

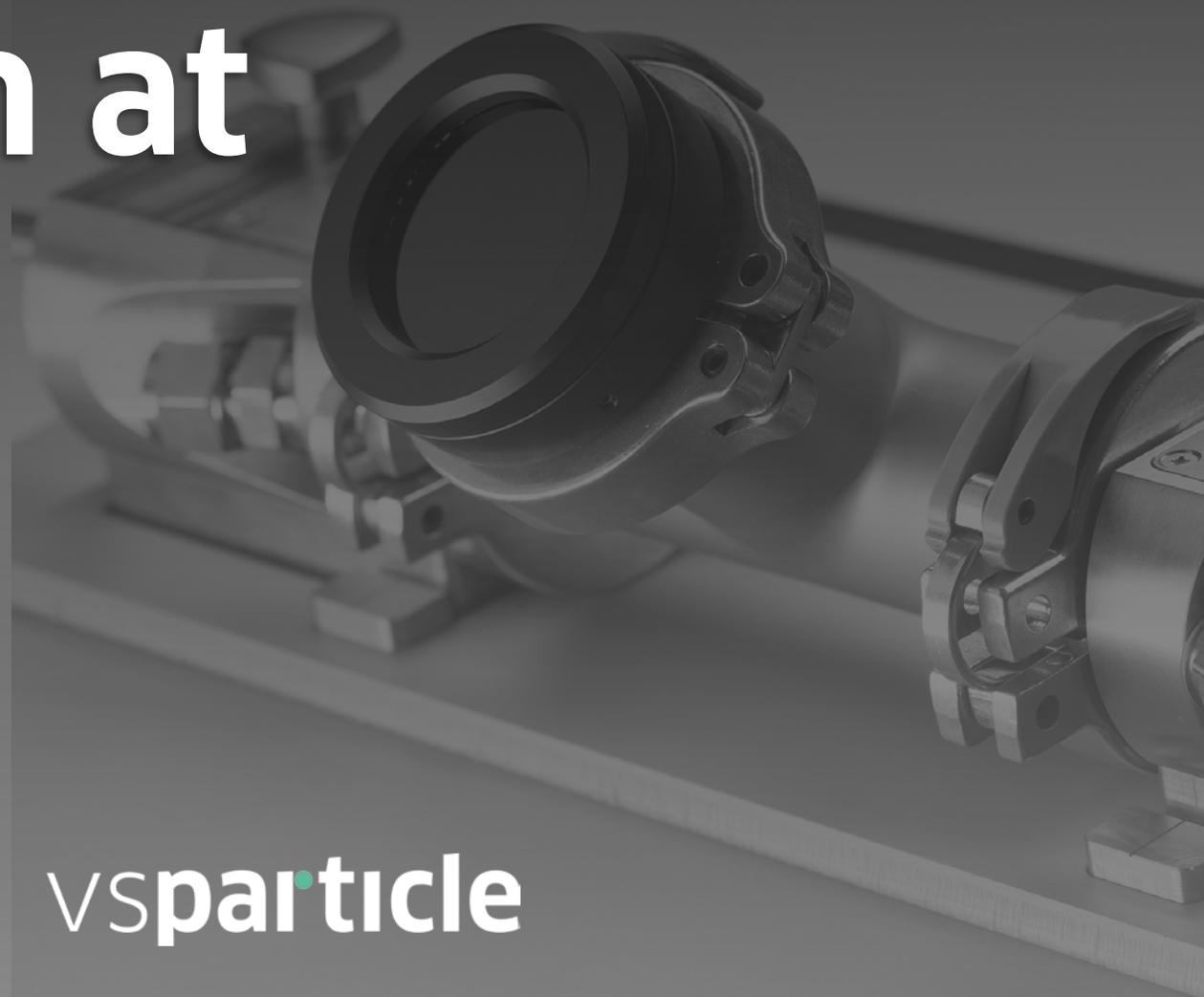
KIVI jaarcongres 2018

Circular design at the nanoscale

*edited for easier reading

CARBON 

vsparticle



vSparticle

Creating new materials

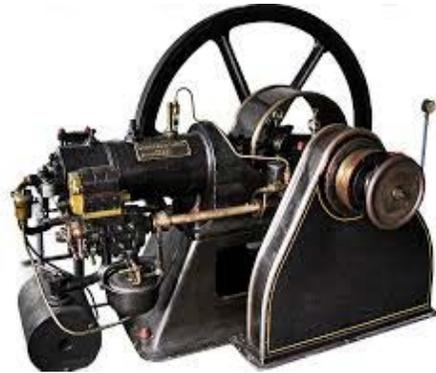
Our ability to craft new materials have played a critical role the evolution of human kind



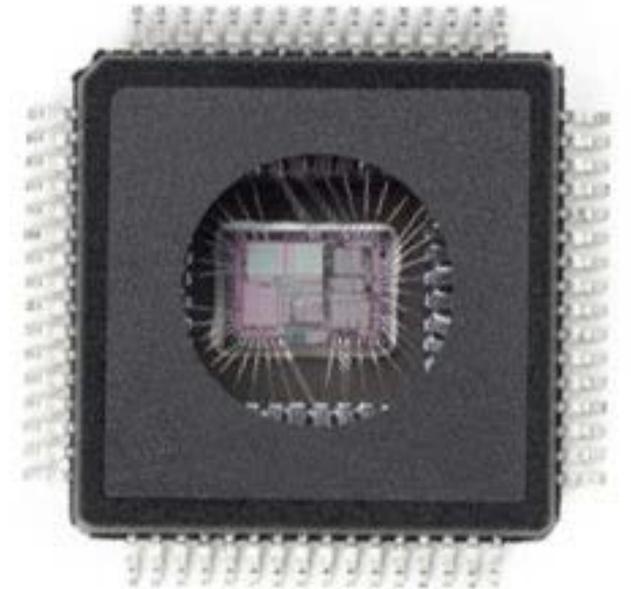
Stone age



Bronze age



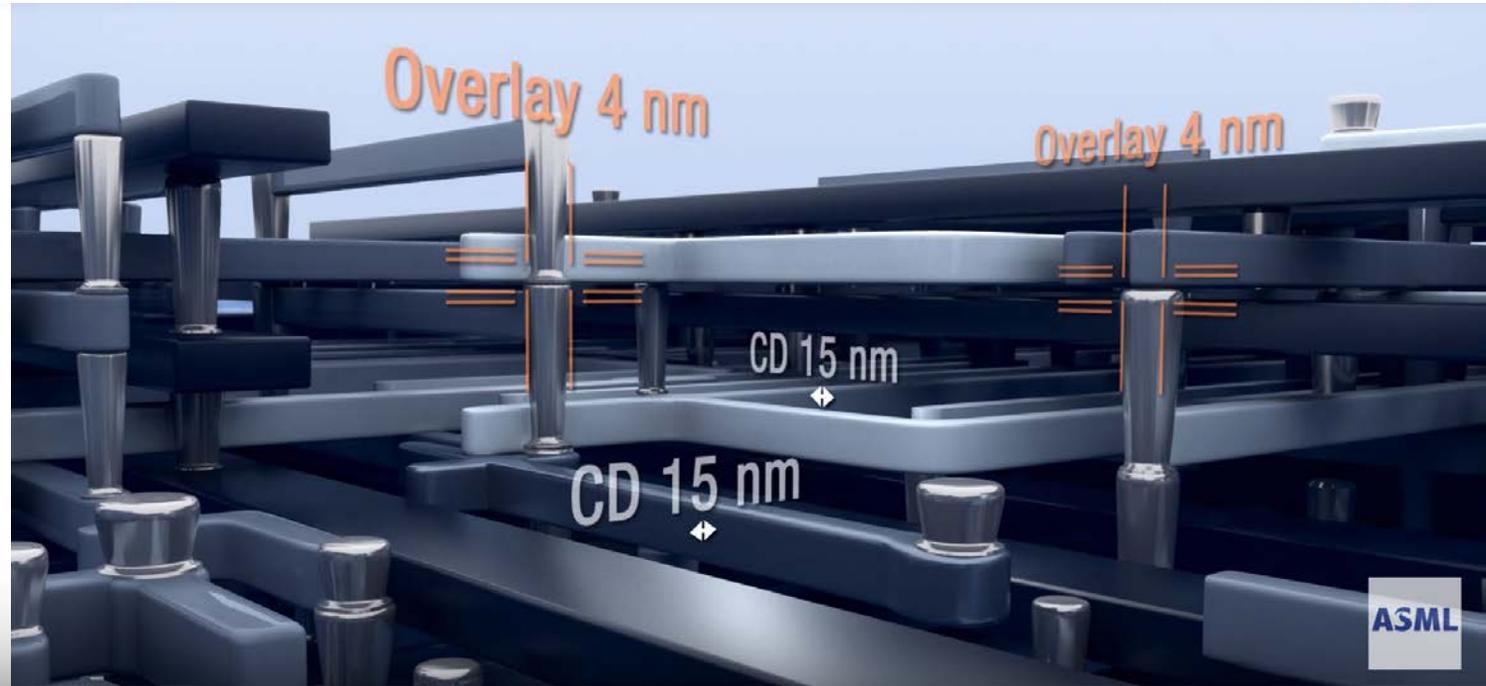
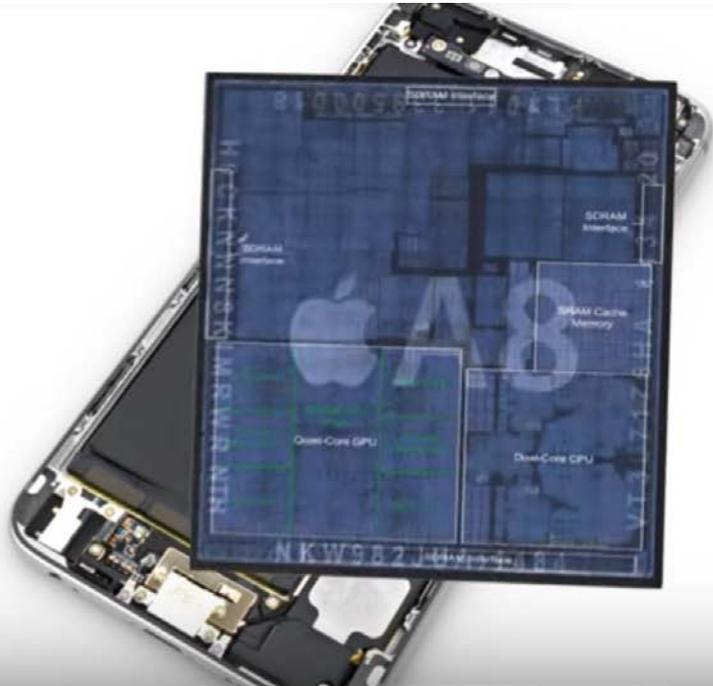
Iron age



