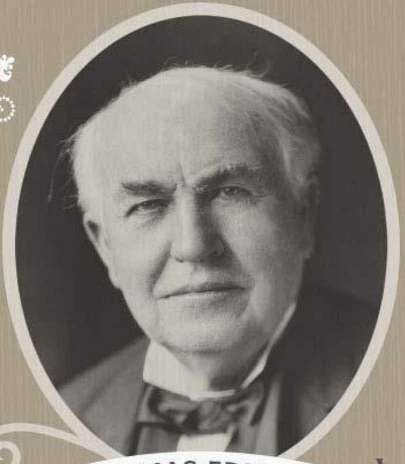
The flow of electricity is in one direction only. The system operates at the same voltage level throughout and is not as efficient for high-voltage, long distance transmission.

Direct current runs through:

- Battery-Powered Devices
- Fuel and Solar Cells
- Light Emitting Diodes

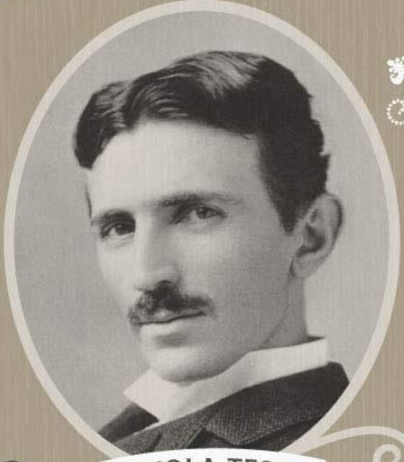
"[TESLA'S] IDEAS ARE SPLENDID, BUT THEY ARE UTTERLY IMPRACTICAL."

- THOMAS EDISON



THOMAS EDISON

VS.



NIKOLA TESLA

AC

ALTERNATING CURRENT

Electric charge periodically reverses direction and is transmitted to customers by a transformer that could handle much higher voltages.

Alternating current runs through:

- Car Motors
- Radio Signals
- Appliances

"IF EDISON HAD A NEEDLE TO FIND IN A HAYSTACK, HE WOULD PROCEED AT ONCE... UNTIL HE FOUND THE OBJECT OF HIS SEARCH. I WAS A SORRY WITNESS OF SUCH DOINGS, KNOWING THAT A LITTLE THEORY AND CALCULATION WOULD HAVE SAVED HIM 90 PERCENT OF HIS LABOR."

- NIKOLA TESLA

You would have never found two geniuses so spiteful of each other beyond turn-of-the-century inventors Nikola Tesla and Thomas Edison. They worked together—and hated each other. Let's compare their life, achievements, and embittered battles.

Thomas Edison		Nikola Tesla
1847	BORN	1858
Milan, Ohio	BIRTHPLACE	Smiljan, Croatia
Wizard of Menlo Park	NICKNAME	Wizard of the West
Home-schooled and self-taught	EDUCATION	Studied math, physics, and mechanics at The Polytechnic Institute at Gratz
Mass communication and business	FORTE	Electromagnetism and electromechanical engineering
Trial and error	METHOD	Getting inspired and seeing the invention in his mind in detail before fully constructing it
DC (Direct Current)	WAR OF CURRENTS: ELECTRICAL TRANSMISSION IDEA	AC (Alternating Current)
Incandescent light bulb; phonograph; cement making technology; motion picture camera; DC motors and electric power	NOTABLE INVENTIONS	Tesla coil - resonant transformer circuit; radio transmitter; fluorescent light; AC motors and electric power generation system
1,093	NUMBER OF US PATENTS	112
0	NUMBER OF NOBEL PRIZES WON	0
1	NUMBER OF ELEPHANTS ELECTROCUTED	0
1931—Passed away peacefully in his New Jersey home, surrounded by friends and family	DEATH	1943—Died lonely and in debt in Room 3327 at the New Yorker Hotel

"Genius is one percent inspiration and ninety nine percent perspiration."

-Thomas Edison

LATE BLOOMER

Thomas Edison, the youngest in his family, didn't learn to talk until he was almost 4 years old.

FALLING OUT

Edison promised Tesla a generous reward if he could smooth out his direct current system. The young engineer took on the assignment and ended up saving Edison more than $100,000 (millions of dollars by today's standards). When Tesla asked for his rightful compensation, Edison declined to pay him. Tesla resigned shortly after, and the elder inventor spent the rest of his life campaigning to discredit his counterpart.

EDISON FRIES AN ELEPHANT

In order to prove the dangers of Tesla's alternating current, Thomas Edison staged a highly publicized electrocution of the three-ton elephant known as "Topsy." She died instantly after being shocked with a 6,600-volt AC charge.

WAR OF CURRENTS OFFICIALLY SETTLED

In 2007, Con Edison ended 125 years of direct current electricity service that began when Thomas Edison opened his power station in 1882. It changed to only provide alternating current.

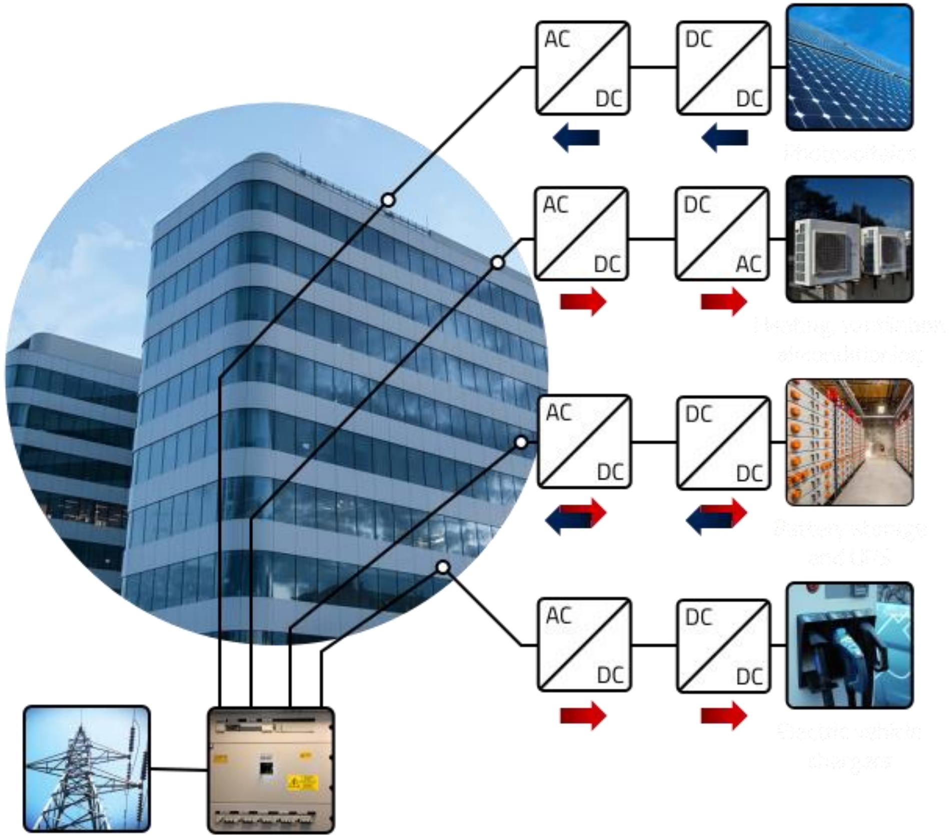
NOBEL PRIZE CONTROVERSY

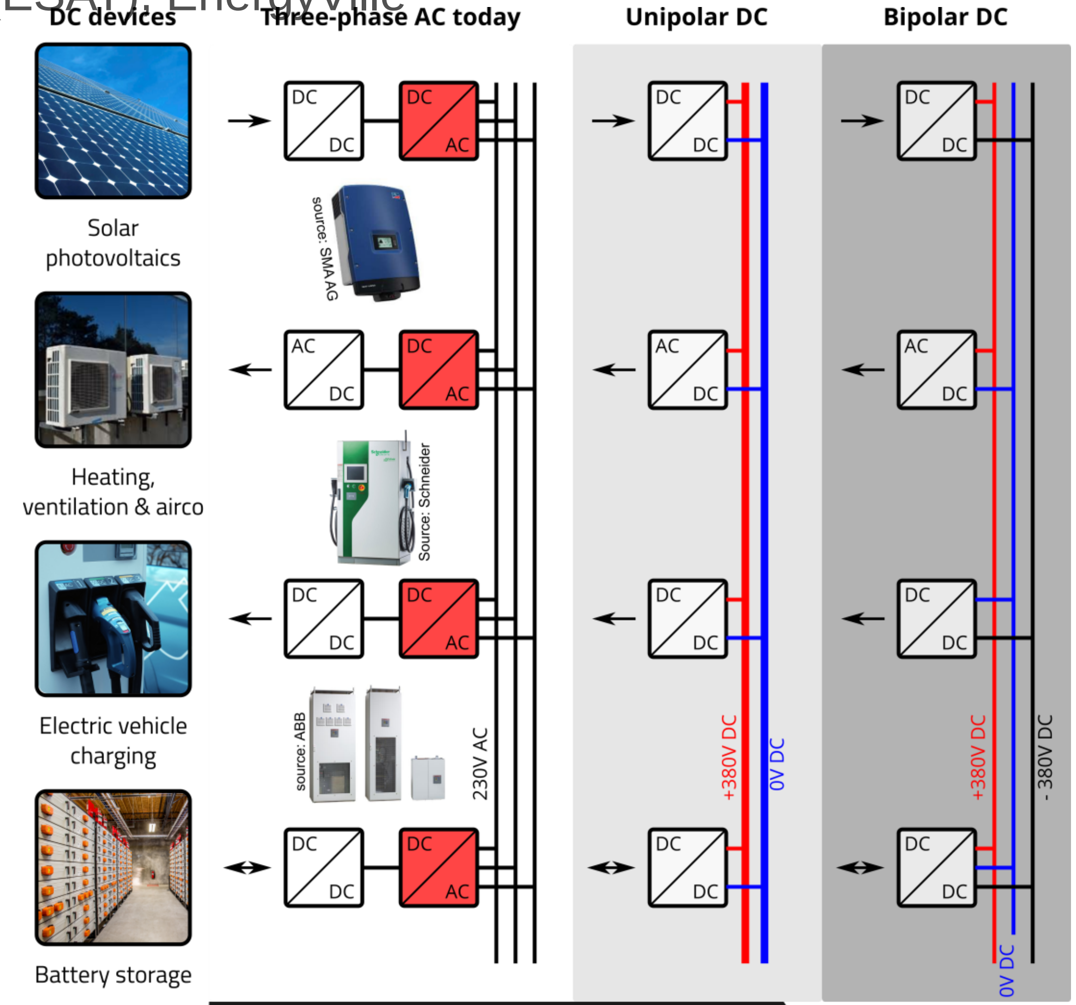
In 1915, both Edison and Tesla were to receive Nobel Prizes for their strides in physics, but ultimately, neither won. It is rumored to have been caused by their animosity towards each other and refusal to share the coveted award.

SOURCES: CHENEY, MARGARET. "TESLA: MAN OUT OF TIME" | UTH, ROBERT. "TESLA: MASTER OF LIGHTNING." | THOMASEDISON.COM | PBS.ORG | WEB.MIT.EDU | WIRED.COM

A COLLABORATION BETWEEN GOOD AND COLUMN FIVE

Rationale





Advantages of DC over AC
Less power conversion stages
More power with less conductor material

Advantages of bipolar over unipolar DC
More power with less conductor material
Two voltage levels available

Energy Ville

Key advantages of DC technology

Why LVDC?

Compatibility ↑

Power conversion efficiency ↑	-10%
System-level availability ↑	0.99999
Reduce CAPEX & OPEX costs	-20%
Increase installation compactness ↑	-20%
Power transfer capability ↑	+40%
Controllability ↑	

Why **bipolar** LVDC?

