KIVI jaarcongres 2018

Circular design at the nanoscale

*edited for easier reading

CARBON X VSparticle

vsparticle

Creating new materials

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

Stone age

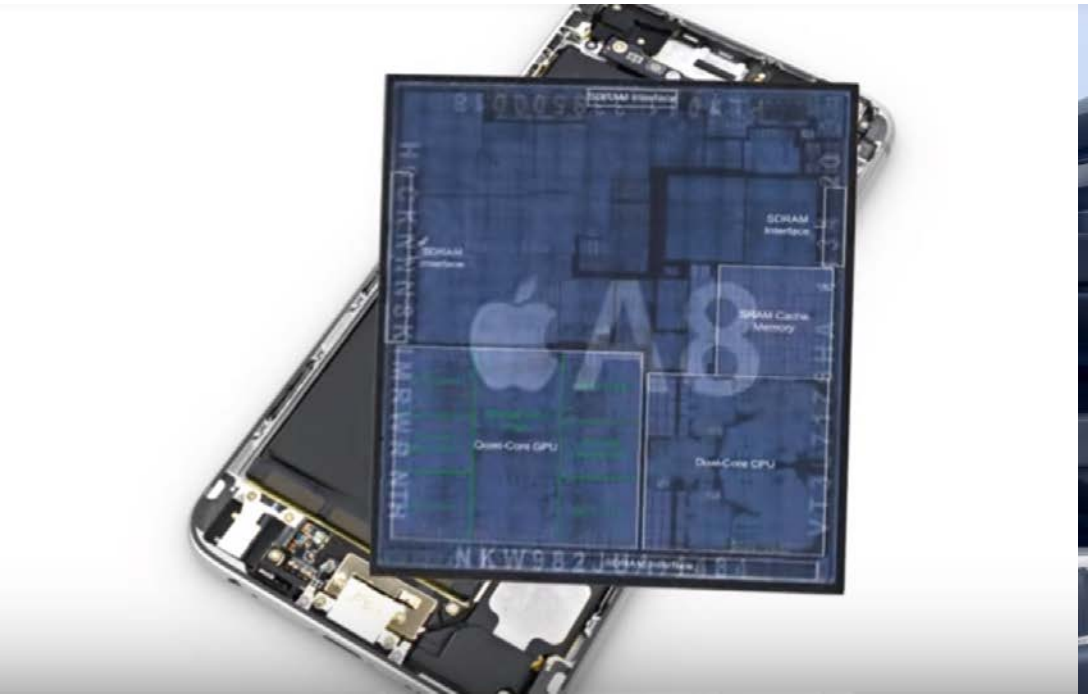
Bronze age

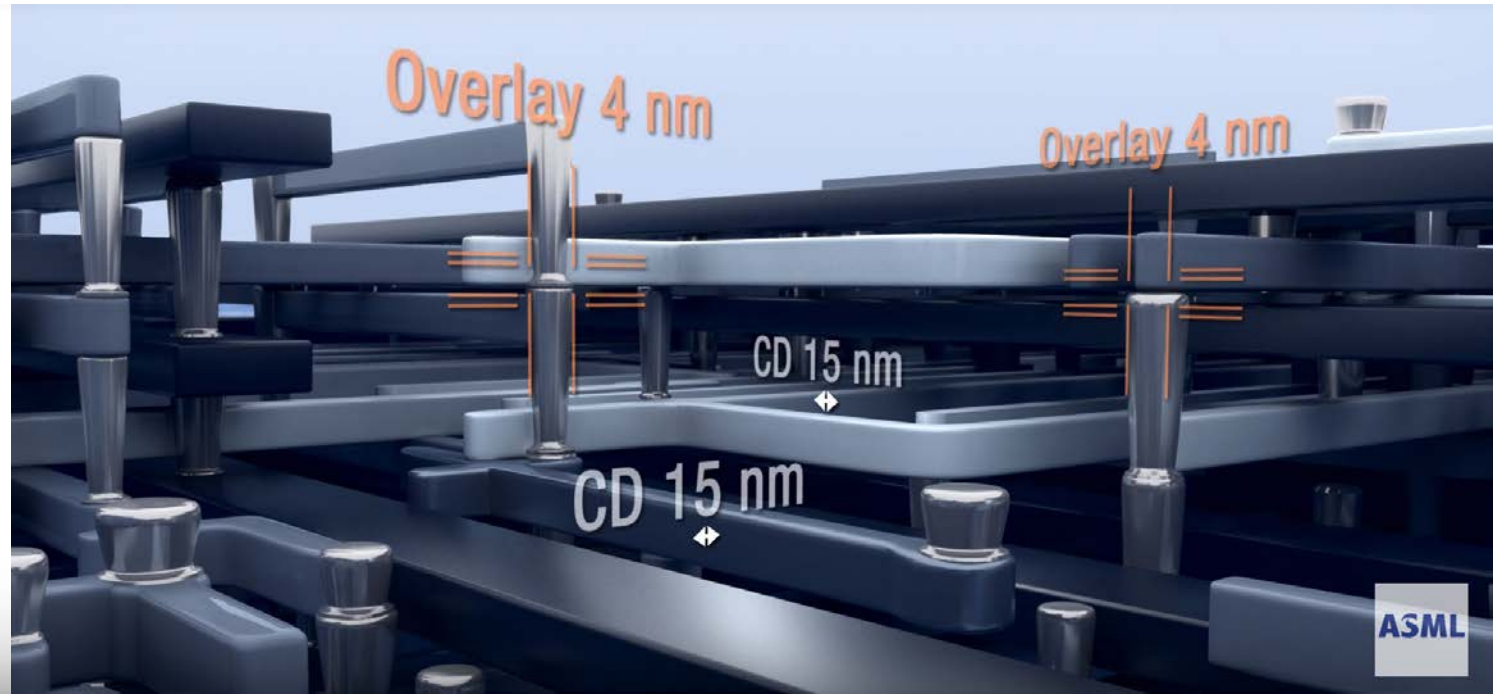
Iron age

Silicon age

Next level control

Crafting and engineering has entered the nanoscale





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

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 then 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.