Silicon age

Next level control

Crafting and engineering has entered the nanoscale



©ASML

The whole video: https://youtu.be/2z9qme_ygRI

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The next era of Materials.

At the nanoscale we are now also able to study materials and discover why a material has certain properties.



We actually see a lot more interaction than what we would expect from an inorganic material:

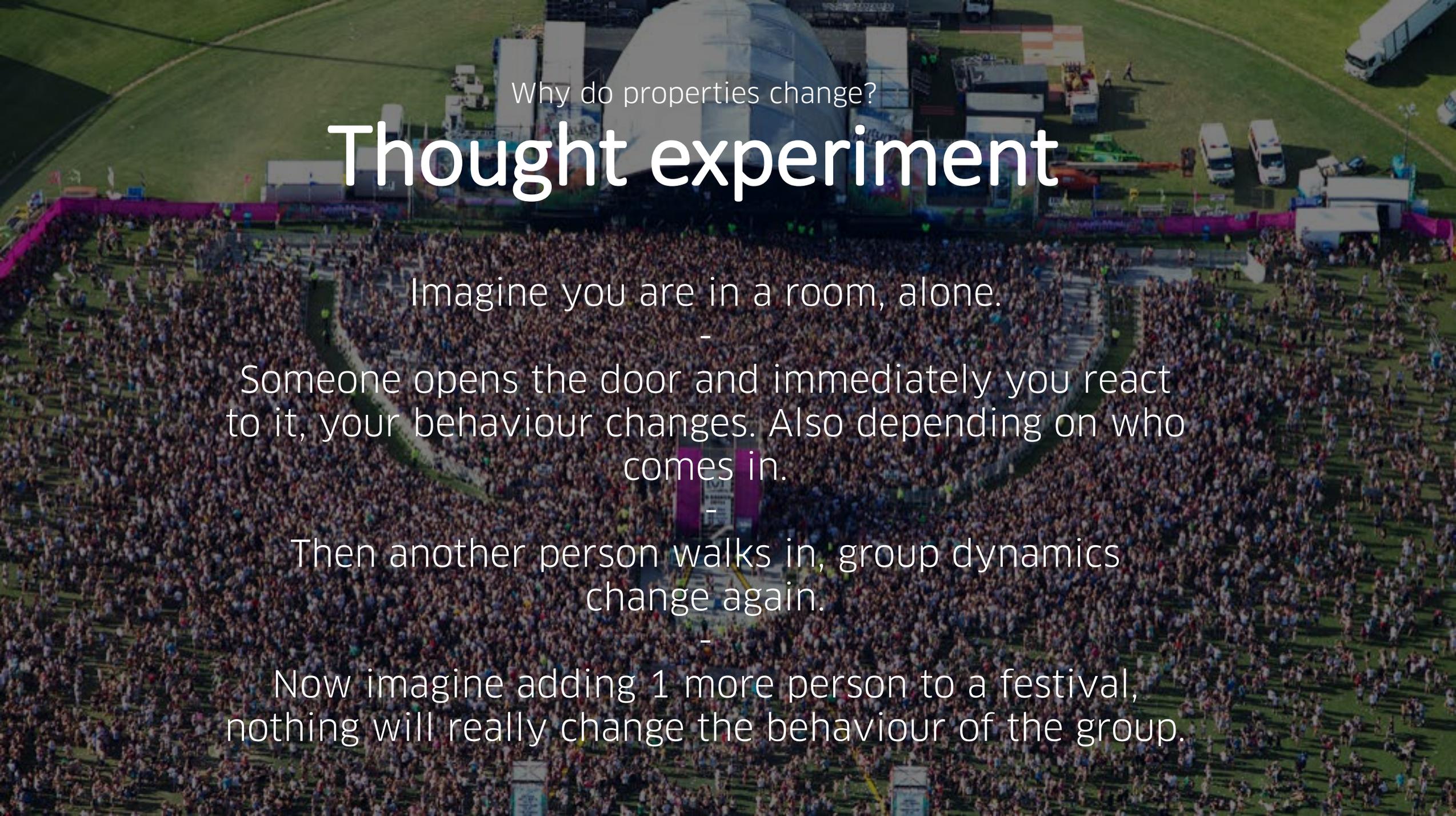
<https://youtu.be/vtZRA6sE4ek>

Source:
www.denssolutions.com

New properties at the nanoscale

At the nanoscale, because of quantum effects, properties change. Silver like below, has a black color when it is made from nanosized bits of material (particles). With such a low melting temperature, that it melts on a simple hot plate and returns to it's 'normal' color and properties.



An aerial photograph of a large outdoor festival. A massive crowd of people fills the lower two-thirds of the frame. In the background, there's a large white dome-shaped structure, possibly a stage or a tent, surrounded by other festival infrastructure like trailers and vehicles. The scene is set on a grassy field under bright daylight.

Why do properties change?

Thought experiment

Imagine you are in a room, alone.

-

Someone opens the door and immediately you react to it, your behaviour changes. Also depending on who comes in.

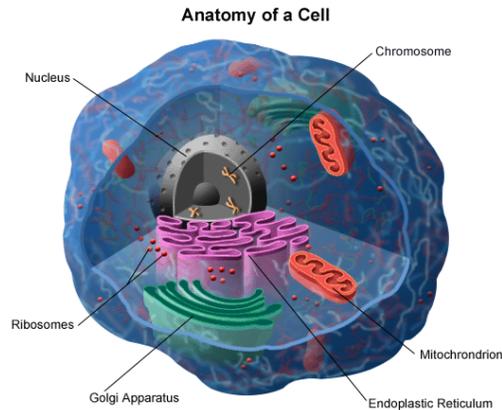
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Then another person walks in, group dynamics change again.

-

Now imagine adding 1 more person to a festival, nothing will really change the behaviour of the group.

Living and dead materials.