Reduce conductor material usage ↓	-68%
Increase conv. efficiency (two voltage levels)	
Retrofit three-phase power cabling	

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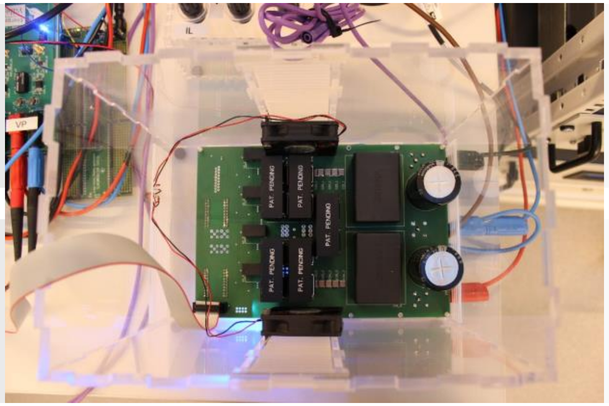
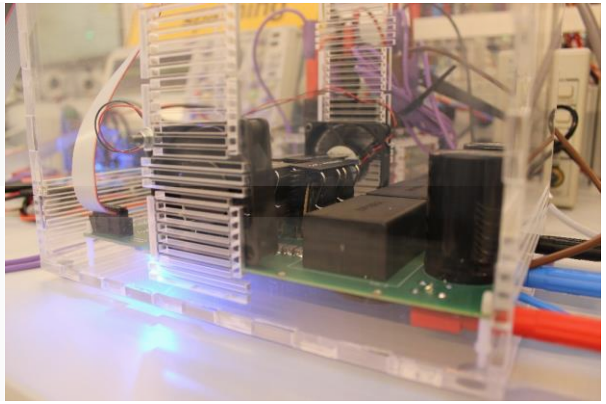
Key technology and knowledge developed

DC-DC converter for interfacing storage and photovoltaics with bipolar LVDC microgrids

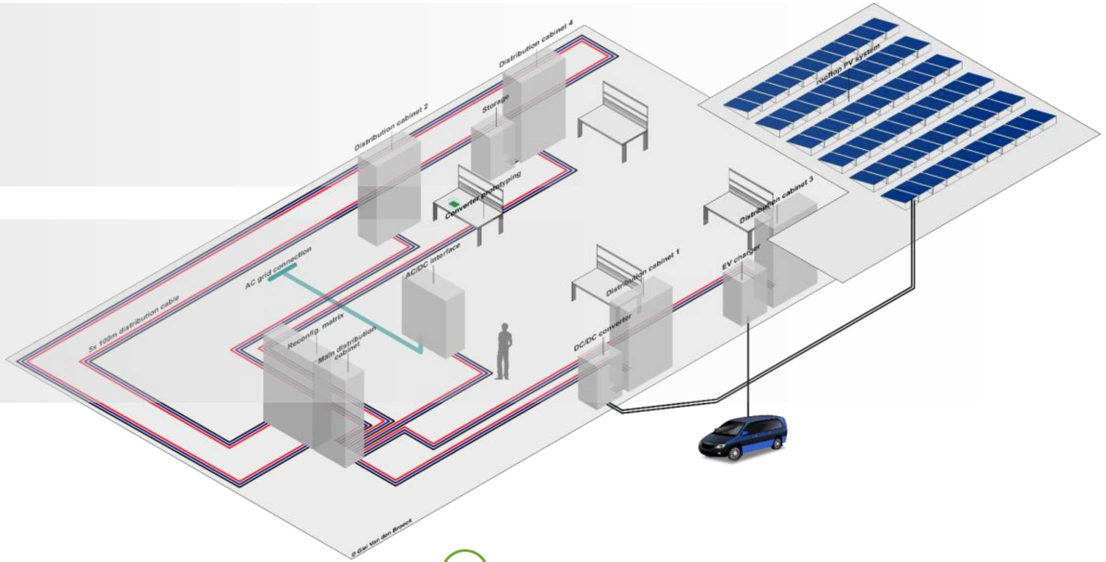
Certified and fully functional bipolar DC microgrid lab facility





Voltage control strategy

Knowledge on standardization and legislation (BE) regarding electrical installations

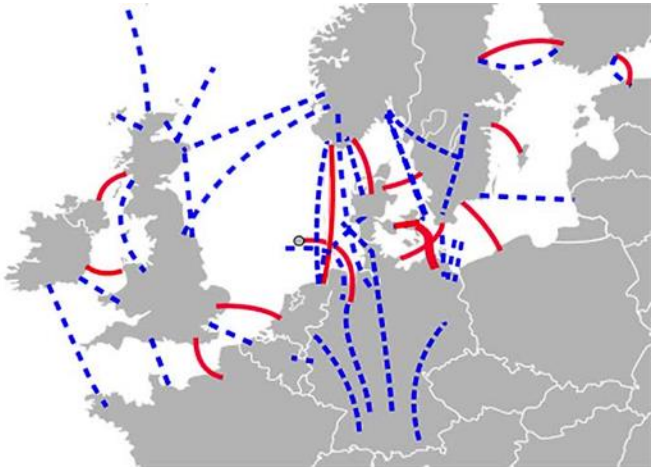


Towards the SuperGrid :

High Voltage DC transmission

Research vision

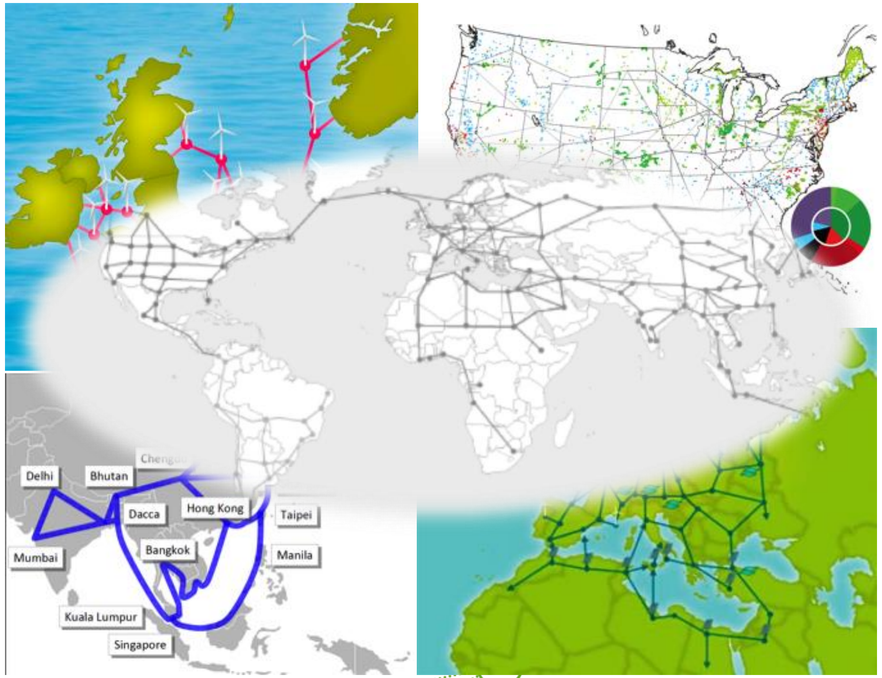
From present and proposed point-to-point connections…



HVDC is key technology for large-scale integration of renewable energy sources

Worldwide HVDC market is in excess of $4 billion annually and rising

towards meshed HVDC grids



Energy Ville

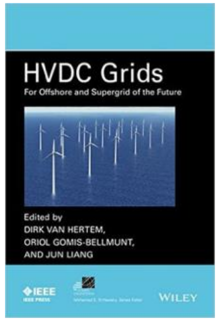
A field in transition

TODAY	IN FUTURE
From **point-to-point** connections …	… to multi-terminal and meshed **grids**
Protection From conventional AC system protection …	… to fast-acting DC &AC system protection
Control From one manufacturer per link …	… to multi-vendor interoperability
Operation From HVDC as "assistance" for AC grid …	… to AC & HVDC grid as parts of same grid
Planning From HVDC as addon element…	… to HVDC (grids) directly included as potential grid element for grid expansion integrating all available "features"
Grid code From complying with AC system/TSO requirements …	… to complying with both AC and DC grid requirements in a multi-stakeholder environment

Energy Ville

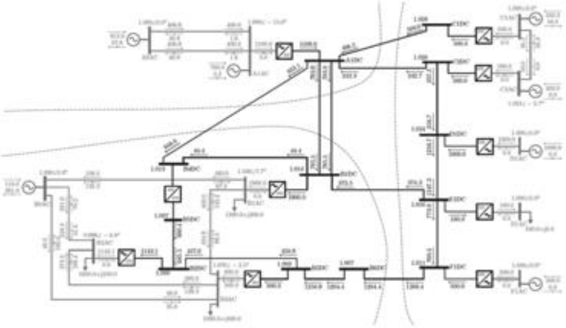
KU Leuven / EnergyVille track record

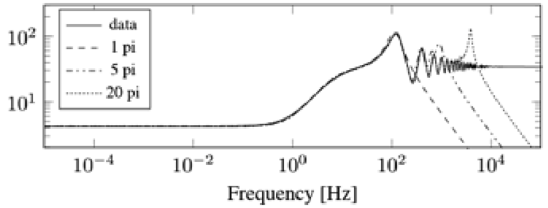
- 15 year track record
  - Leading role within CIGRE Technical WG
    - a.o. Convener and secretary positions
  - Leading role within IEEE PES HVDC & FACTS Committee
    - WG Chair
  - Top-cited research team on HVDC grids
    - Internationally awarded research
    - Editor first book on HVDC grids



  - Tutorials and panel sessions at major technical conferences and meetings

- State-of-the-art tools and models for control, protection and operation
  - High-bandwidth cable model for control interaction studies
  - MatACDC & PowerModelsACDC: Open-source power flow software for future HVDC grids





- PROMOTioN (H2020)
  - Pioneering project towards HVDC grid protection
  - Major academic partner on a.o. multi-vendor interoperability

kris.baert@esat.kuleuven.be

Prediction tool for life time assessment of materials in electrochemistry driven applications - energy storage and corrosion -

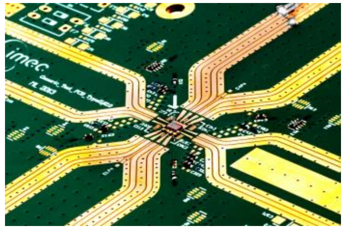
Annick Hubin, Herman Terryn
annick.hubin@vub.be

Research Group Electrochemical and Surface Engineering

VRIJE UNIVERSITEIT BRUSSEL

Domains

corrosion & corrosion protection
self-healing coatings



electrodeposition
functional properties

surface treatments
3D printing

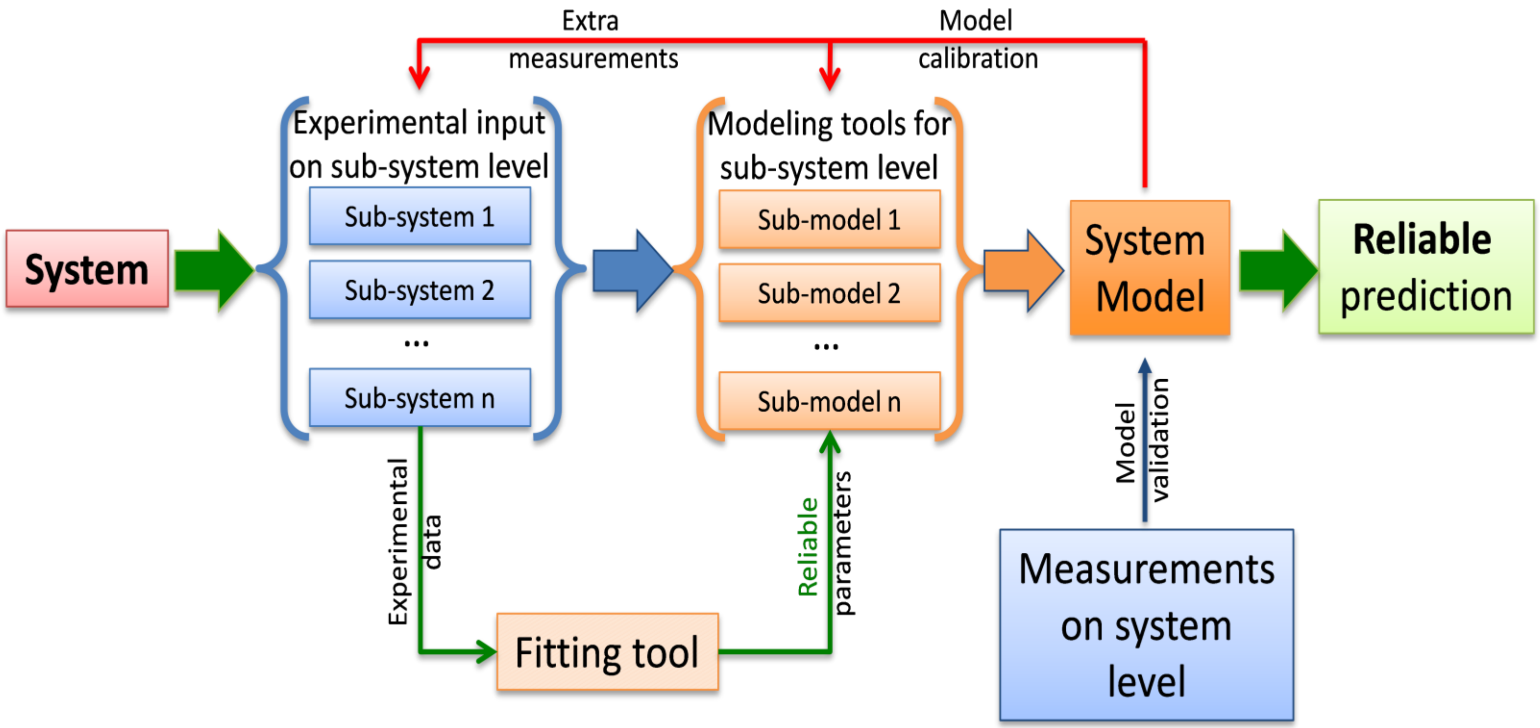
nanoparticles synthesis & modifications
electrocatalysis
rechargeable energy systems