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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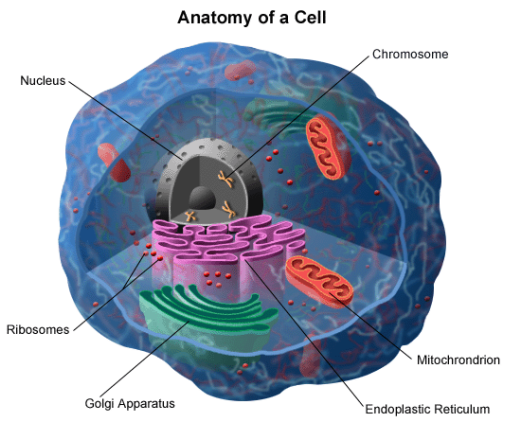
Then another person walks in, group dynamics change again.

-

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 a 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

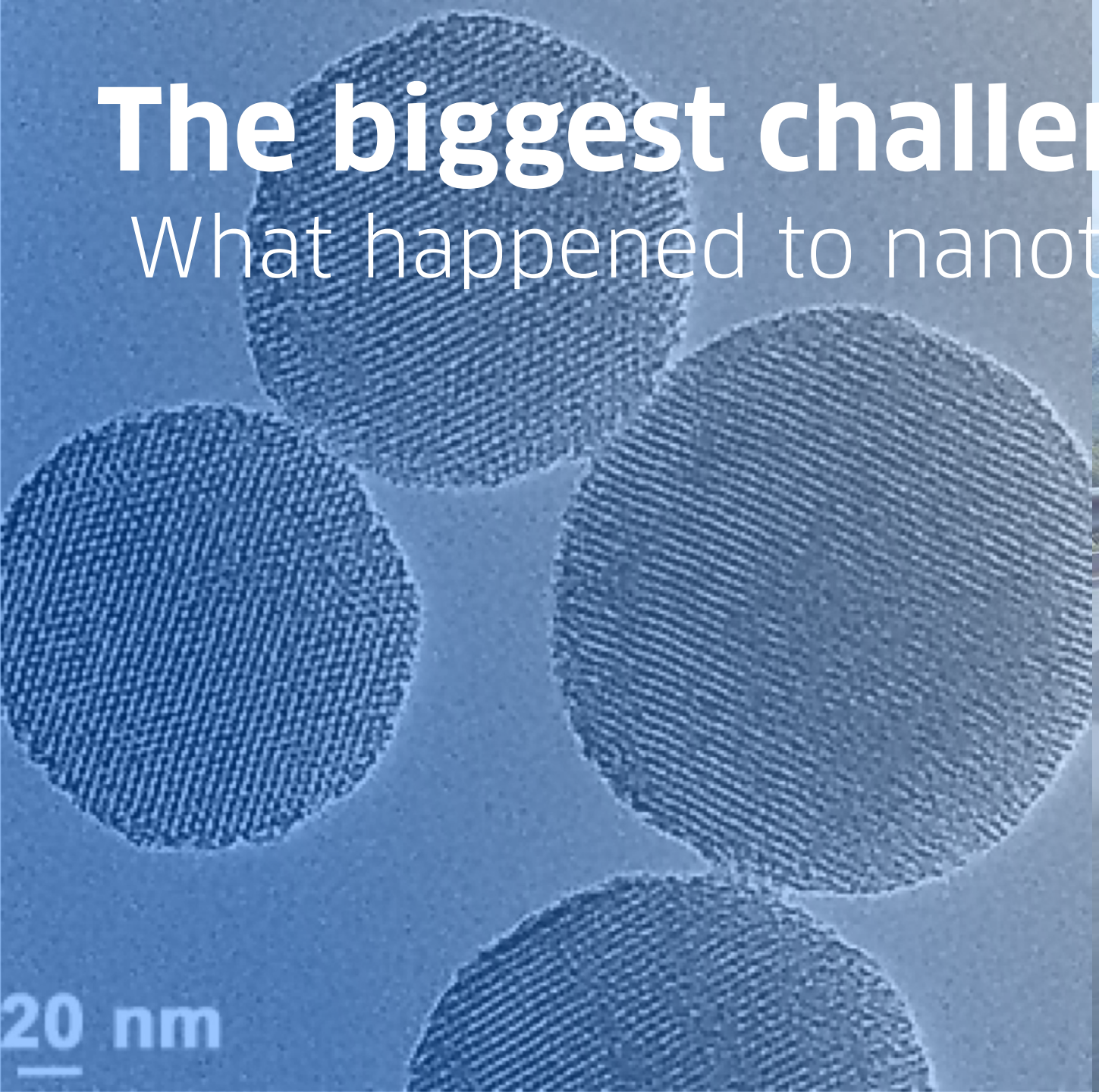
Our lives our becoming increasingly electrified. Inorganic materials, simple organisms are used everywhere: like a solar panel, battery, sensors, cars.