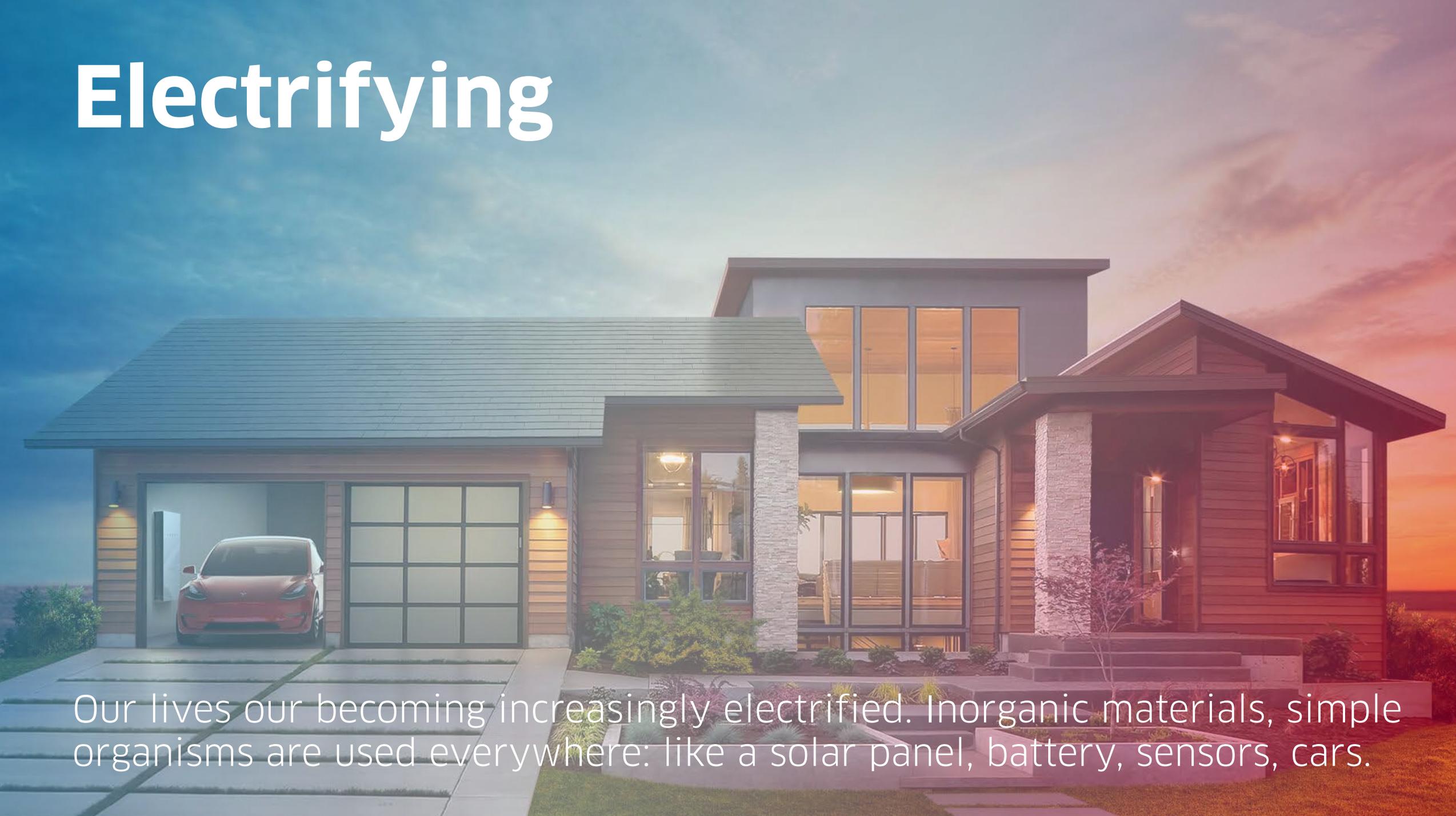


Complex organism

Simple organism

In a way, we could say there are two types of 'organisms'. Inorganic materials could be seen as simple organisms that we can predict, control and (re)program by playing with size, composition and environment.

Electrifying

A modern, two-story house with a mix of wood siding and stone accents. The house is illuminated from within, showing a bright interior. A red car is parked in the garage on the left. A solar panel is visible on the roof. The sky is a mix of blue and orange, suggesting dusk or dawn. The overall scene is clean and modern, representing a sustainable and electrified lifestyle.

Our lives are becoming increasingly electrified. Inorganic materials, simple organisms are used everywhere: like a solar panel, battery, sensors, cars.

When it comes to material properties, it is so complex and huge that only a fraction has been explored. Scientists and engineers are discovering new properties and applying them to new products on the go.

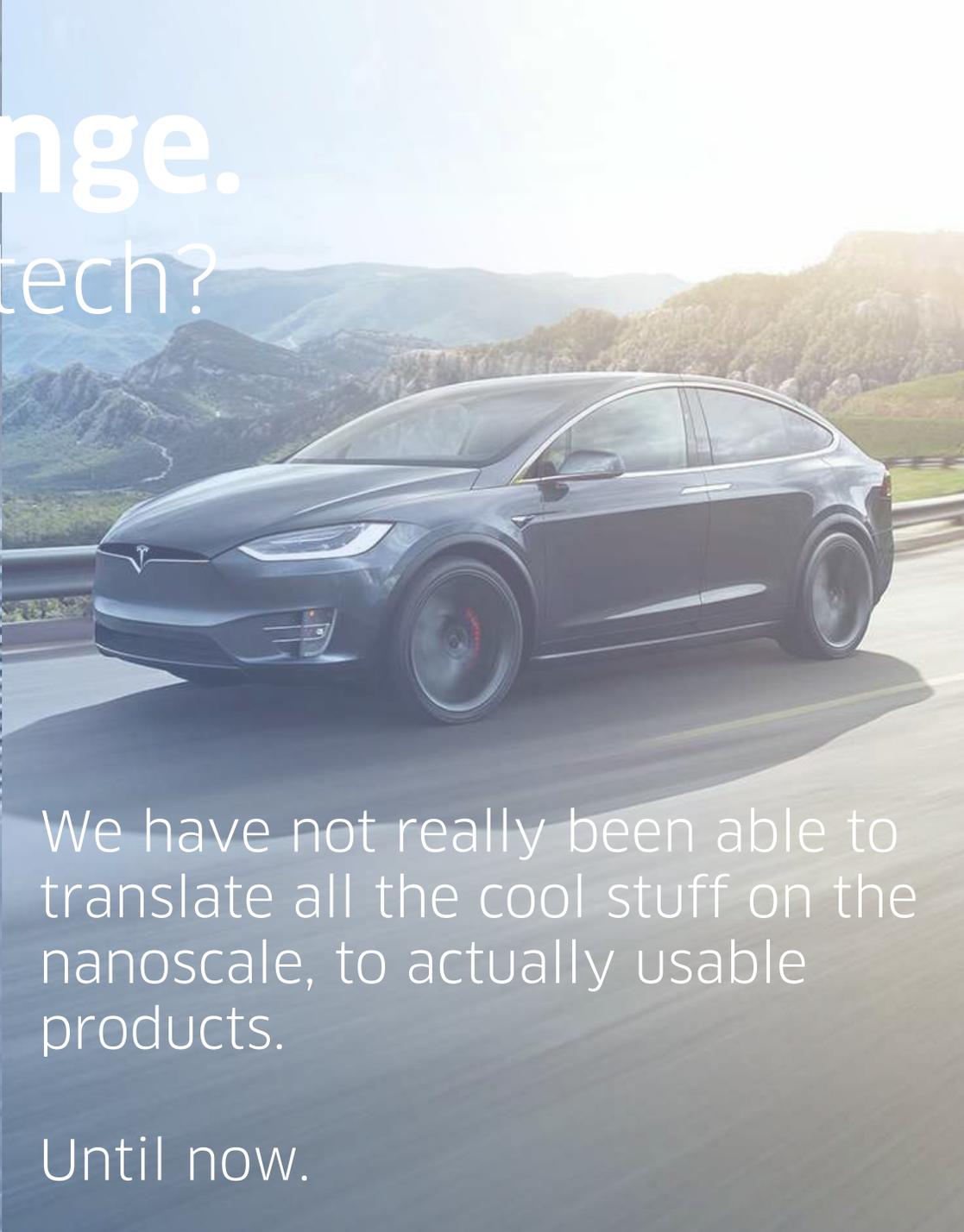
Basically we are discovering a whole new dimension of the periodic table.



The biggest challenge.

What happened to nanotech?

20 nm

A dark blue Tesla Model X is shown driving on a paved road that curves through a scenic mountainous landscape. The car is in the foreground, moving towards the right. The background features rolling hills and mountains under a bright sky, suggesting a sunrise or sunset. The overall scene conveys a sense of modern technology integrated into a natural environment.