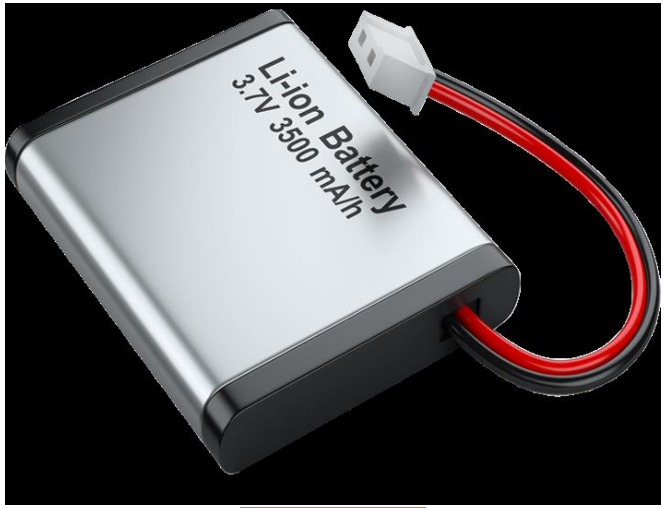
Core competences

- **SURF**
  - Electrochemistry
    - Global Electrochemistry
    - Local Electrochemistry
    - Spin off companies: Zensor, CellSine
  - Surface Treatments & Organic coatings
    - Surfaces & coatings
    - Interfaces
  - Surface Analysis
    - Ex Situ Surface Analysis
    - In Situ Surface Analysis
  - FEM Electrochemical Modelling

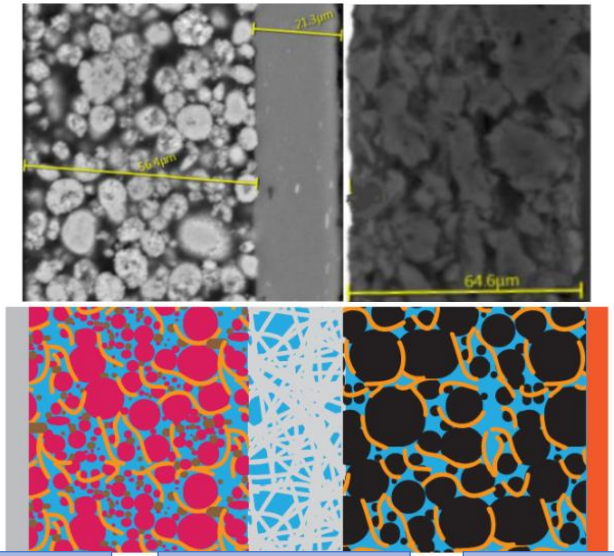
www.surfgroup.be

Strategy for reliable prediction of lifetime and aging in electrochemical systems





System



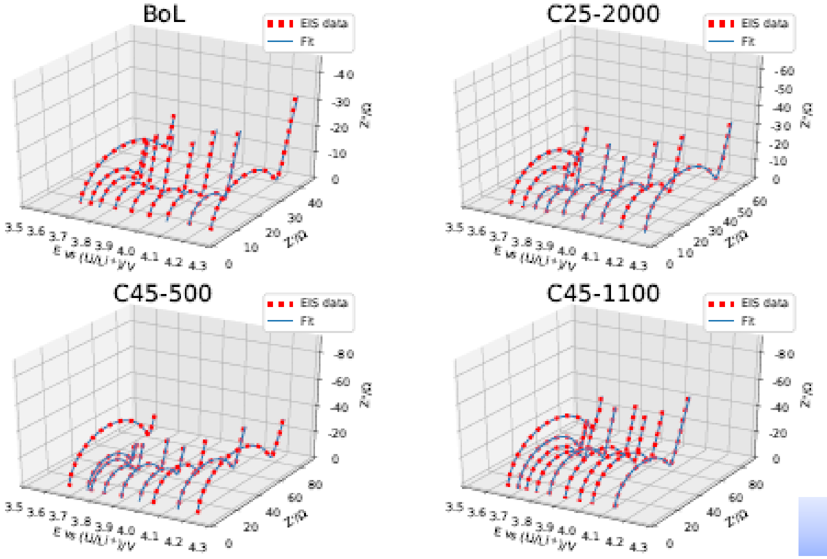
Sub-system 1

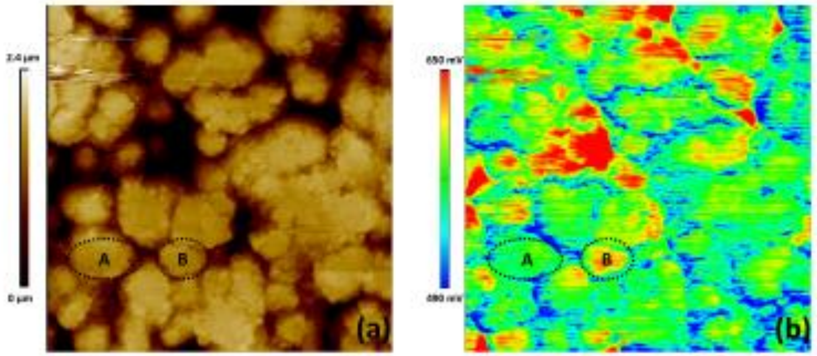
Sub-system 2

Sub-system 3

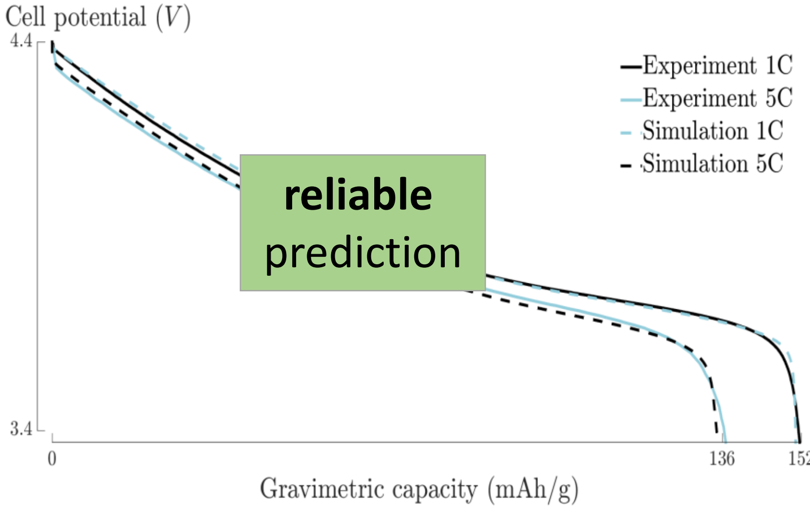
Equation
Electric conduction in the electrode $$\frac{\partial}{\partial x}\left(\sigma_{\text{eff}}\frac{\partial \Phi_s}{\partial x}\right)=0$$
Lithium diffusion in the Active Material $$\frac{\partial c_s}{\partial t}=\frac{1}{r^2}\frac{\partial}{\partial r}\left(D_s r^2\frac{\partial c_s}{\partial r}\right)$$
Salt transport in the electrolyte $$\epsilon_e\frac{\partial \bar{c}_e}{\partial t}=\frac{\partial}{\partial x}\left(\bar{D}_{\text{eff}}\frac{\partial \bar{c}_e}{\partial x}\right)+\frac{\partial}{\partial x}\left(\frac{\omega_{+,\text{eff}}}{\nu_+}\frac{\partial \bar{\Phi}_e}{\partial x}\right)+\epsilon_a\bar{j}$$ $$\frac{\partial}{\partial x}\left(\kappa_{\text{eff}}\frac{\partial \bar{\Phi}_e}{\partial x}\right)+\frac{\partial}{\partial x}\left(\gamma_{\text{eff}}\frac{\partial \bar{c}_e}{\partial x}\right)+Fz_+\epsilon_a\bar{j}=0$$

sub-models & system model





experimental data on sub-system level



reliable prediction

measurements on system level

Polymer Microwave Fiber

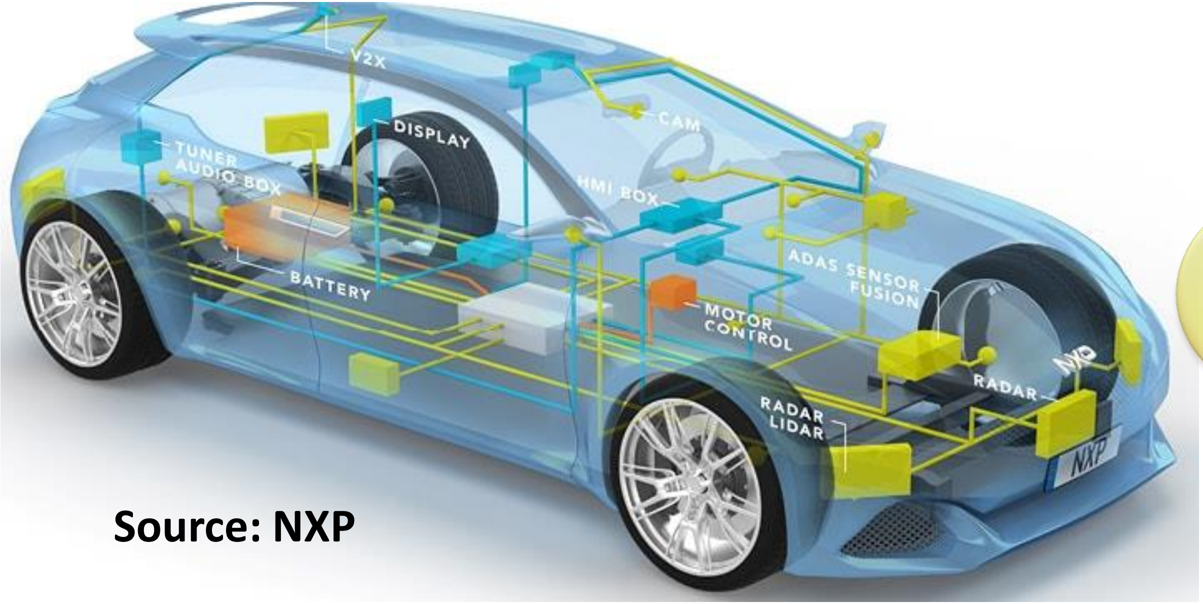
a blend of RF, copper and optical communication