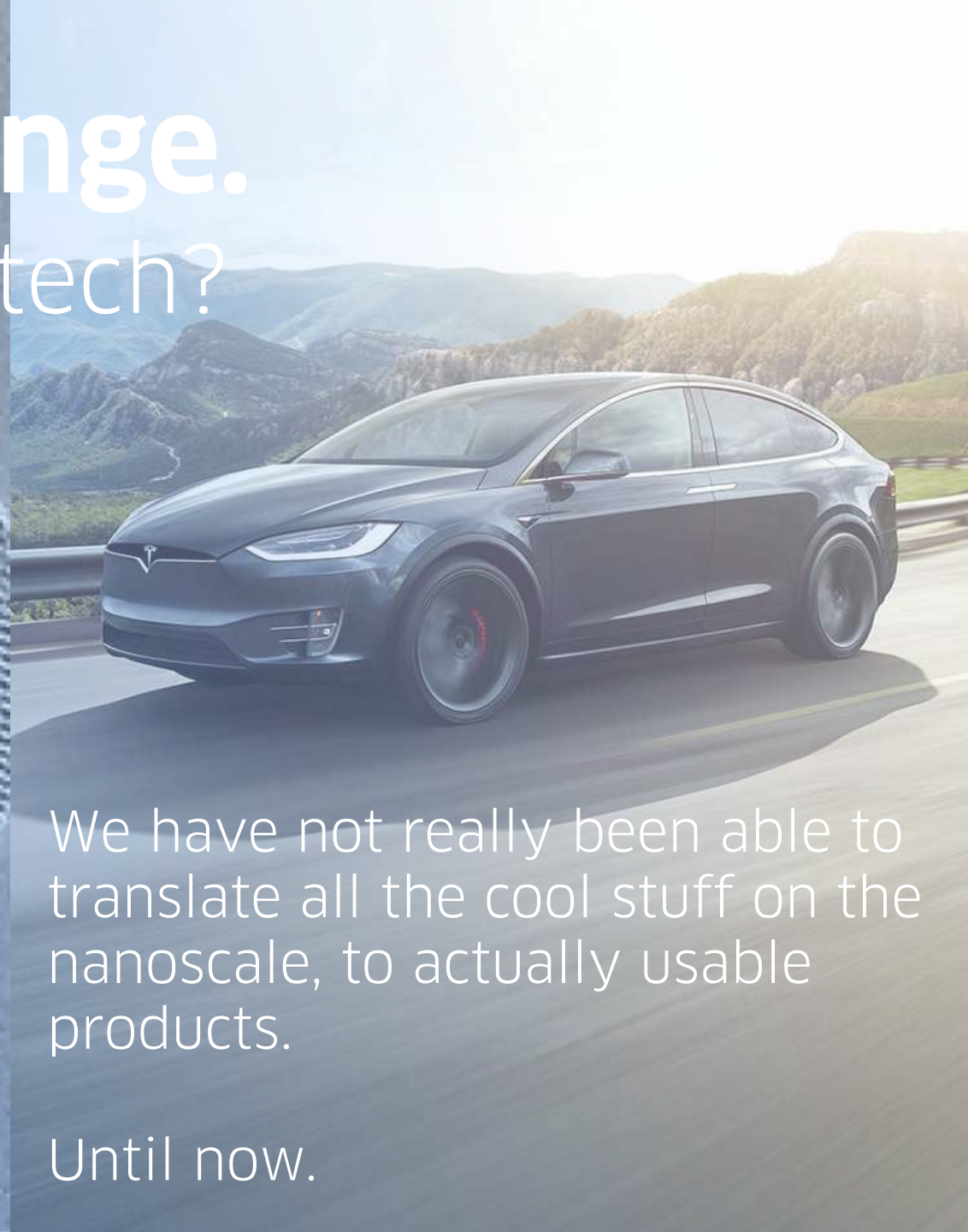
When it comes to material properties, it is so complex and huge that only a fraction has been explored. Scientists and engineers are discovering new properties and applying them to new products on the go.

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

The biggest challenge.

What happened to nanotech?