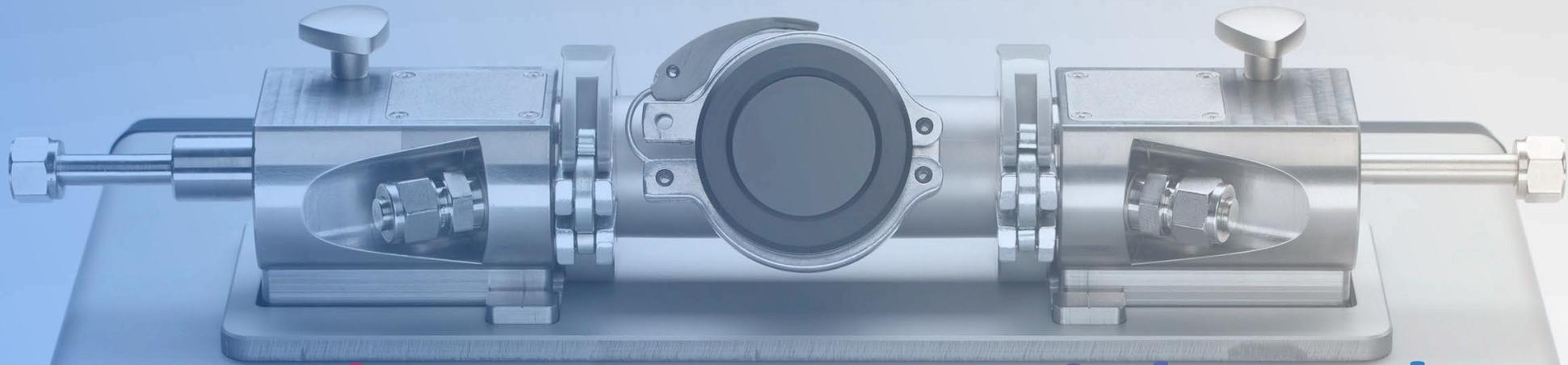
We have not really been able to translate all the cool stuff on the nanoscale, to actually usable products.

Until now.

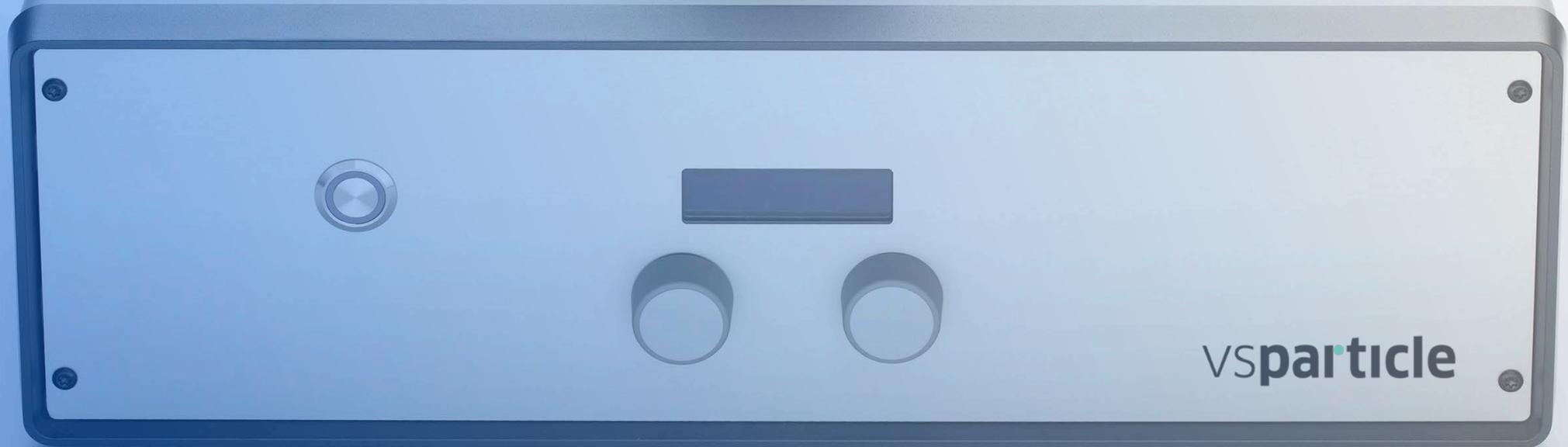


CHANGING THE FUTURE WITH THE PUSH OF A BUTTON

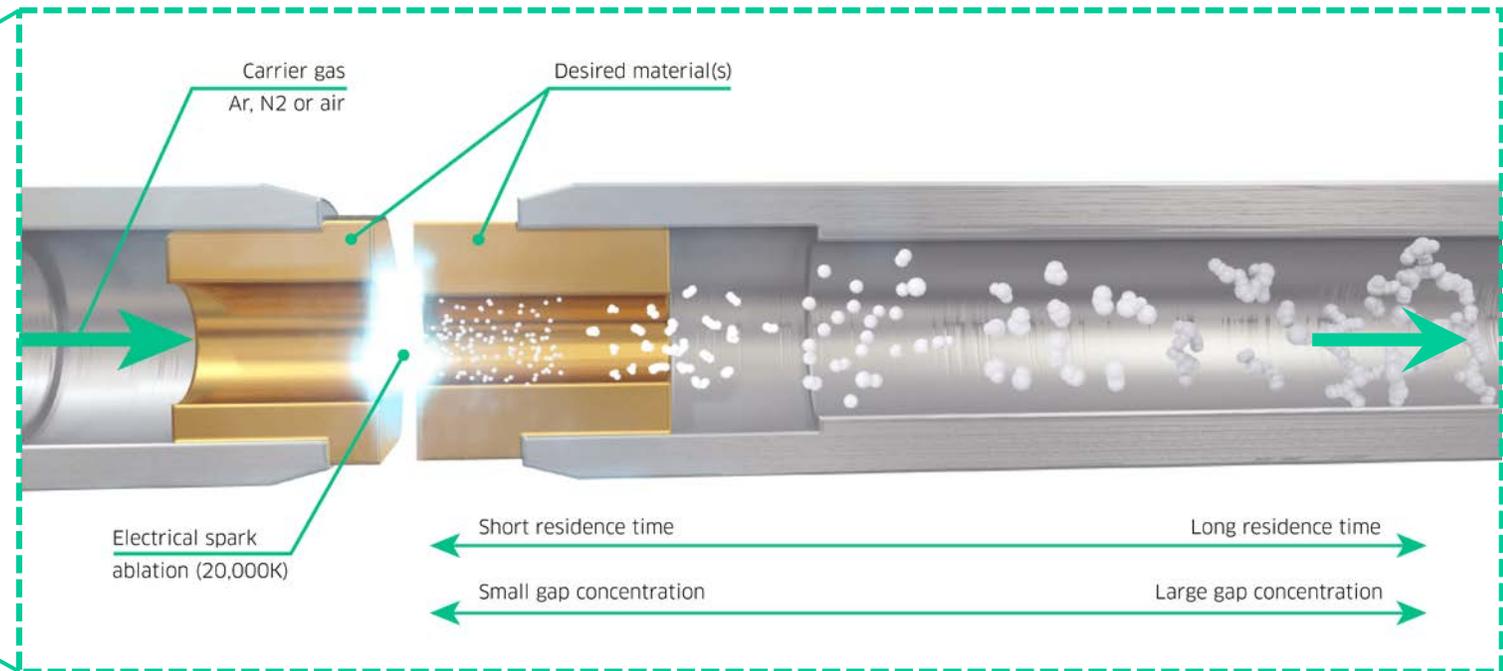
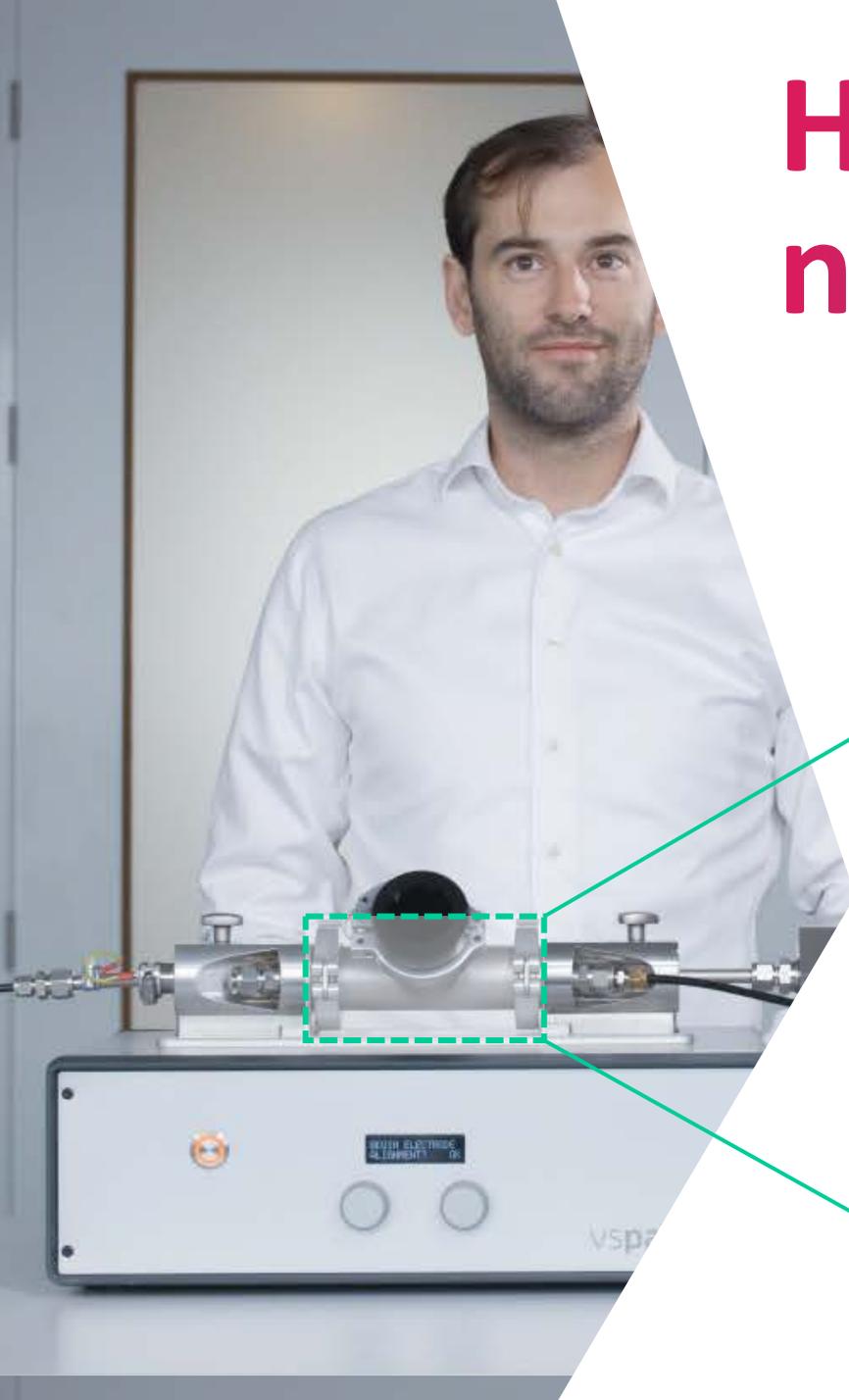
Watch -> <https://youtu.be/ey72790sLG4>