David Maes

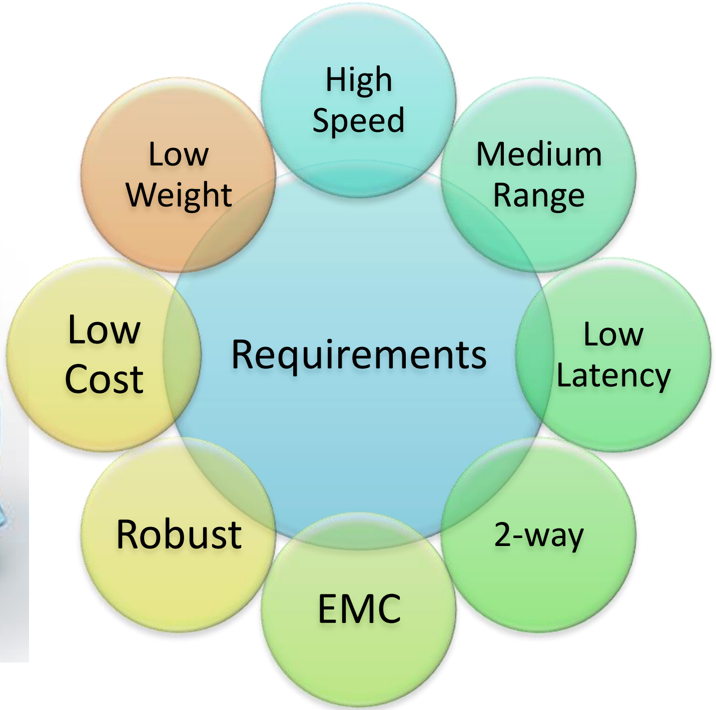
KU LEUVEN

KU LEUVEN micas

In-car data communication

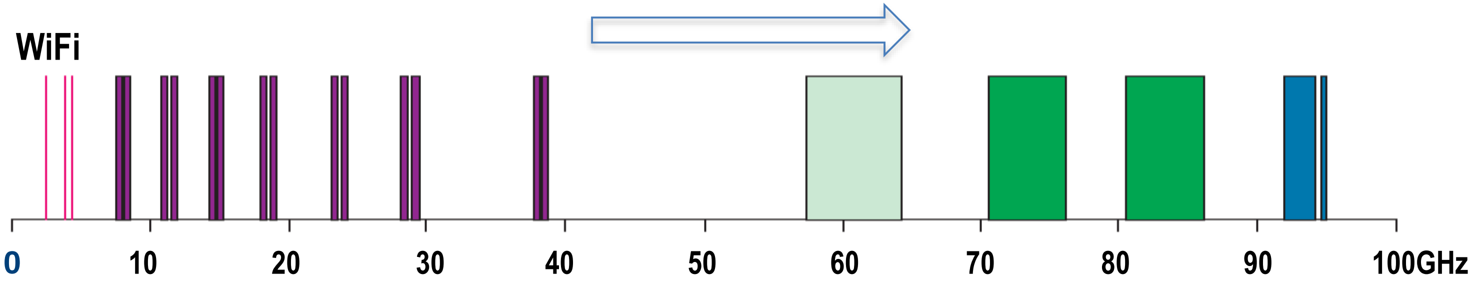


Source: NXP

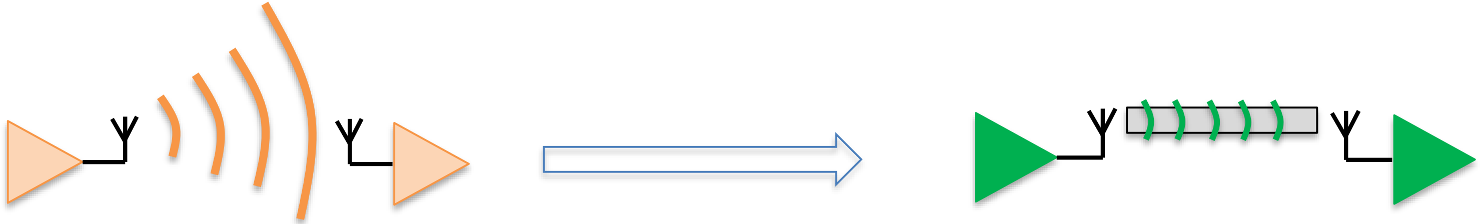


How to get there

Step 1: Go to higher frequencies for higher bandwidth



Step 2: Confine signal in a small medium



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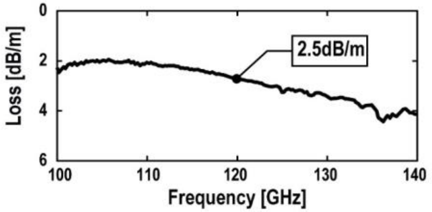
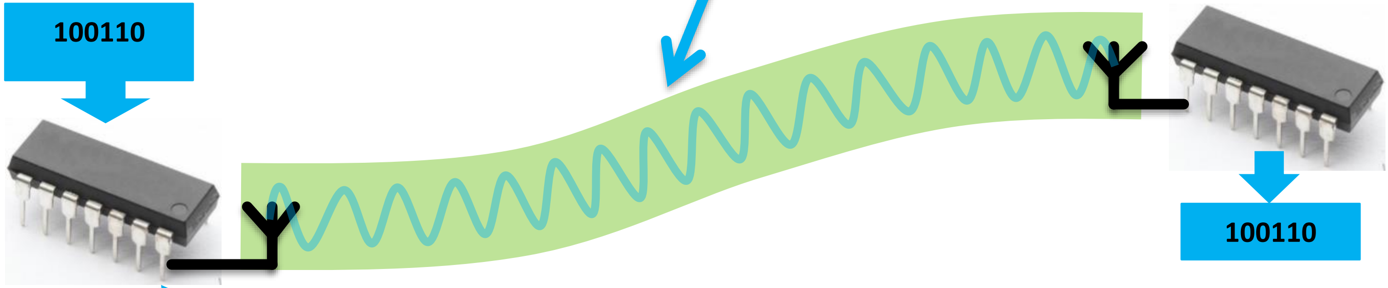
It is possible!

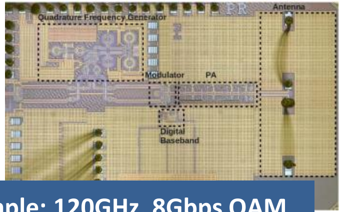
KEY: Cheap thin plastic fibers have low-loss for these mm-waves

Example: 2.5dB/m at 120GHz, for “Do-It-Yourself-grade” ø 2 mm Teflon tube

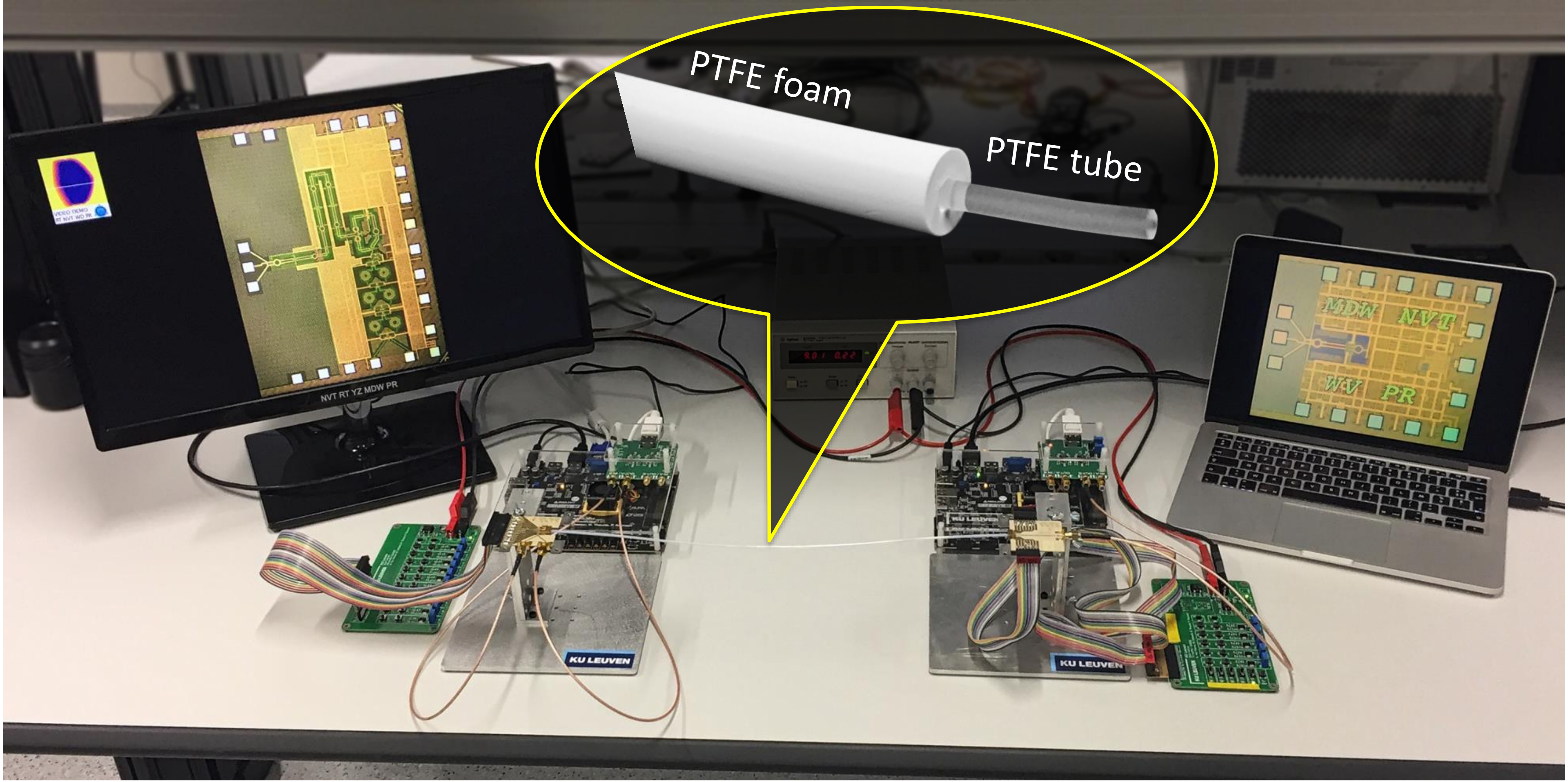




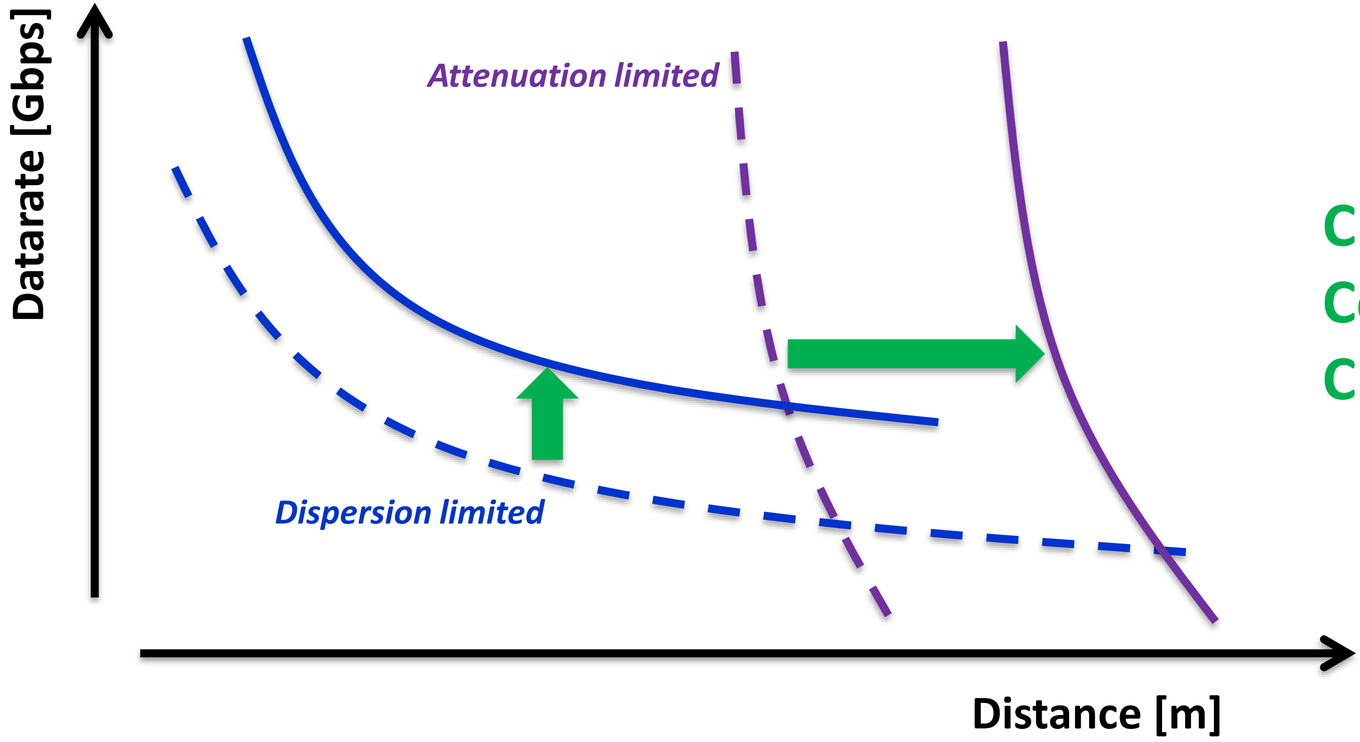
KEY: Moore’s Law makes it possible to design mm-wave CMOS transceivers with integrated antennas