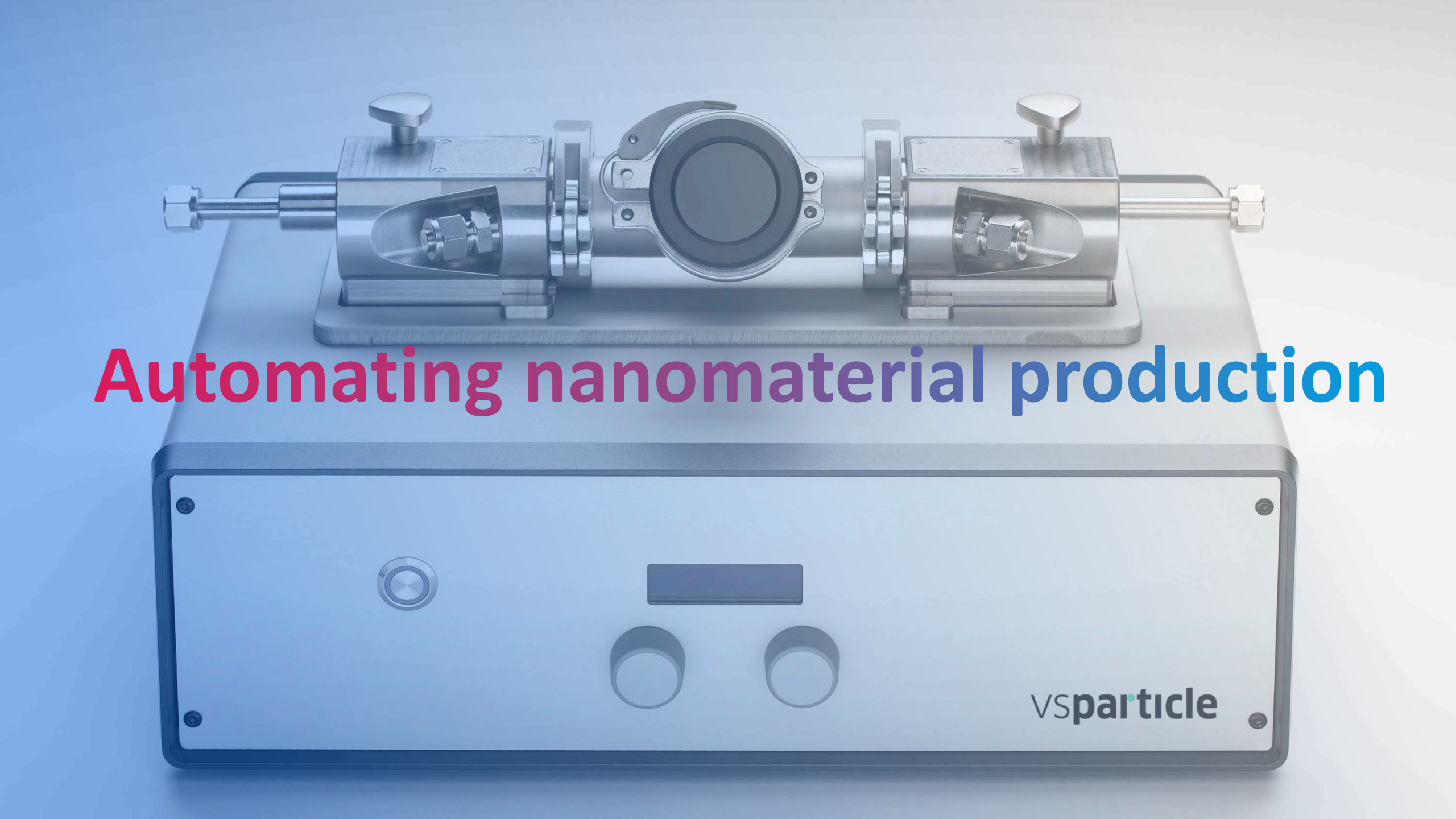


We have not really been able to translate all the cool stuff on the nanoscale, to actually usable products.