Automating nanomaterial production



How it works: making the nanoparticles

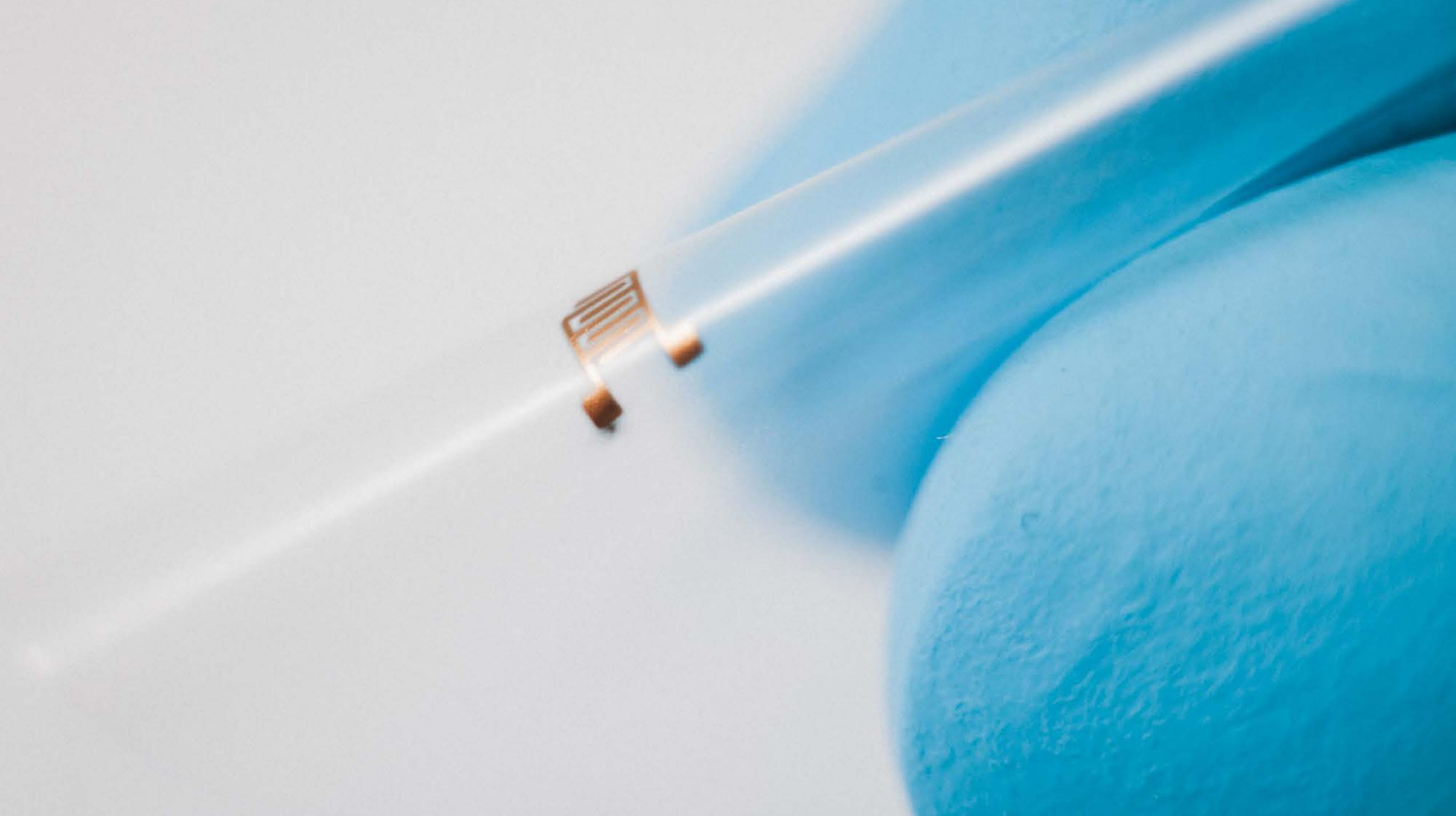


Printing materials with new properties

VSP

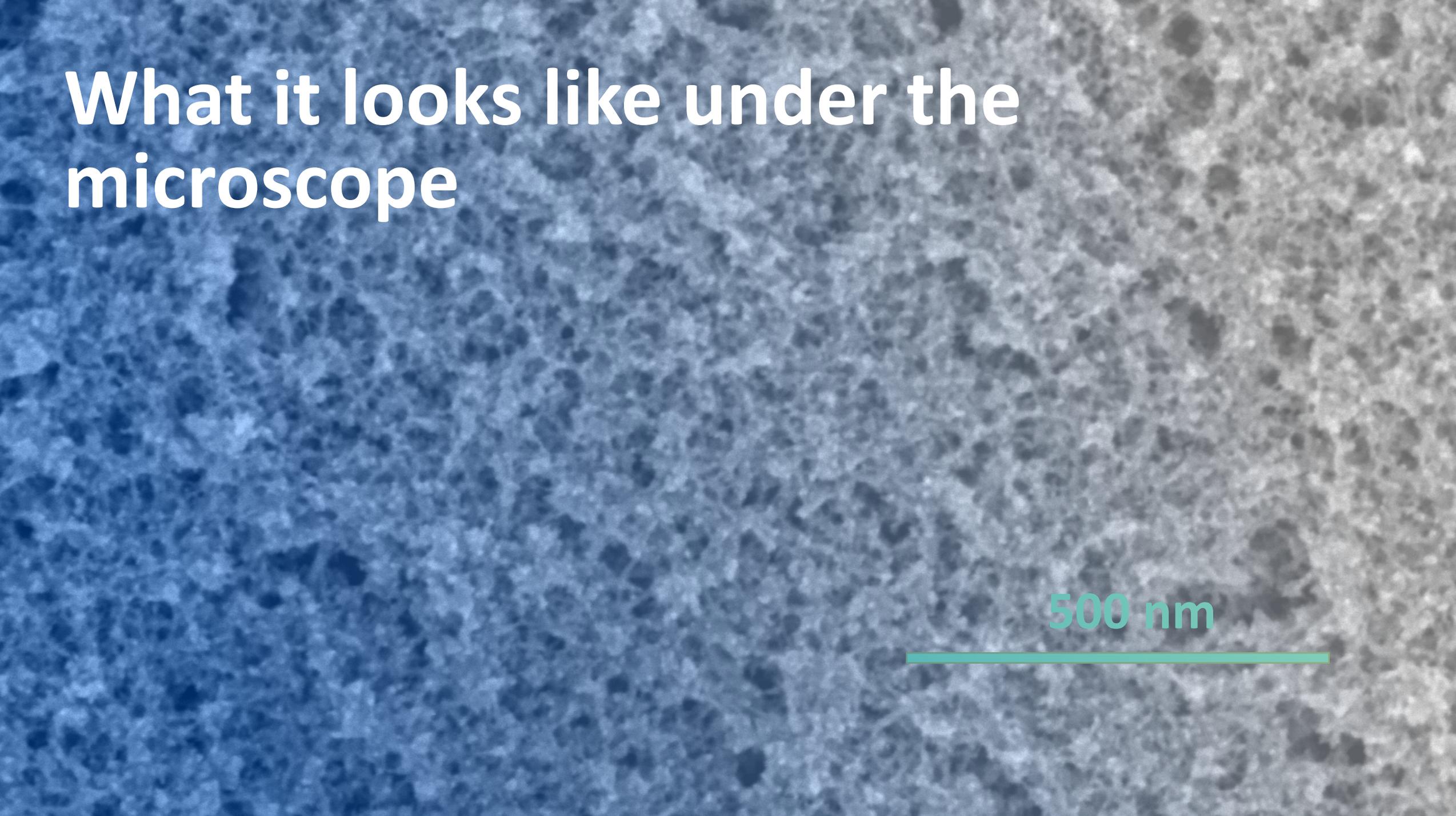
VSP





What it looks like under the microscope

500 nm

A scanning electron micrograph (SEM) showing a highly porous, interconnected network of fibers or filaments. The structure is dense and appears to be a sponge-like or foam-like material. The fibers are thin and form a complex, three-dimensional lattice. A horizontal scale bar is located in the lower right quadrant, with the text "500 nm" positioned above it.