Example: 120GHz, 8Gbps QAM transmitter in 40nm CMOS

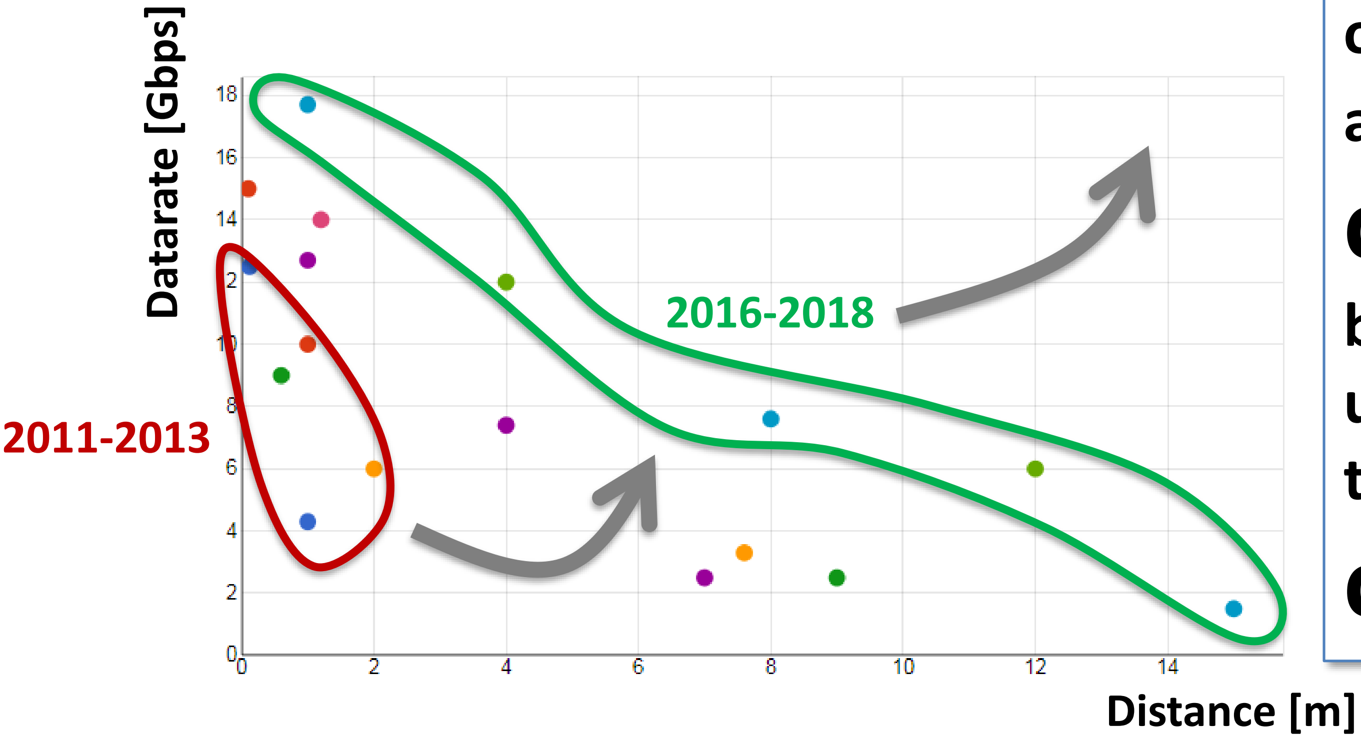

PTFE foam
PTFE tube
NVT RT YZ MDW PR
MDW
NVT
WV
PR
KU LEUVEN
KU LEUVEN

How to improve datarate and distance



Chips
Couplers
Channel

The end is not in sight!



We'll take care of the chips and the couplers, but we could use help on the channel…

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FACULTY OF SCIENCES

DEPARTMENT OF SOLID STATE SCIENCES
RESEARCH GROUP COCOON

Surface coating and functionalization of particles

Geert Rampelberg

Industry Meets Universities (BiR&D), Grimbergen, 2019/03/19

GHENT UNIVERSITY

erc

fwo

AGENTSCHAP INNOVEREN & ONDERNEMEN

Need for surface functionalization in particle technology

Problems to be solved:

- **Protection against environment**: air, moisture, chemicals, controlled release
- **Compatibility with environment**: adhesion, solubility, hydrophobicity
- **Rheology, tribology,…**
- **Active functionality on the surface**: catalysts, electrical conductivity

Solution:

Ultrathin conformal coatings

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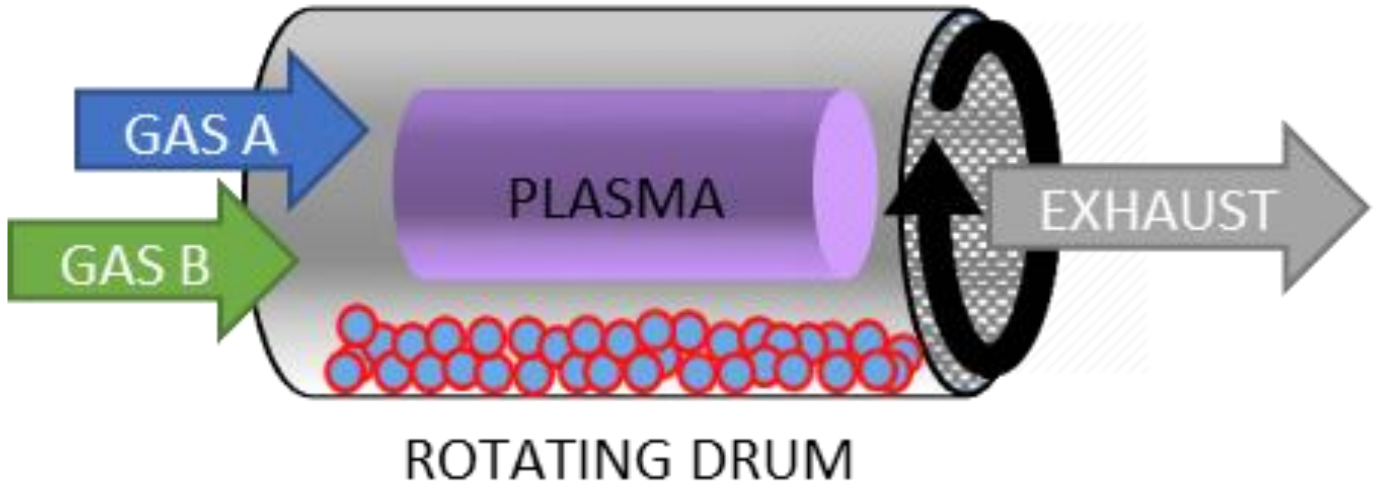
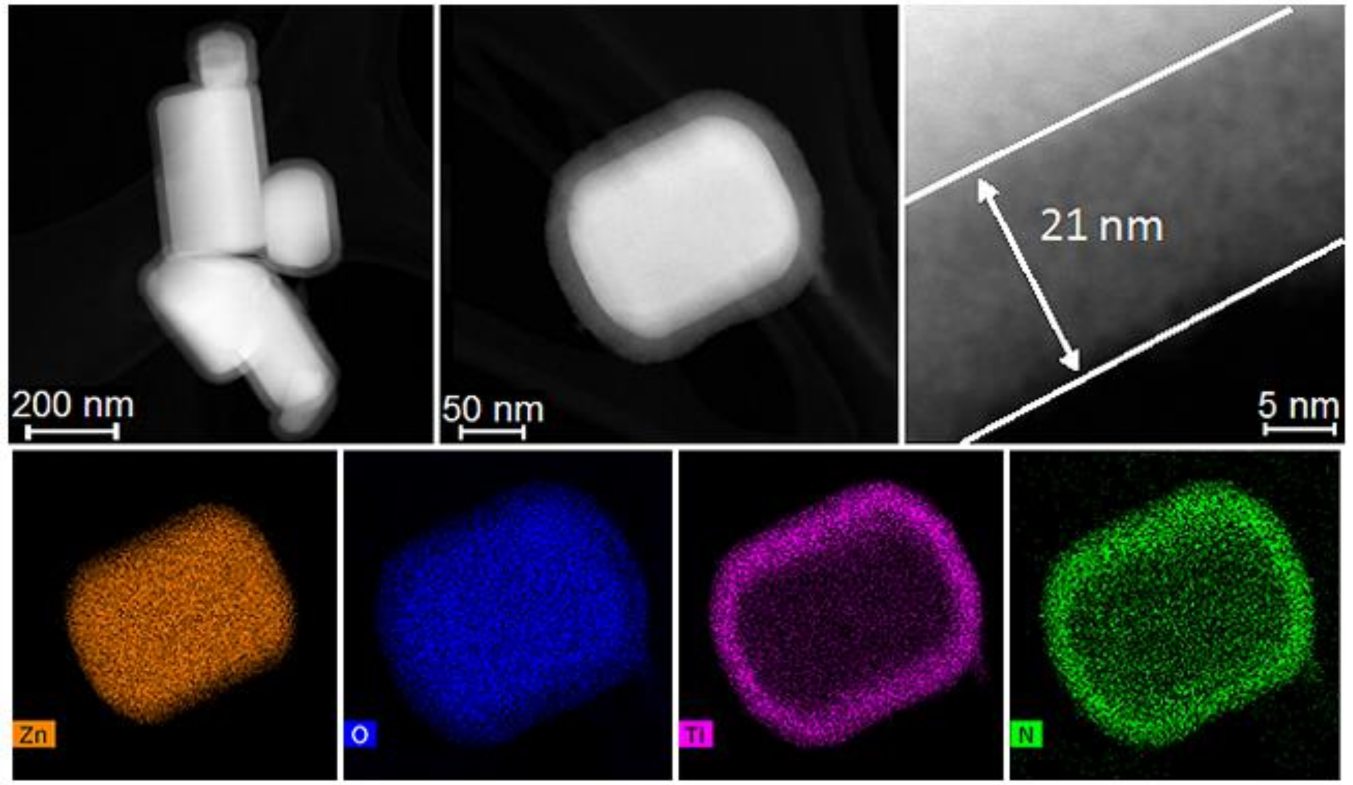
Atomic Layer Deposition (ALD)

- ✓ Gas-phase cyclic deposition process
- ✓ Layer-by-layer growth
- ✓ **Nanometer** thin coatings: 0.1-100nm
- ✓ **Conformal coatings into porous materials**
- ✓ **Metal oxides/nitrides**: Al_2O_3, SiO_2, TiO_2, TiN, ZrO_2, ZnO,…
- ✓ Noble metals