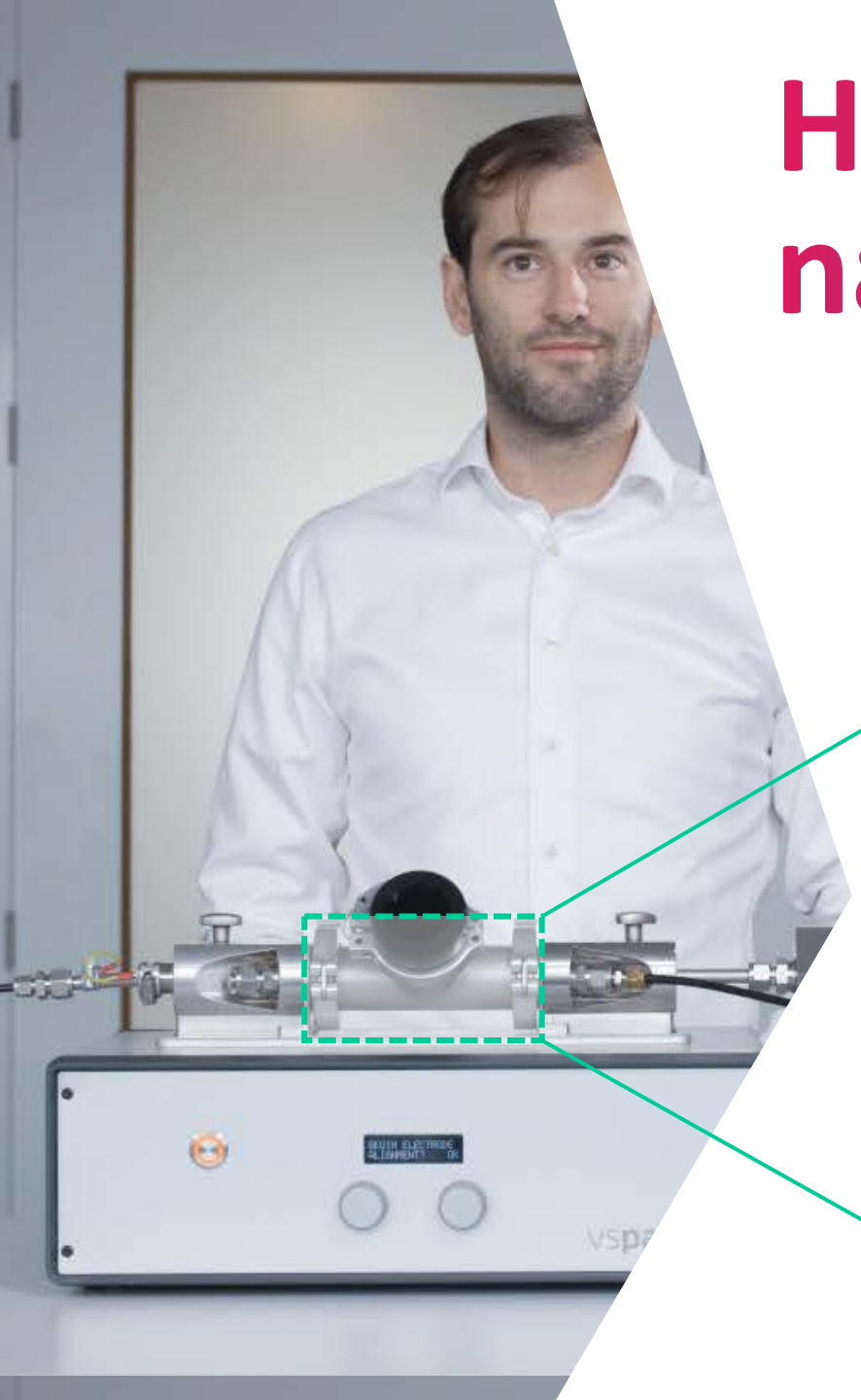
Until now.