Why we need materials with new properties?

What a sustainable and circular economy demands from products is changing, and most of it has to do with its materials.

restorative

zero-waste

CO2 neutral/negative

non-toxic

efficient

...

Design complexity

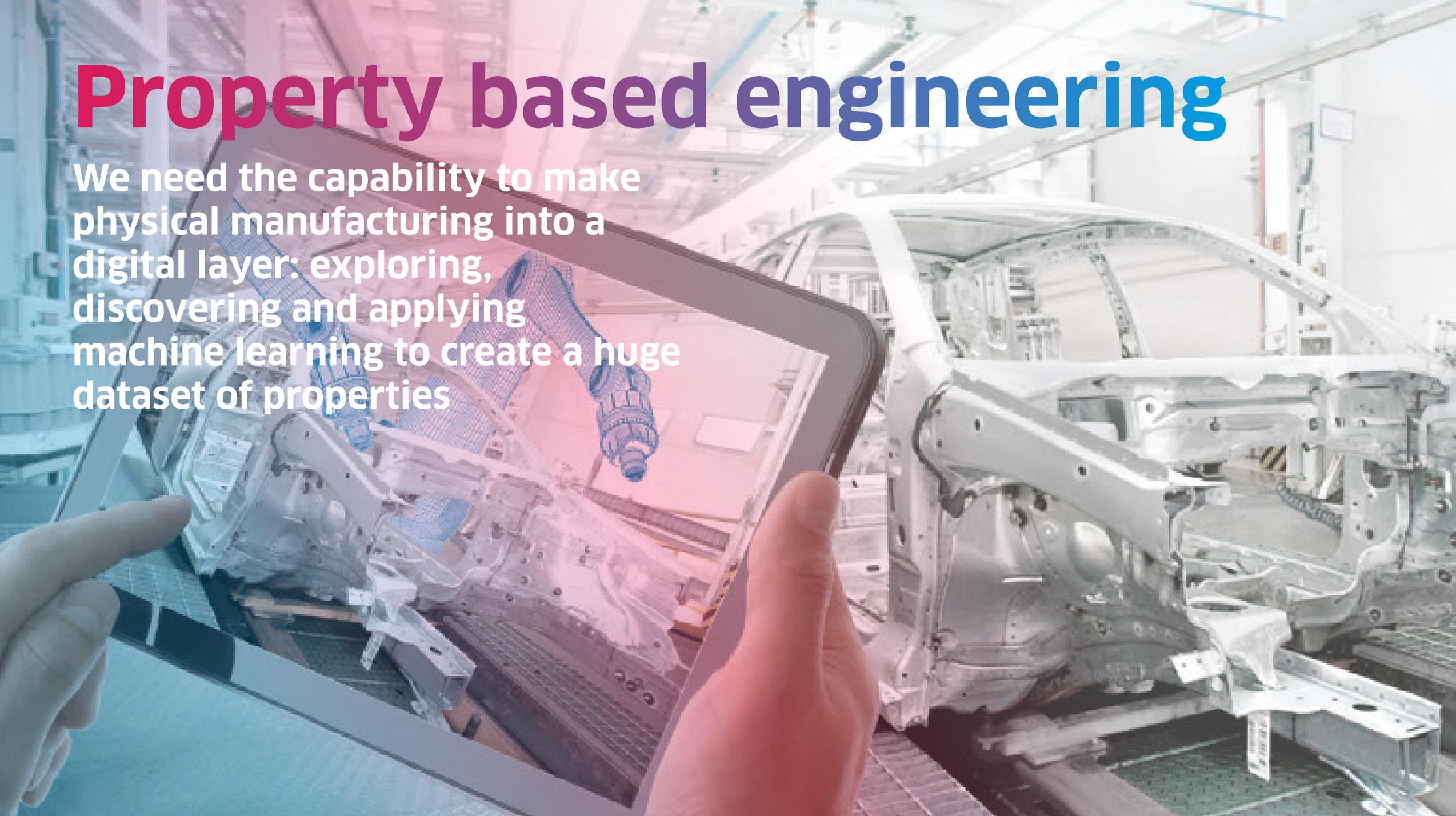
You can't just design a product anymore, without looking at its entire value chain. If we don't design products as a part of a system, we can't become a sustainable and circular economy.

Challenges and gains lie in the design and choice of materials.



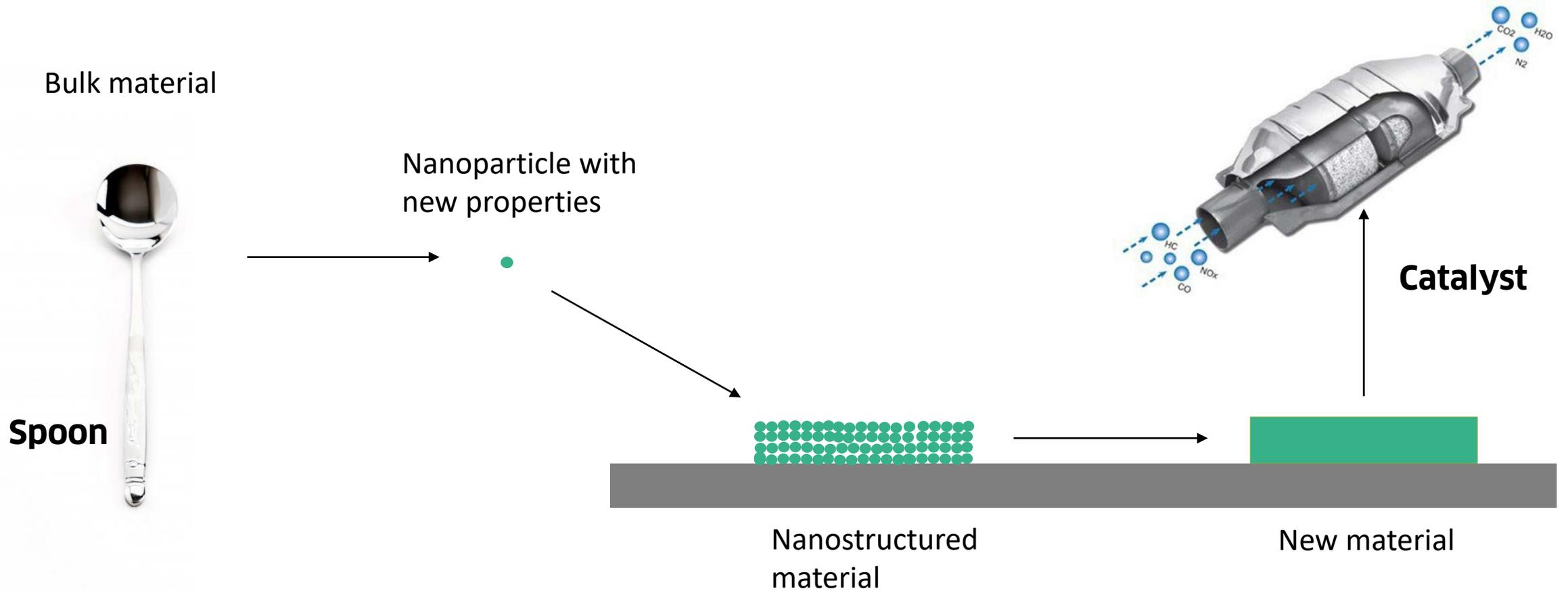
Property based engineering

We need the capability to make physical manufacturing into a digital layer: exploring, discovering and applying machine learning to create a huge dataset of properties



Low worth use - to - optimized use

So we can (re)program material and use resources in its optimum state



See the abundance



Thank you!

Any questions, please let me know.