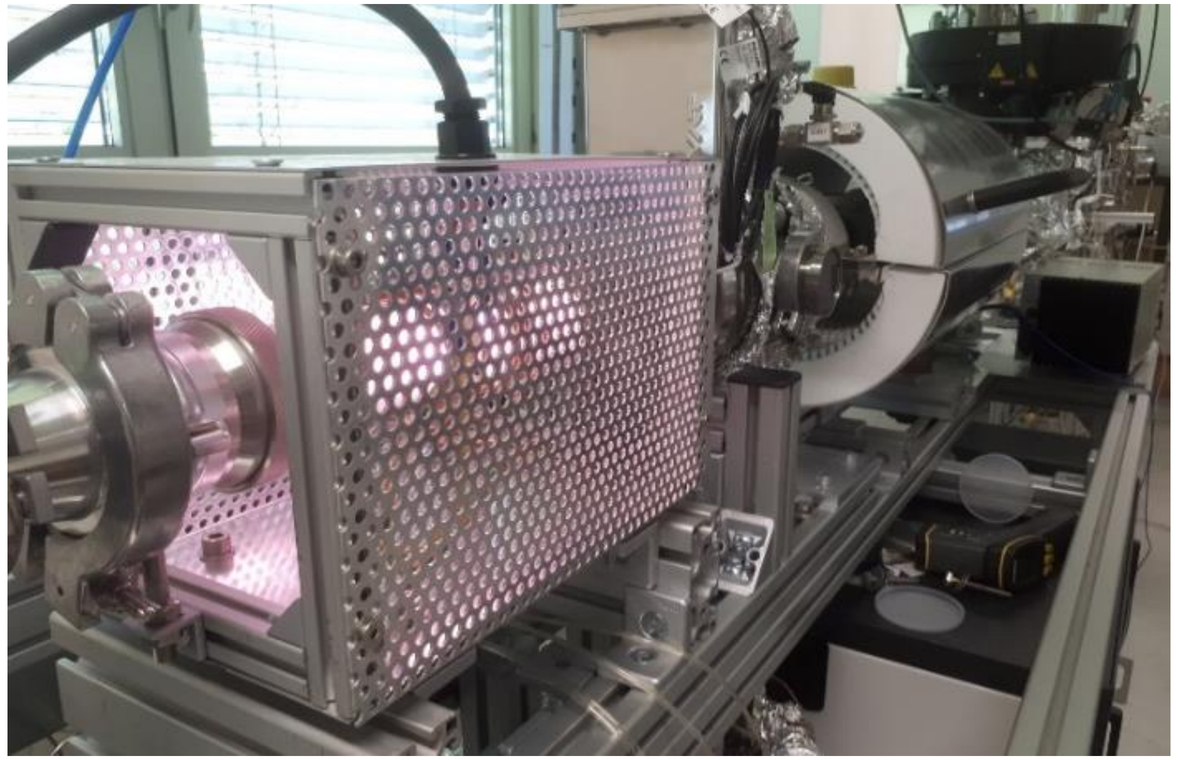
- ✓ **Patented rotary reactor**
- ✓ **Lab-system with kilogram scale capacity**
- ✓ **First customer in pipeline**



Conformal TiN coating around nano ZnO particles

Plasma-enhanced ALD (PE-ALD):

- ✓ **Cheaper**
- ✓ **Cleaner**
- ✓ **Safer**
- ✓ **Higher quality coatings**



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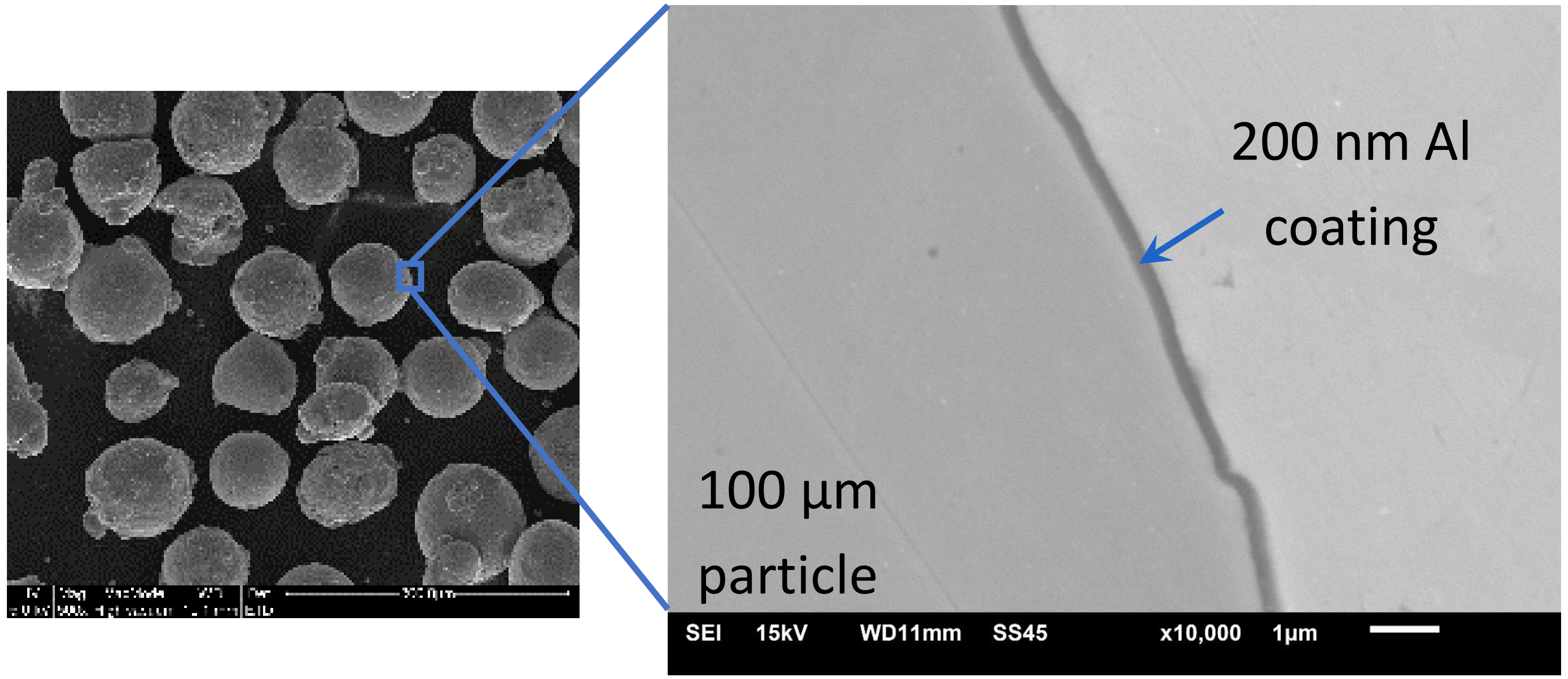
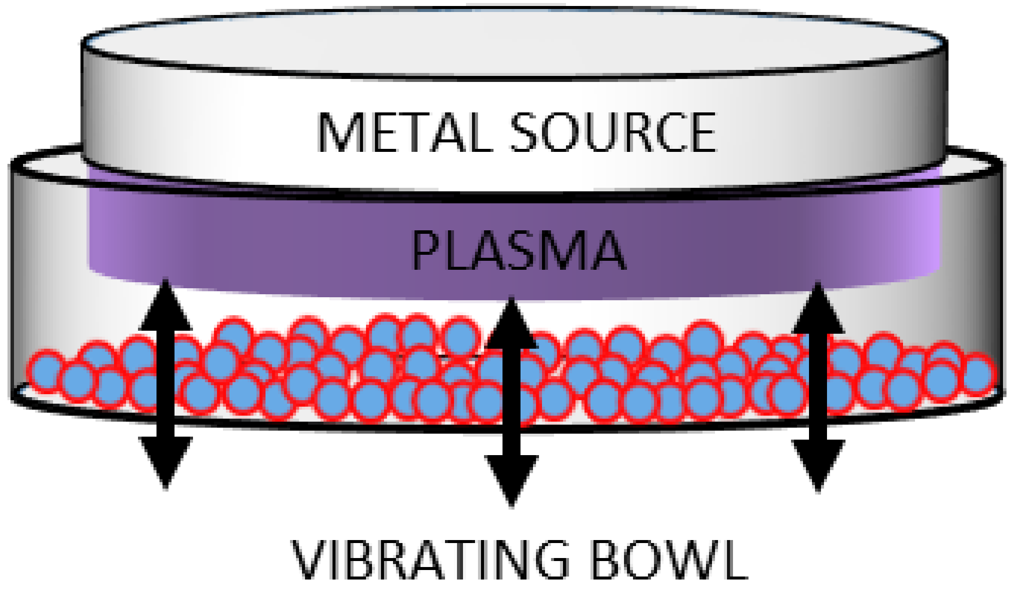
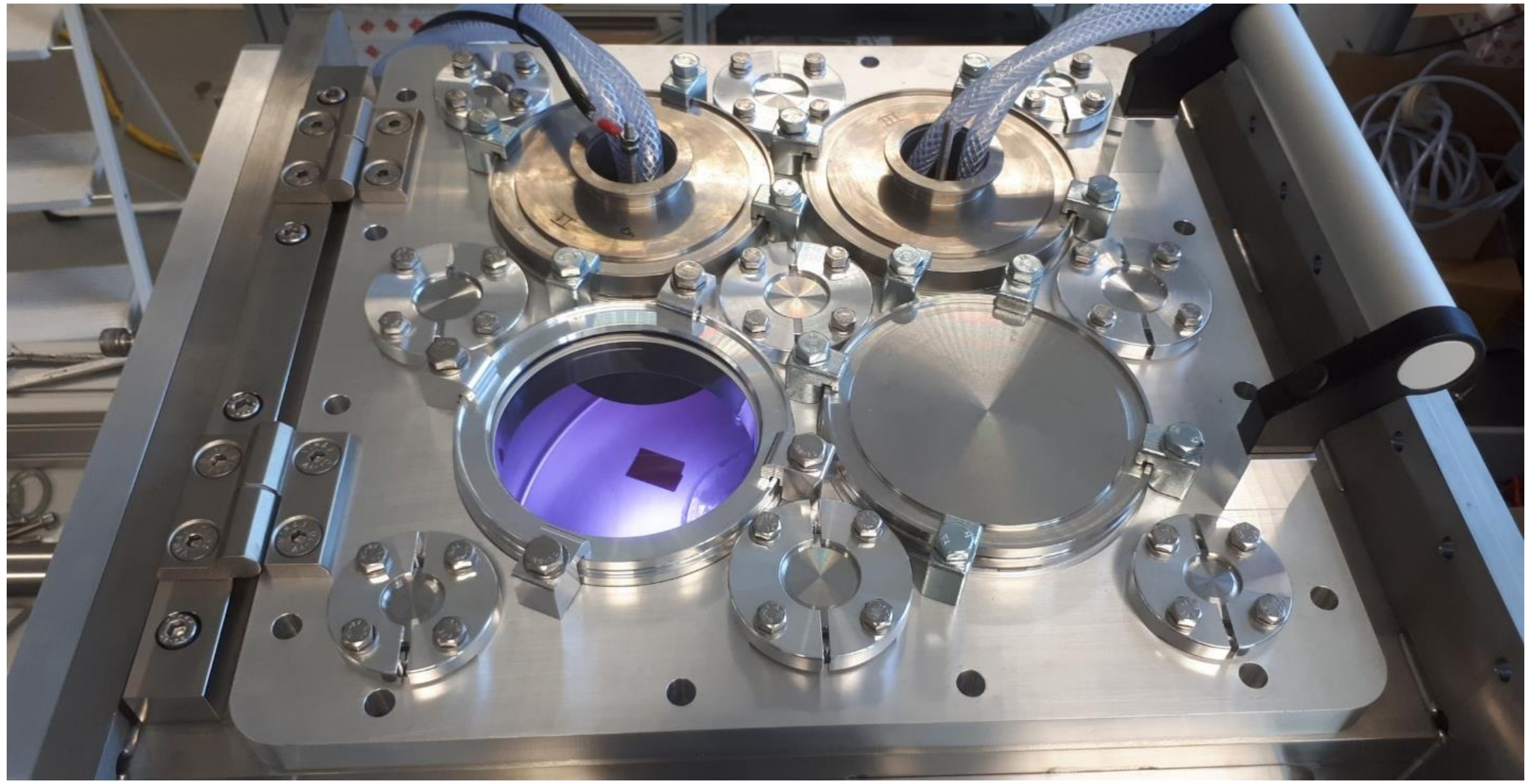
Magnetron sputtering (PVD)

- ✓ Gas-phase deposition
- ✓ Thicker coatings: 10nm – 1µm
- ✓ Conformal coatings onto **non-porous materials**
- ✓ **Metallic coatings**





- ✓ **Lab-system with kilogram scale capacity**
- ✓ **First system installed at customer**