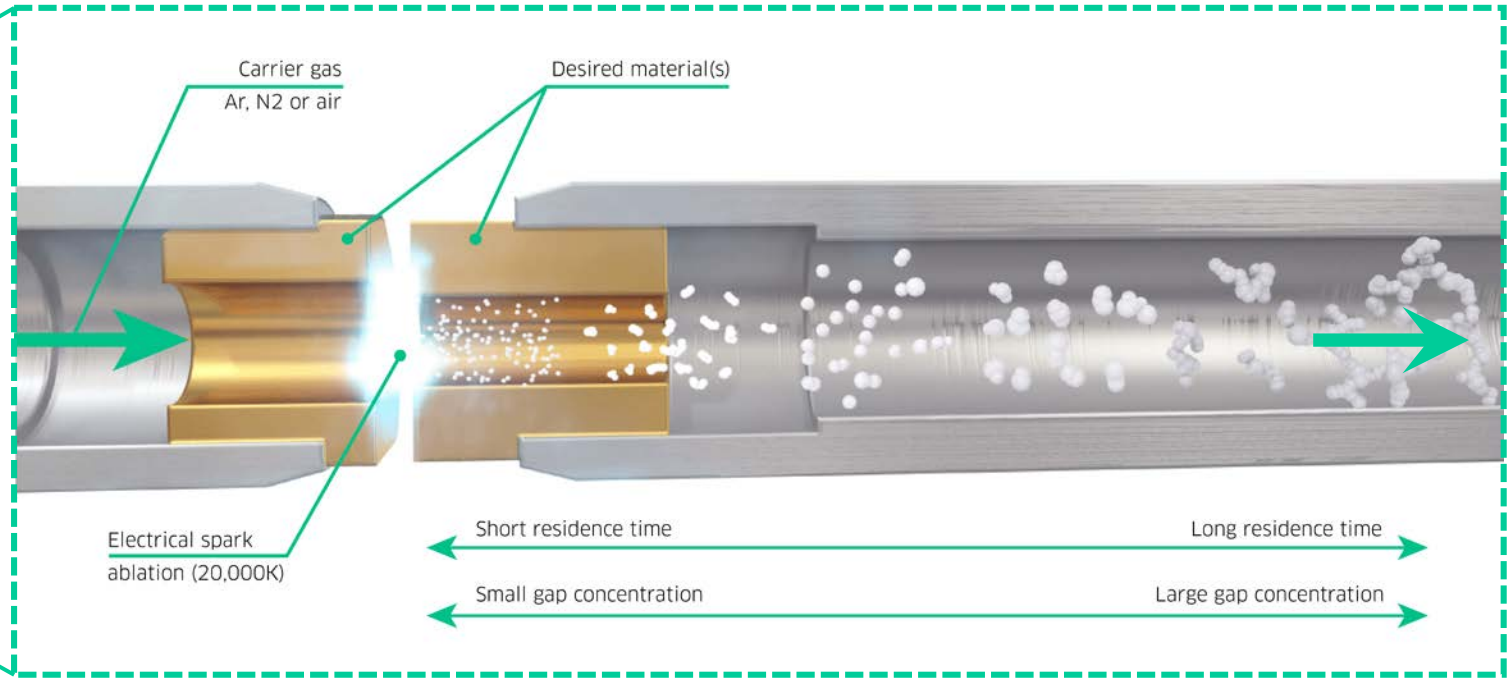
Watch -> https://youtu.be/ey72790sLG4

Automating nanomaterial production

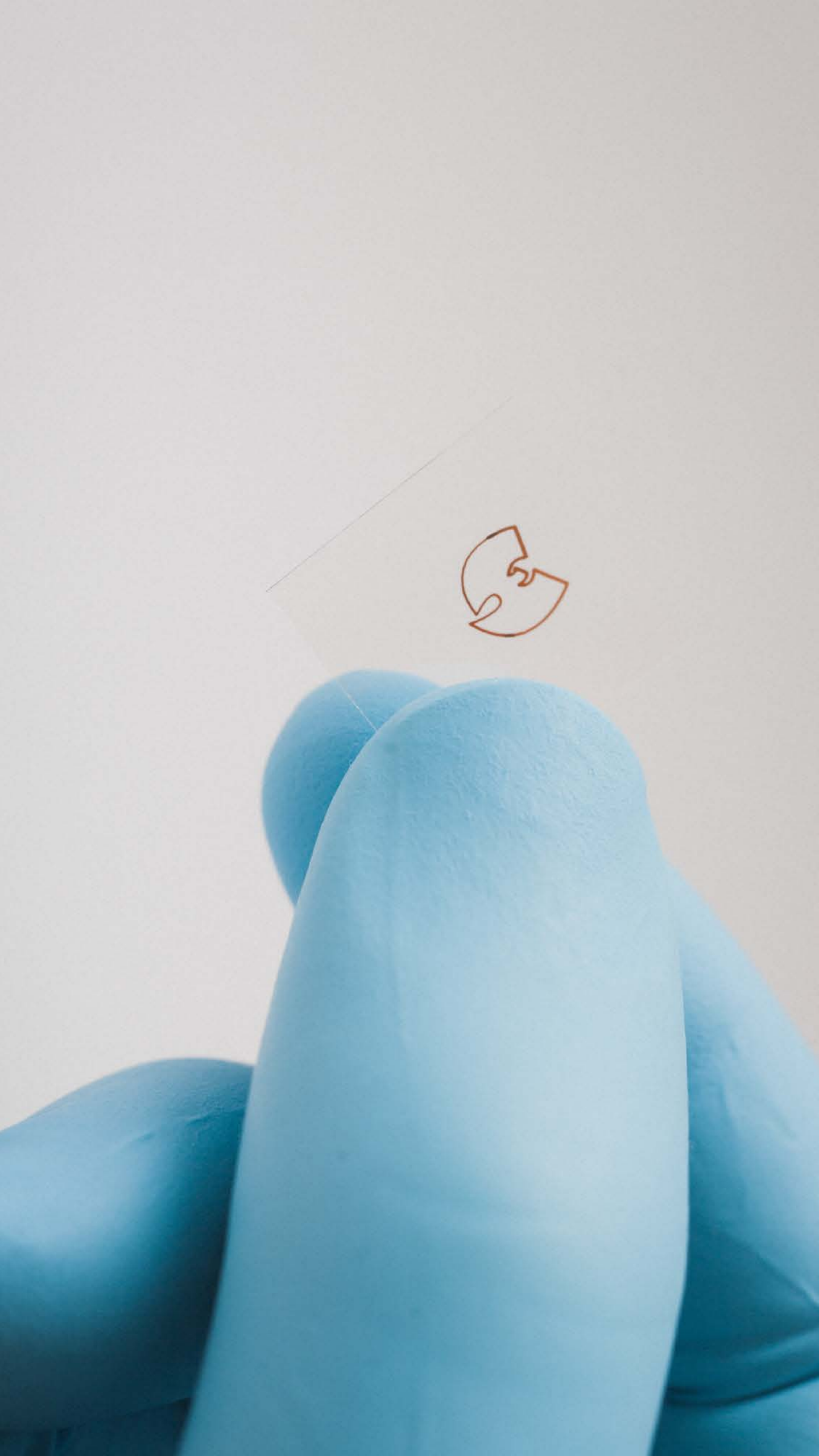


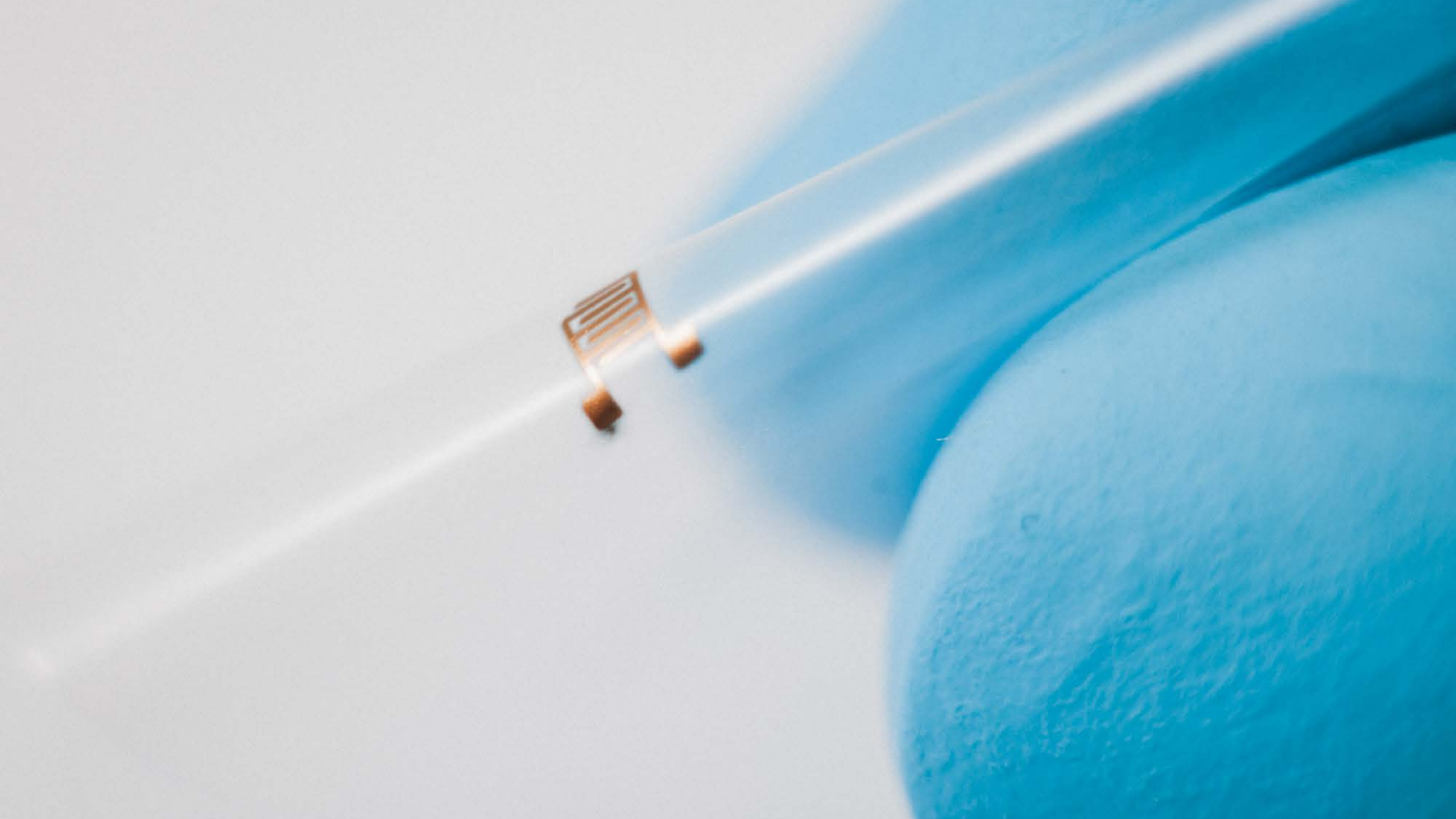
How it works: making the nanoparticles