Eva Rennen

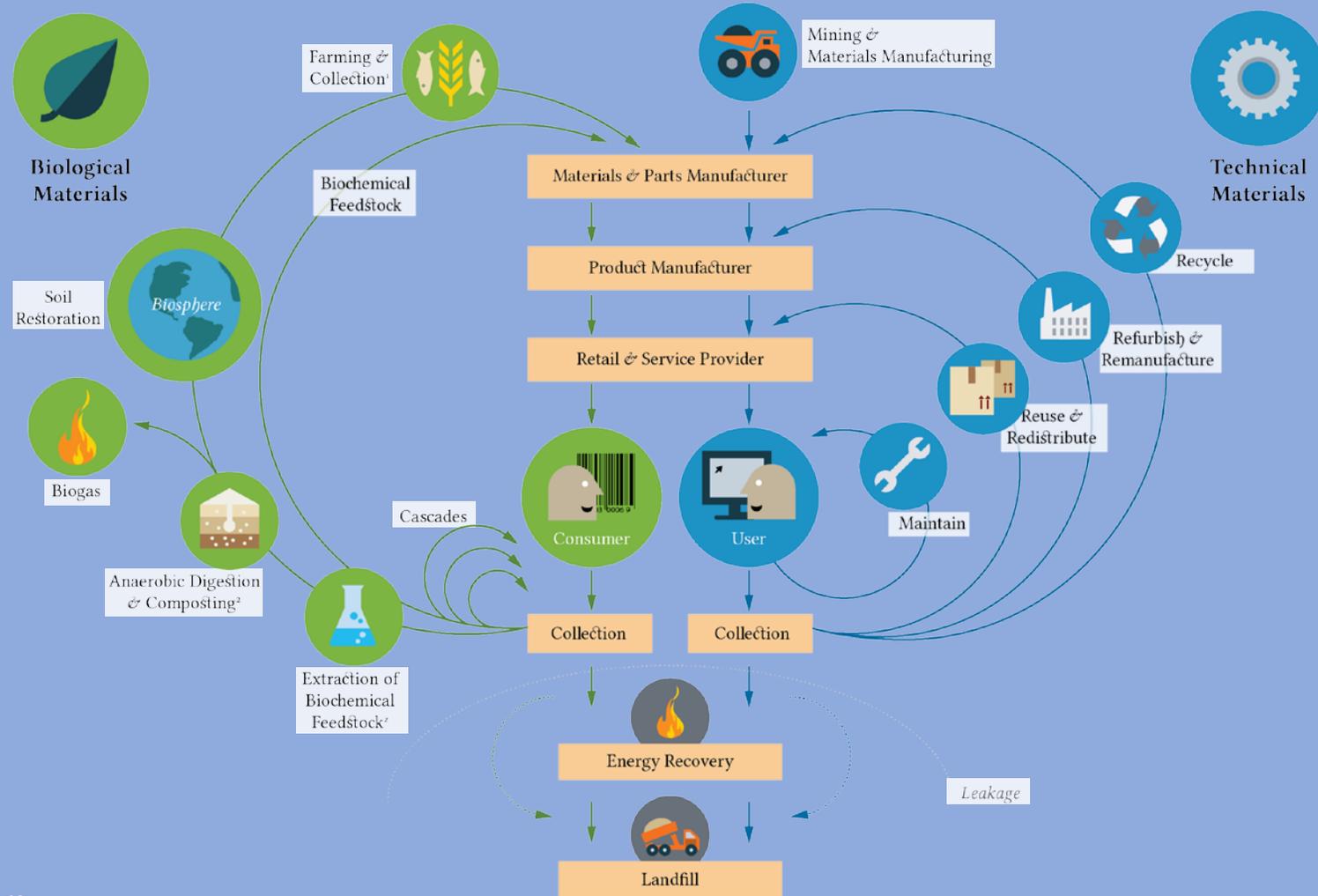
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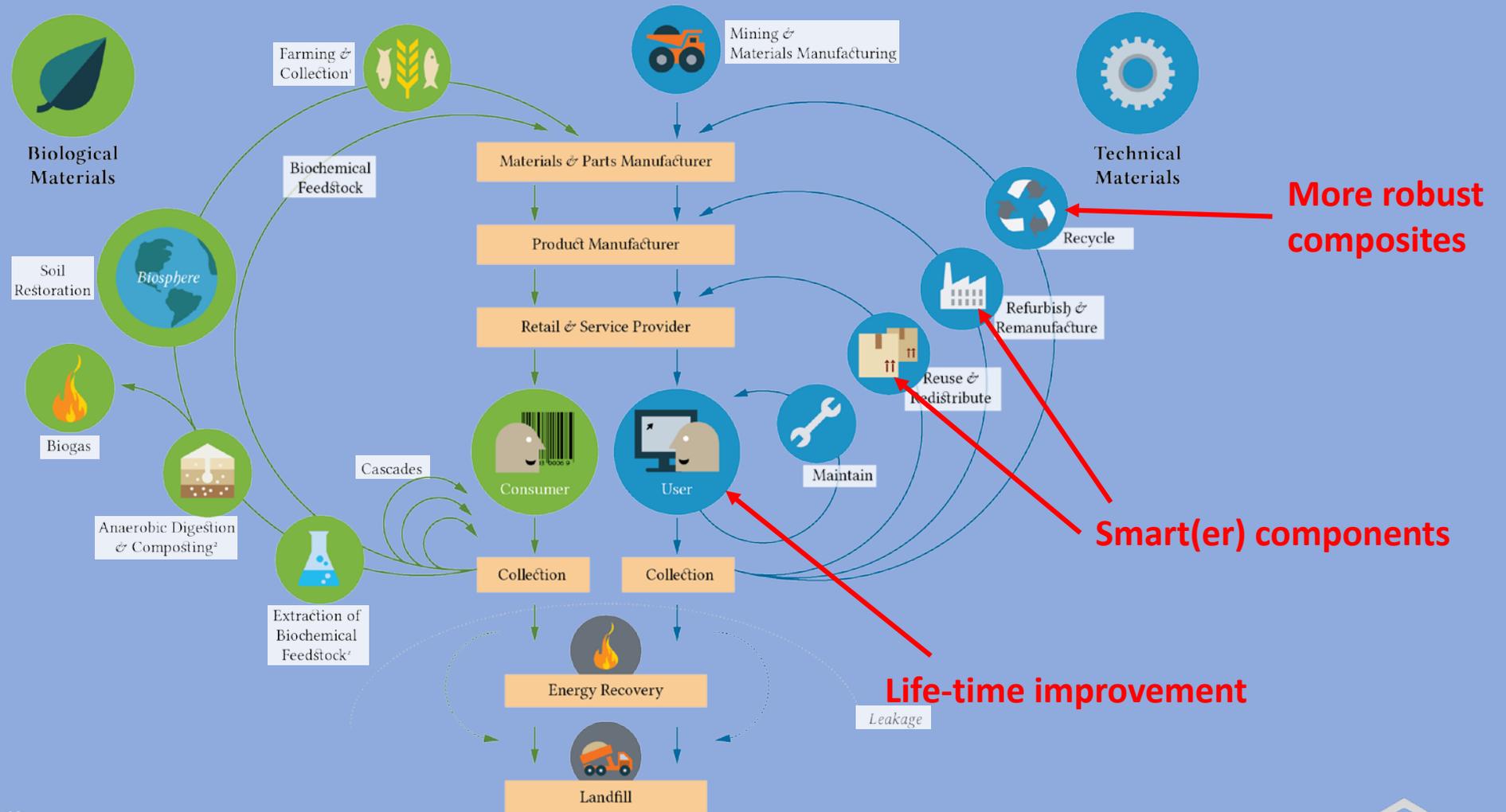
The Circular Economy