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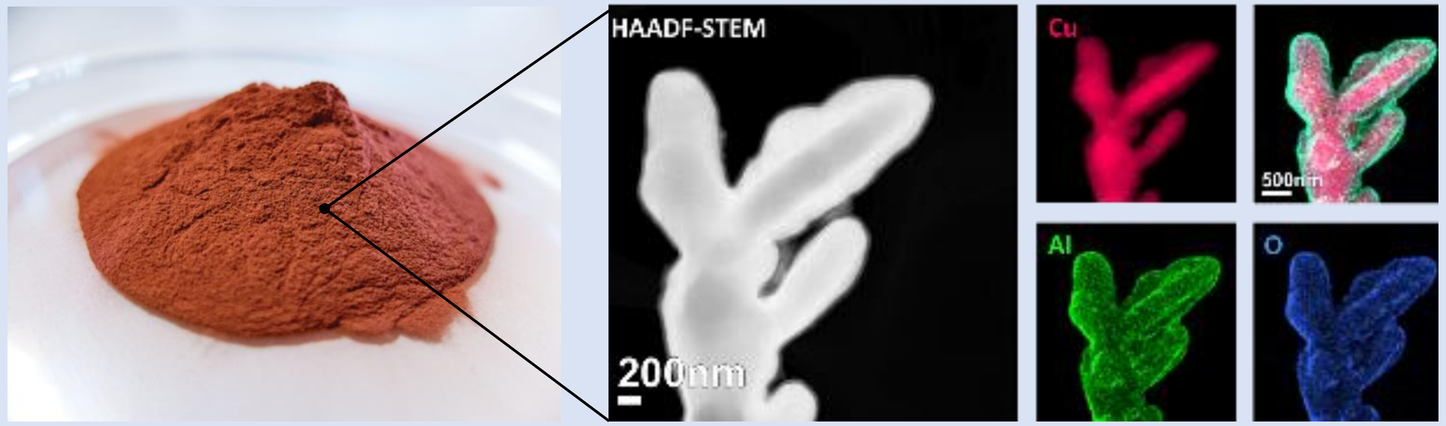
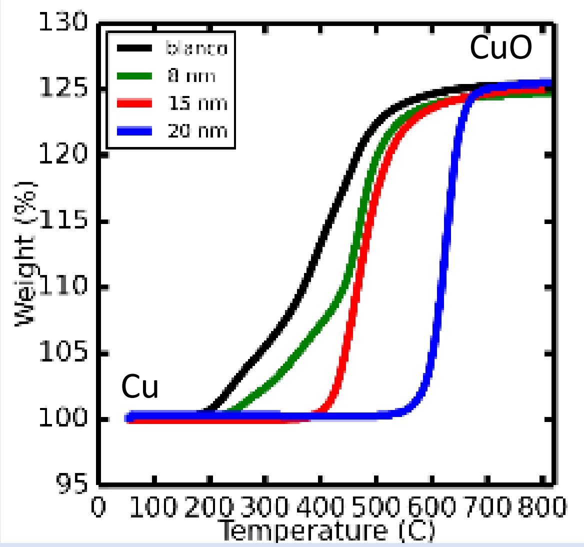
What we offer

Particles:
- ✓ Polymers, ceramics, metals,…
- ✓ nm → cm sized
- ✓ Porous & non-porous

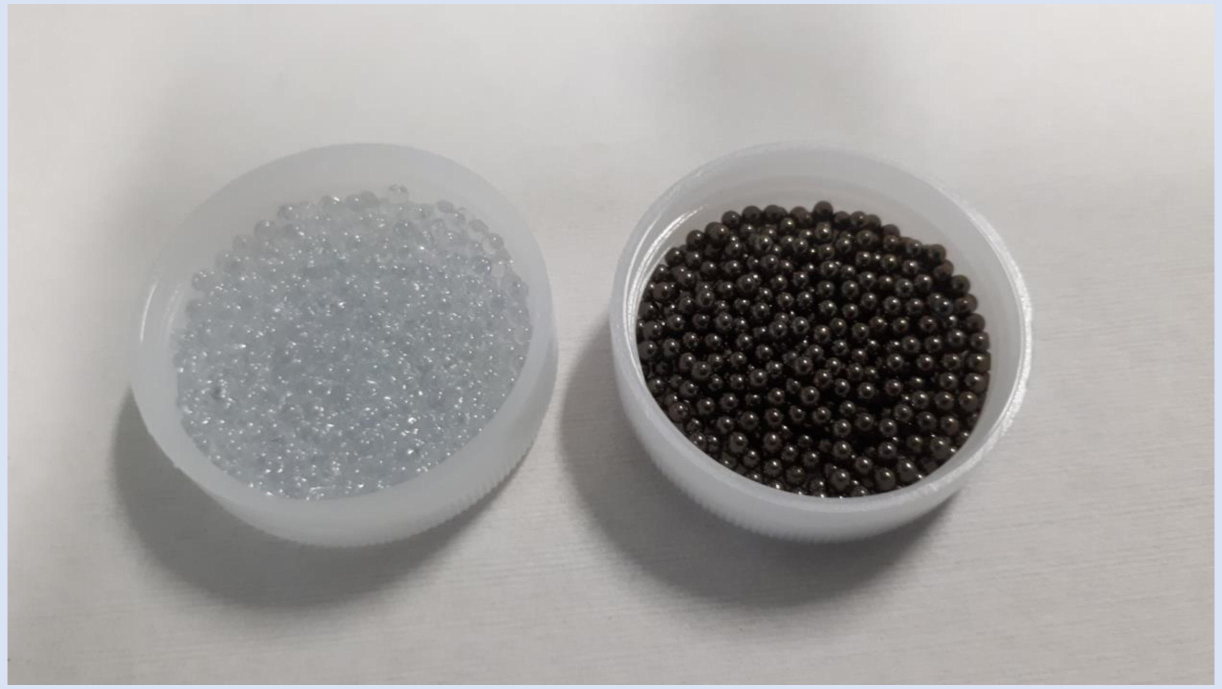
Coatings:
- ✓ Metal oxides/nitrides
- ✓ Metals
- ✓ … and more

Capabilities and prospects:
- ✓ Kilogram scale available
- ✓ Inert handling via glovebox
- ✓ Upscaling via spin-off

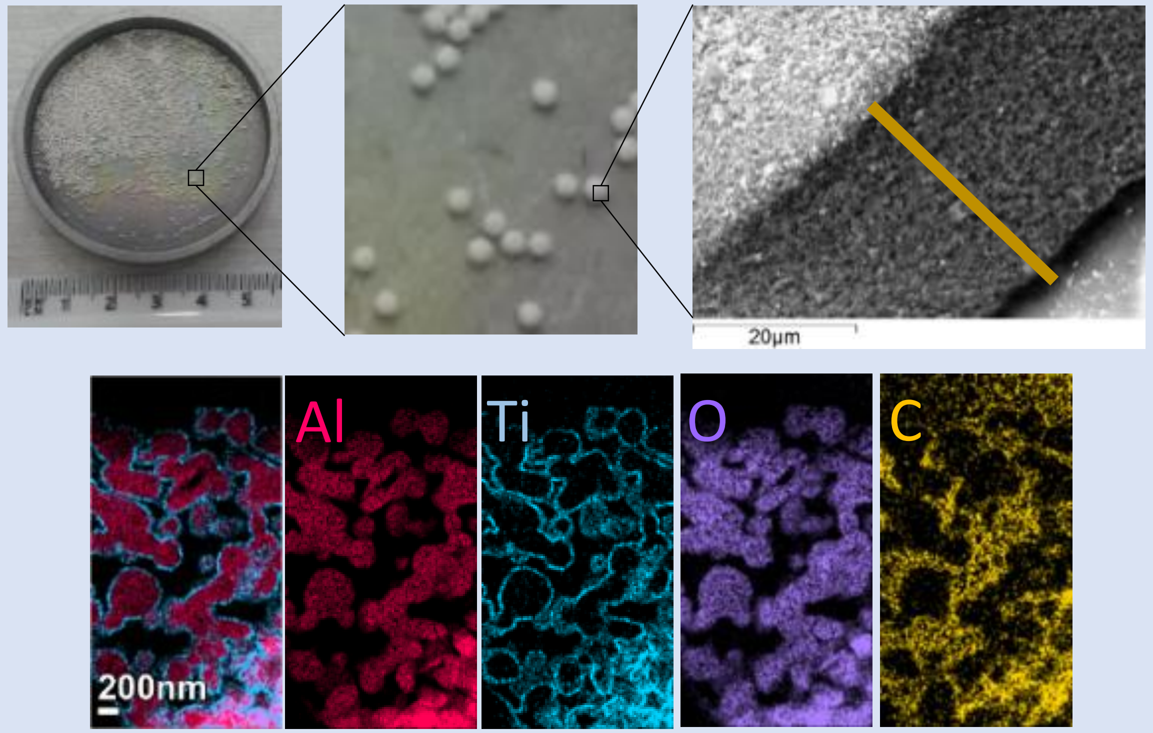




ALD – Conformal protective Al_2O_3 coating on copper powder



PVD – Metallized glass beads



ALD – Depth tuning of TiO_2 coating inside porous Al_2O_3 particles

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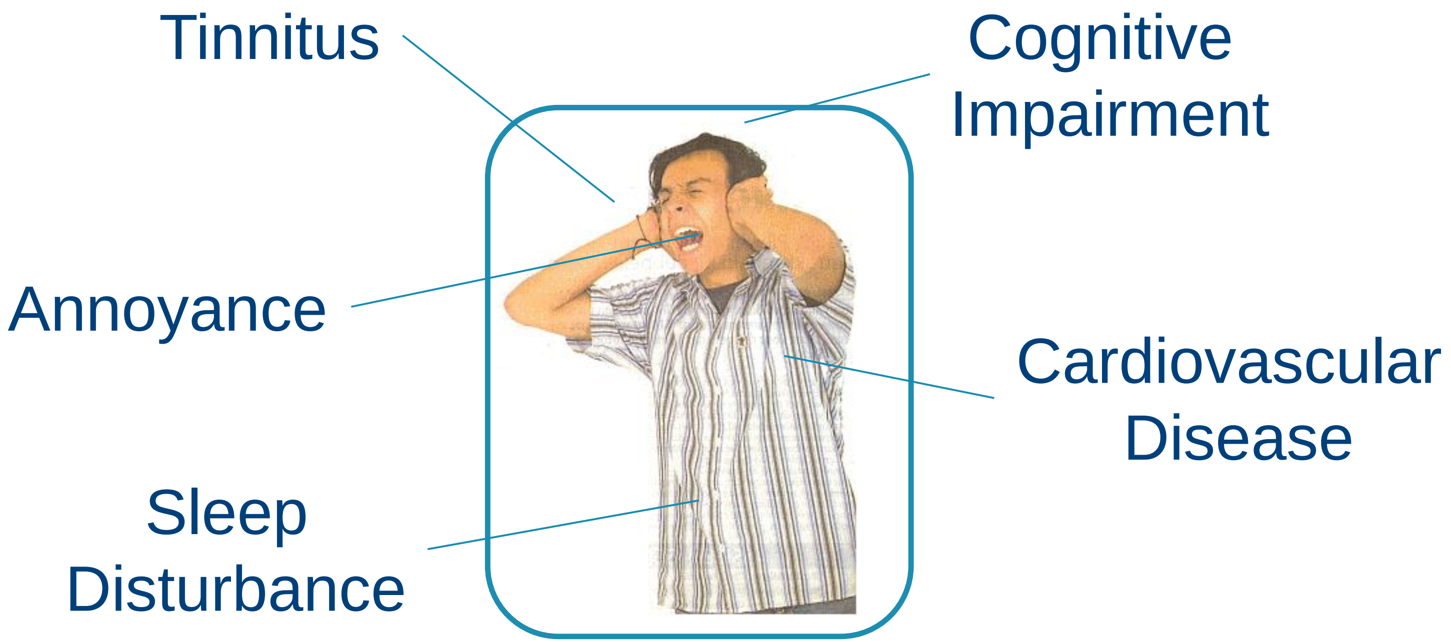
KU LEUVEN