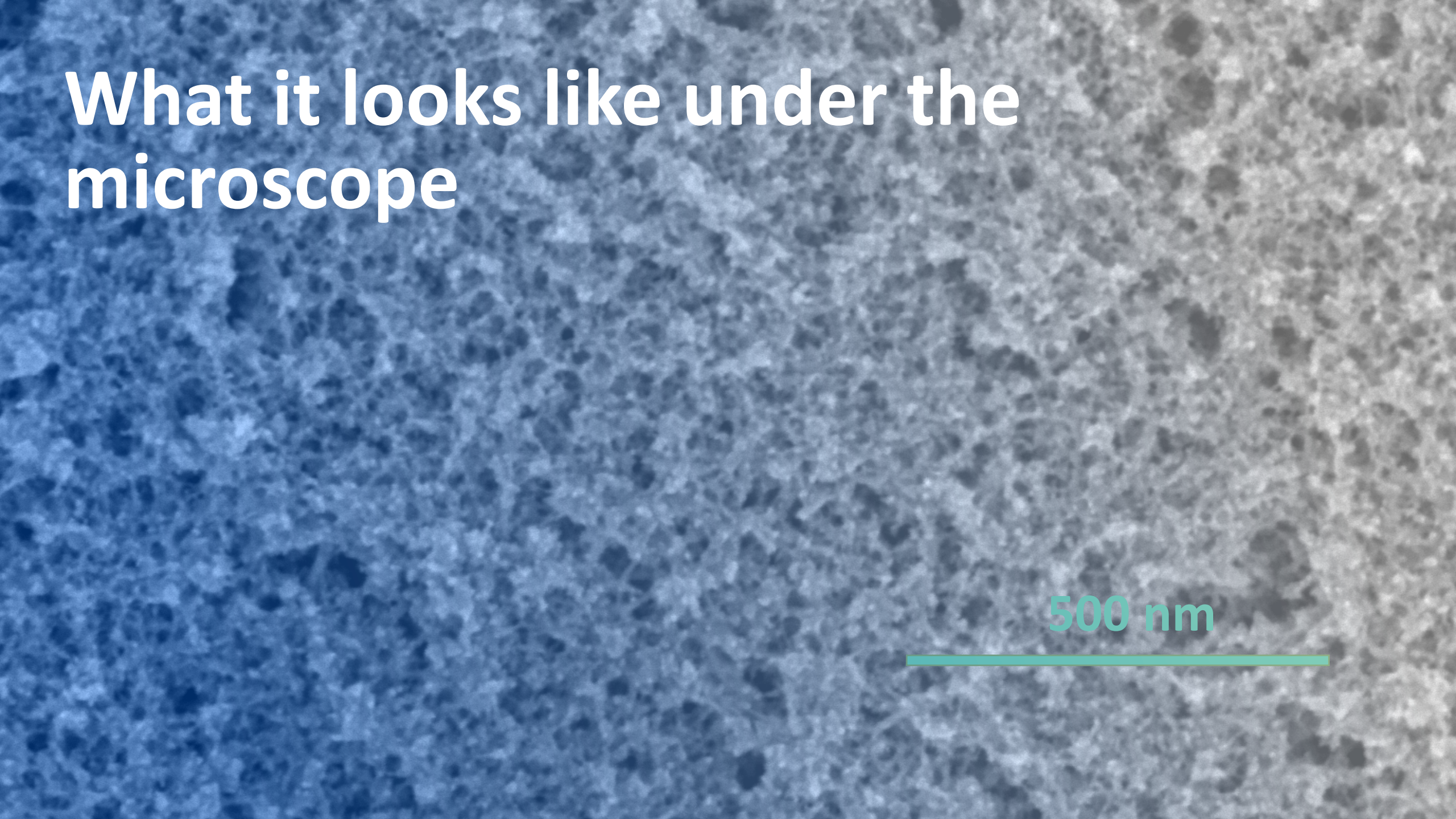


Printing materials with new properties





What it looks like under the microscope



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.

CO2 neutral/negative