System diagram



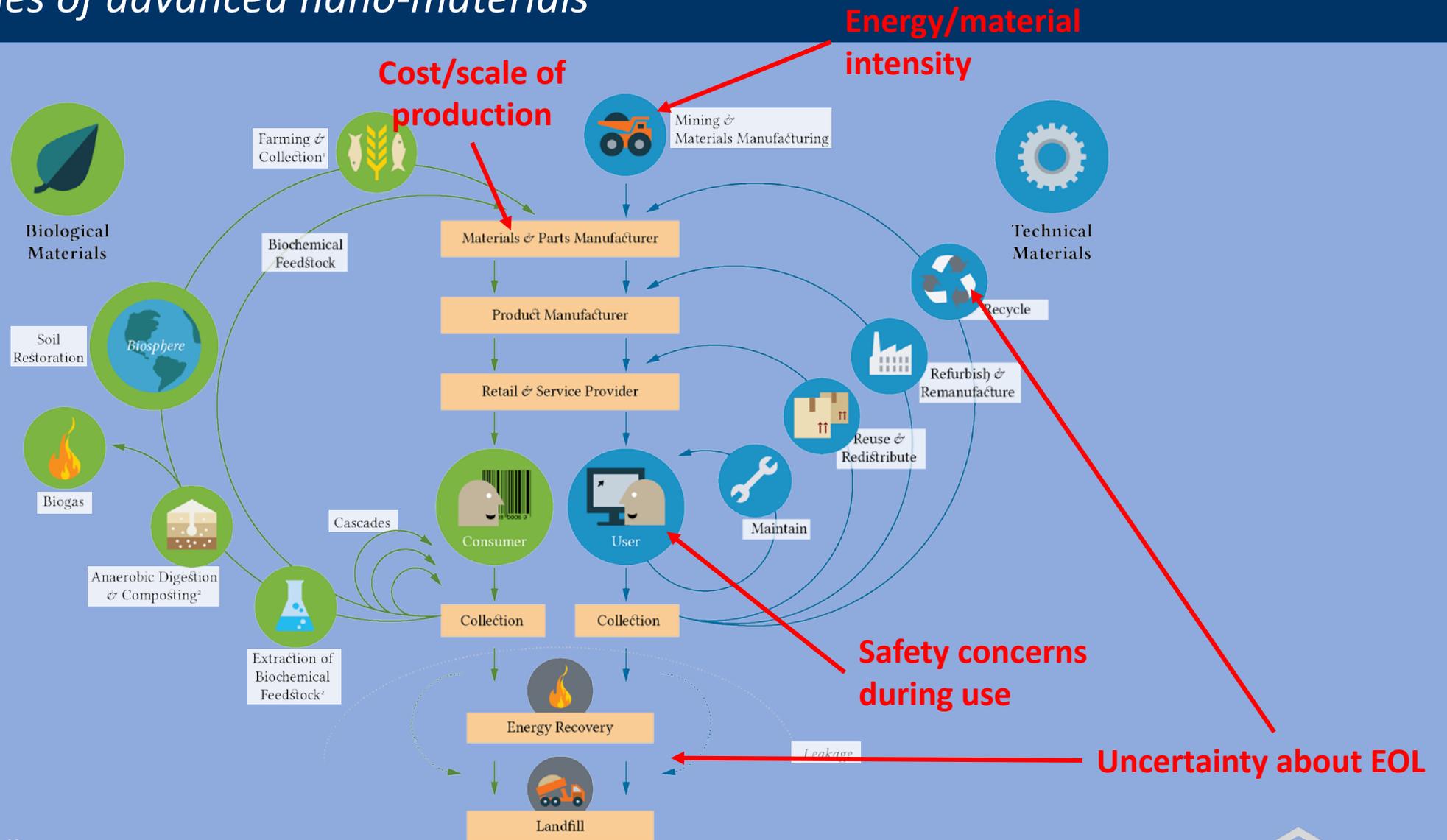
The Circular Economy

The role of advanced nano-materials



The Circular Economy

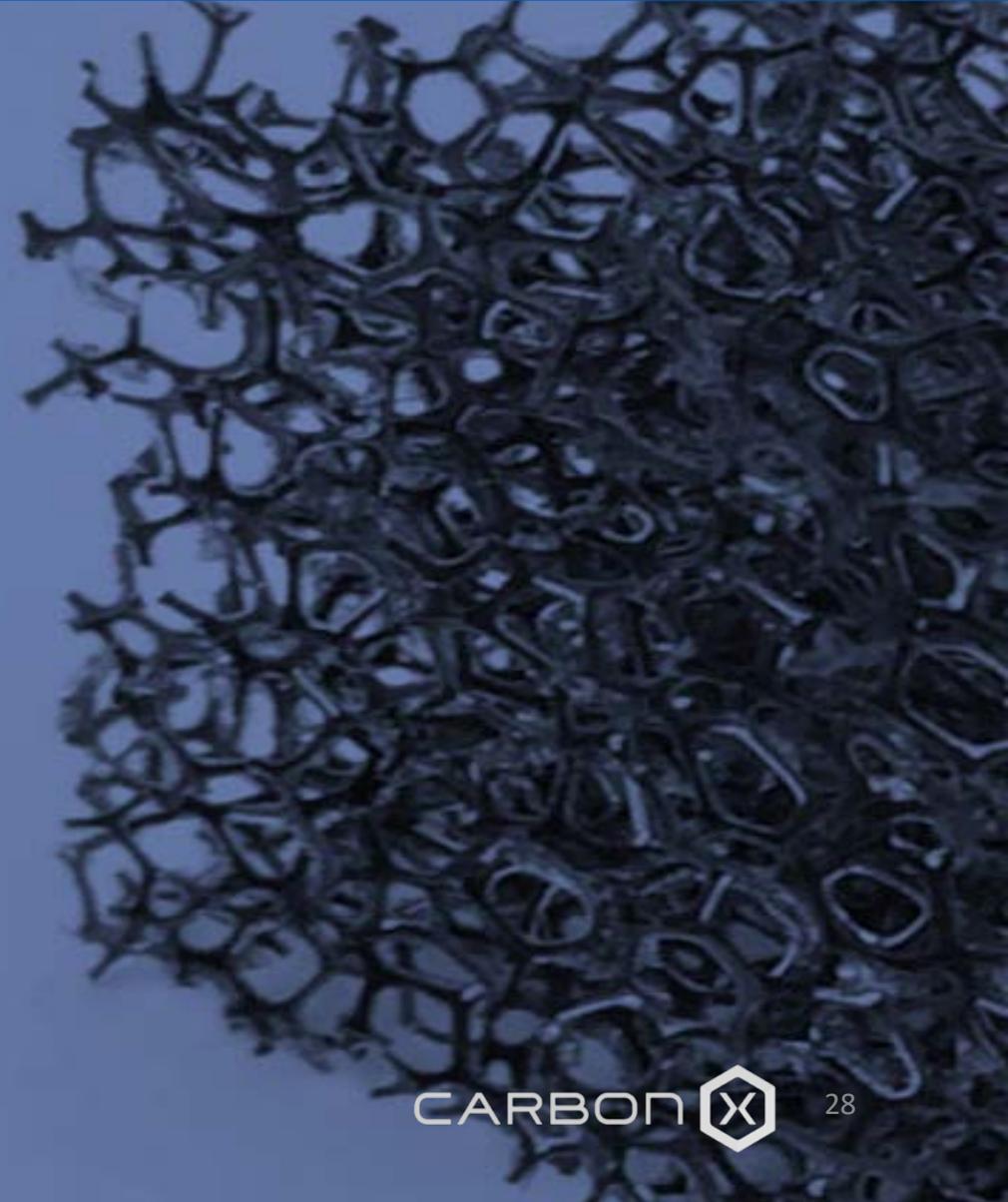
The challenges of advanced nano-materials



CarbonX

A revolutionary new carbon

- Carbon nanofibers linked into a structured network
- Boosts material performance
- Scalable, low cost production
- A high value added, durable material



CarbonX

Natural and synthetic carbon materials

Hydrocarbons
(oil and gas)

Biomass

Graphite

Diamond

Charcoal

Soot

Graphene

0,1nm

Carbon nanofiber/tube

3nm – 100nm

Carbon Black

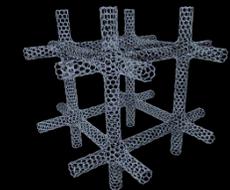
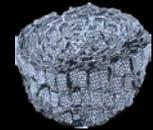
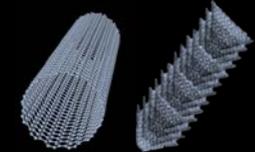
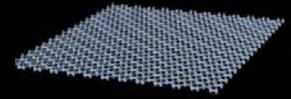
10nm – 500nm

Carbon nanofiber network

30nm – 3000nm

Carbon fiber

5000nm – 10000nm



CarbonX

Benefits to a circular economy

- Life-time improvements
- Components recyclability
- Smart monitoring
- Reduced material input
- Use-phase efficiency

CarbonX

Fields of application



Composites



3D printing



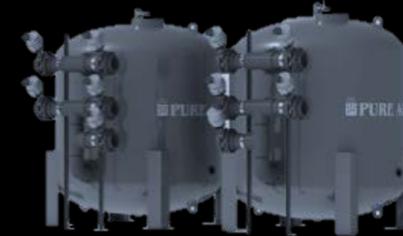
Tyres



Coatings



Batteries



Purification

CarbonX

Process scalability and sustainability implications

- **CarbonX is produced in Carbon Black reactors and plants**
- Production is efficient and comparatively inexpensive
- Most of the feedstock is a by-product

Take home messages

- Trade-off between circularity and sustainability of macro scaled components and the nano-scaled materials in them
- Lots of opportunities to design and engineer nano materials to fulfil this role
- Engineers and industry leaders must strive to scale-up the production in a way that is fully sustainable and fully circular



Carbon productivity

Process scalability and sustainability implications