Vibro-acoustic metamaterials

towards light and compact vibro-acoustic solutions

claus.claeys@kuleuven.be

Noise is the second most deadly pollutant in western Europe

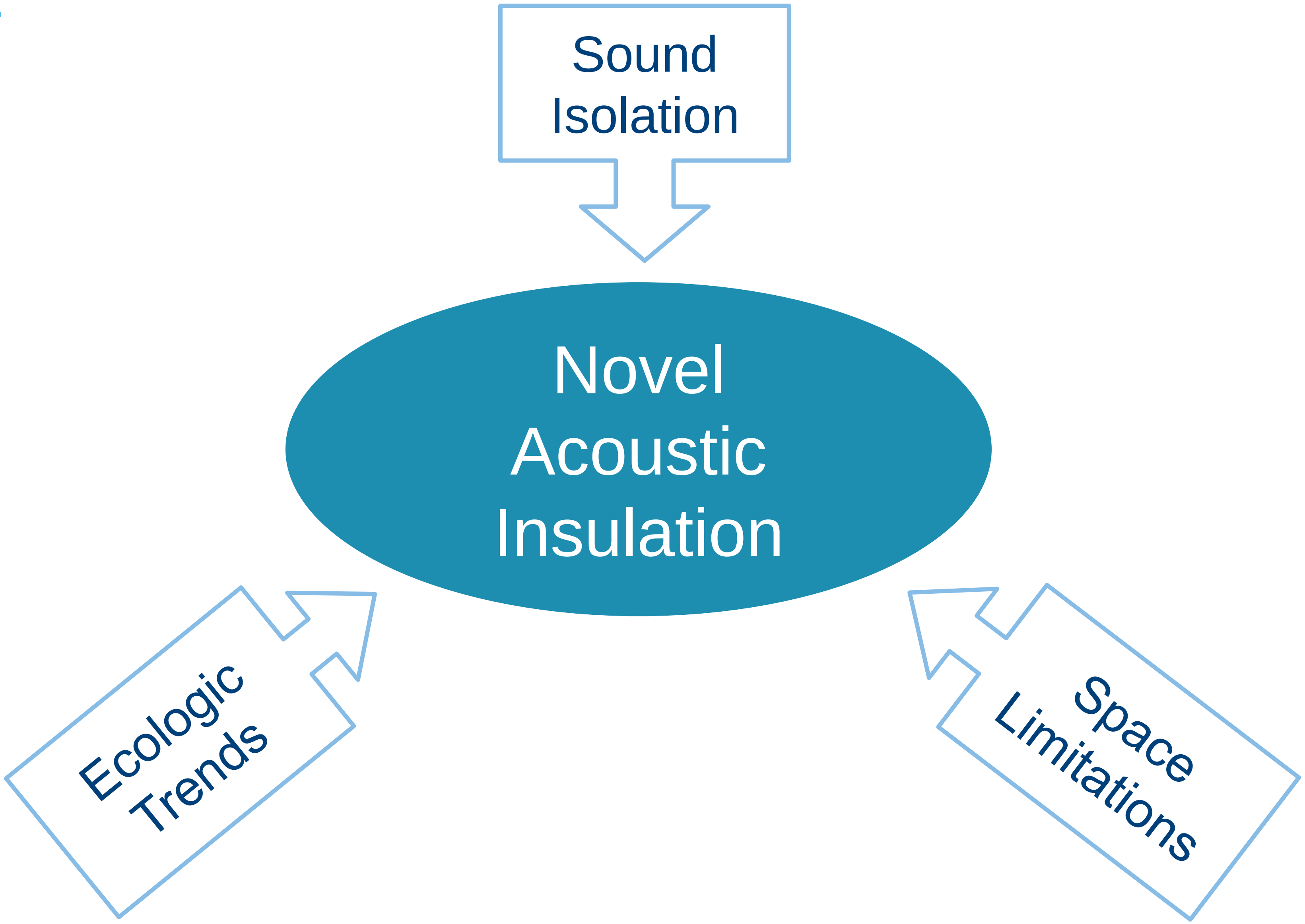


*“At least **one million healthy life years** are **lost** every year from traffic related **noise** in the western part of Europe”*

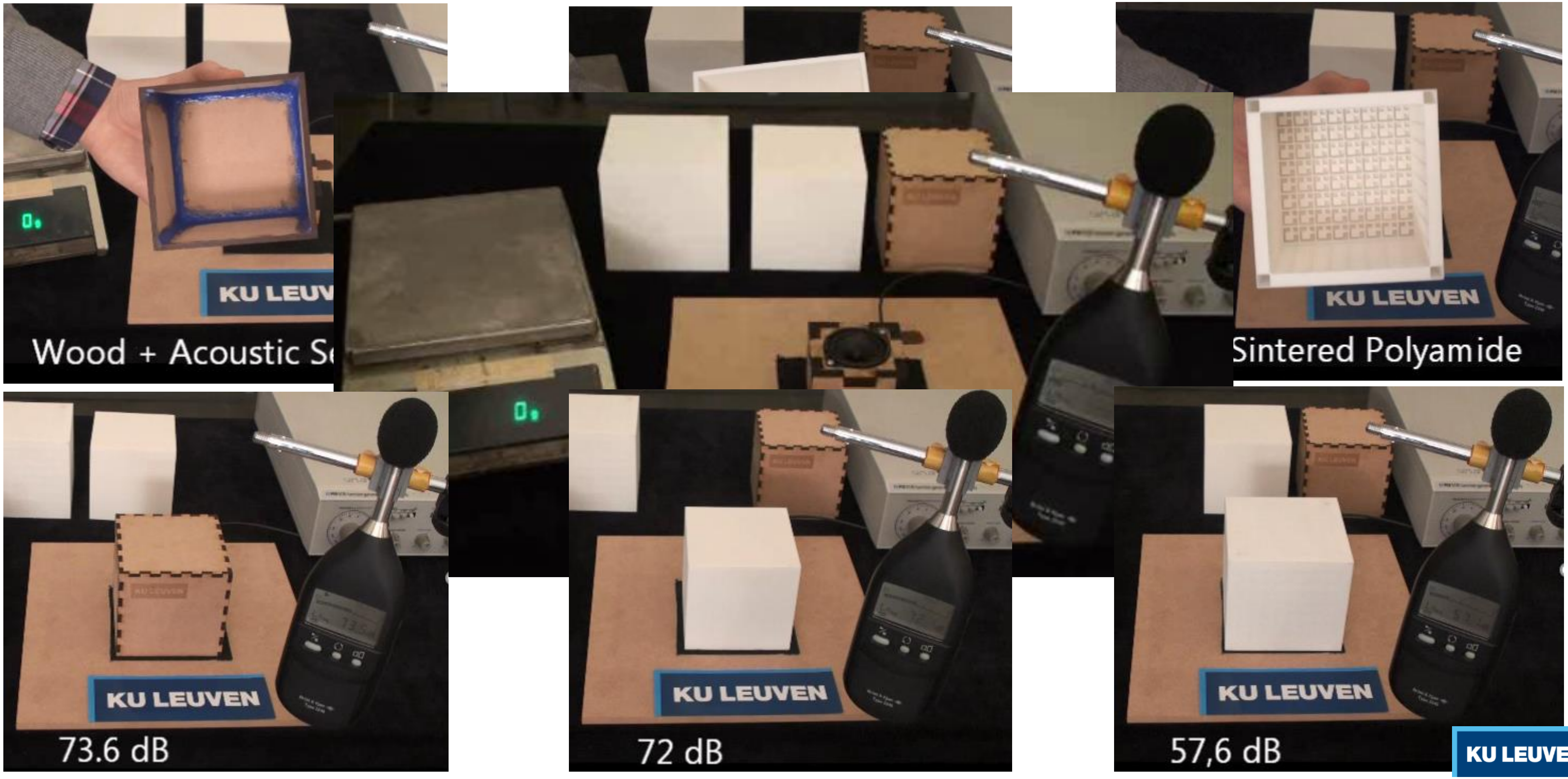
How to block noise?

by adding **volume** and/or **mass**

Conflict

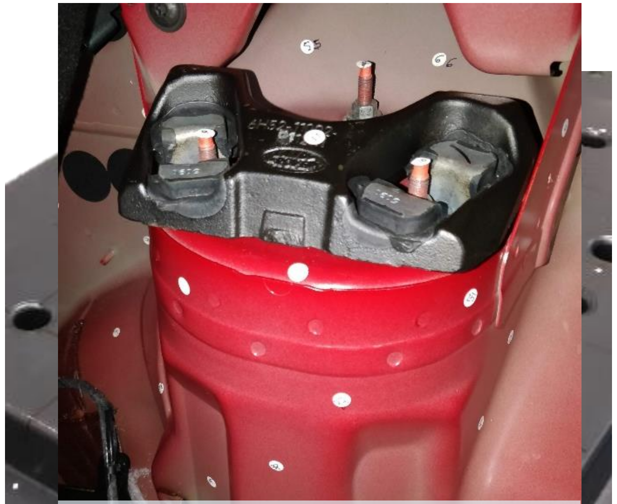

Sound Isolation
Novel Acoustic Insulation
Ecologic Trends
Space Limitations

Novel acoustic insulation



Metamaterial concept

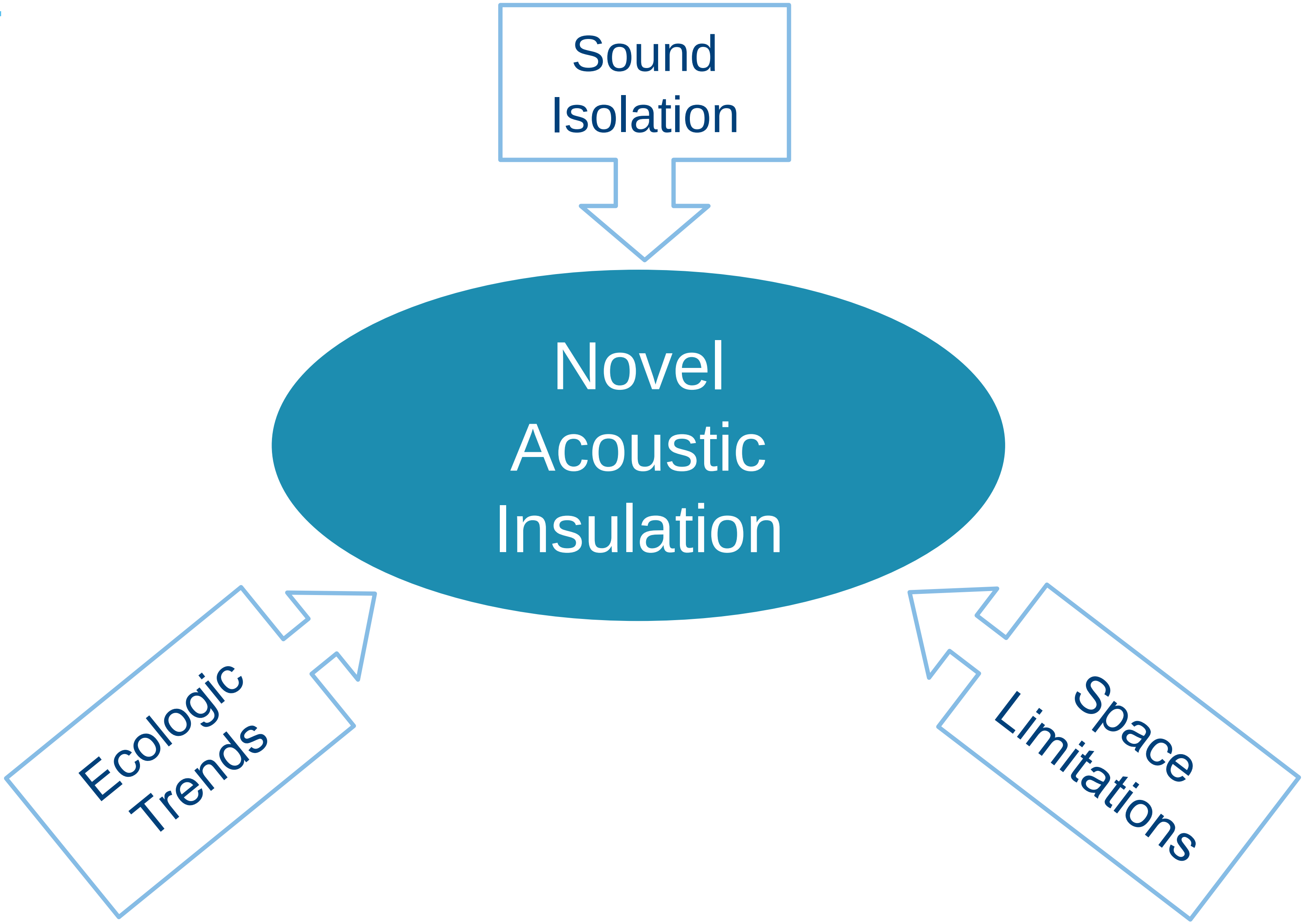
- Favourable vibro-acoustic behaviour (transmission loss or vibration attenuation) in desired frequency bands
- Large design freedom: shape, materials, production process…



current solution
vibration absorber: 2.92 kg

proposed solution
metamaterial: 1.52 kg

Conflict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Ecologic Trends
Space Limitations

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