zero-waste

restorative

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.

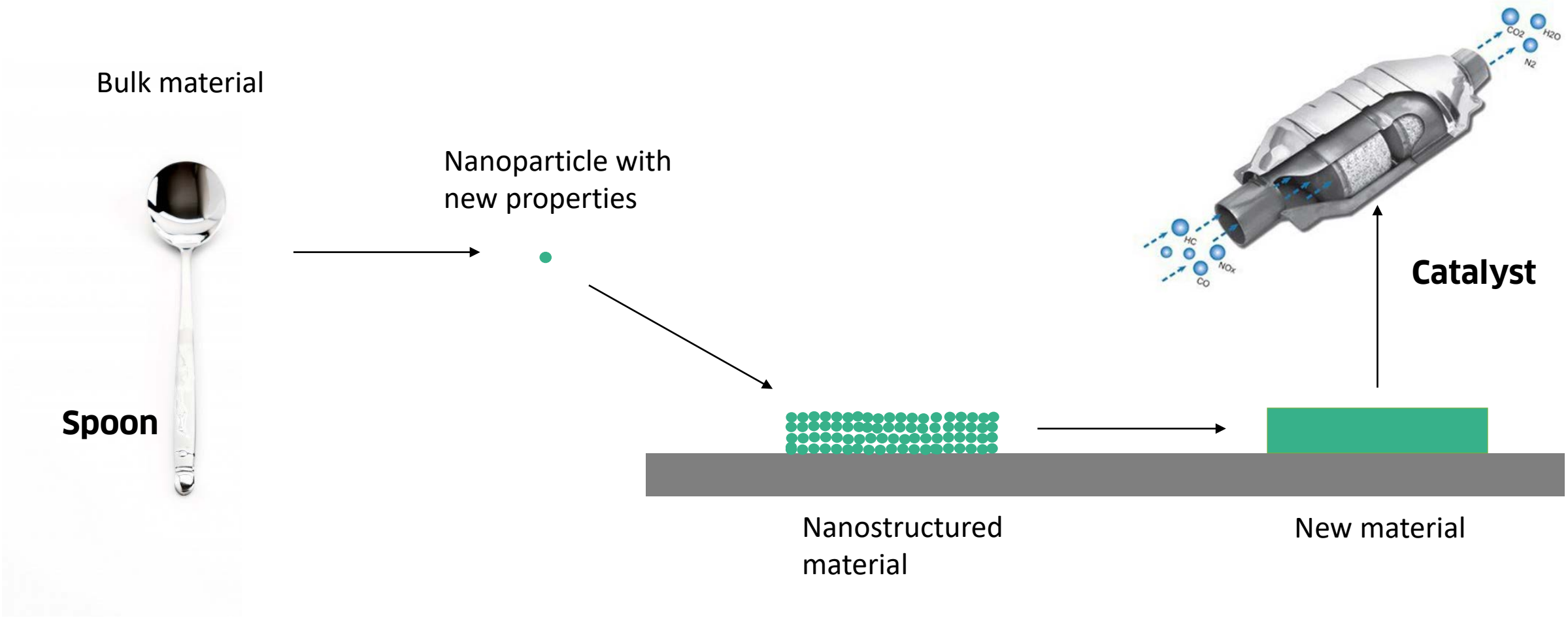
Challenges and gains lie in the design and choice of materials.

Property based engineering

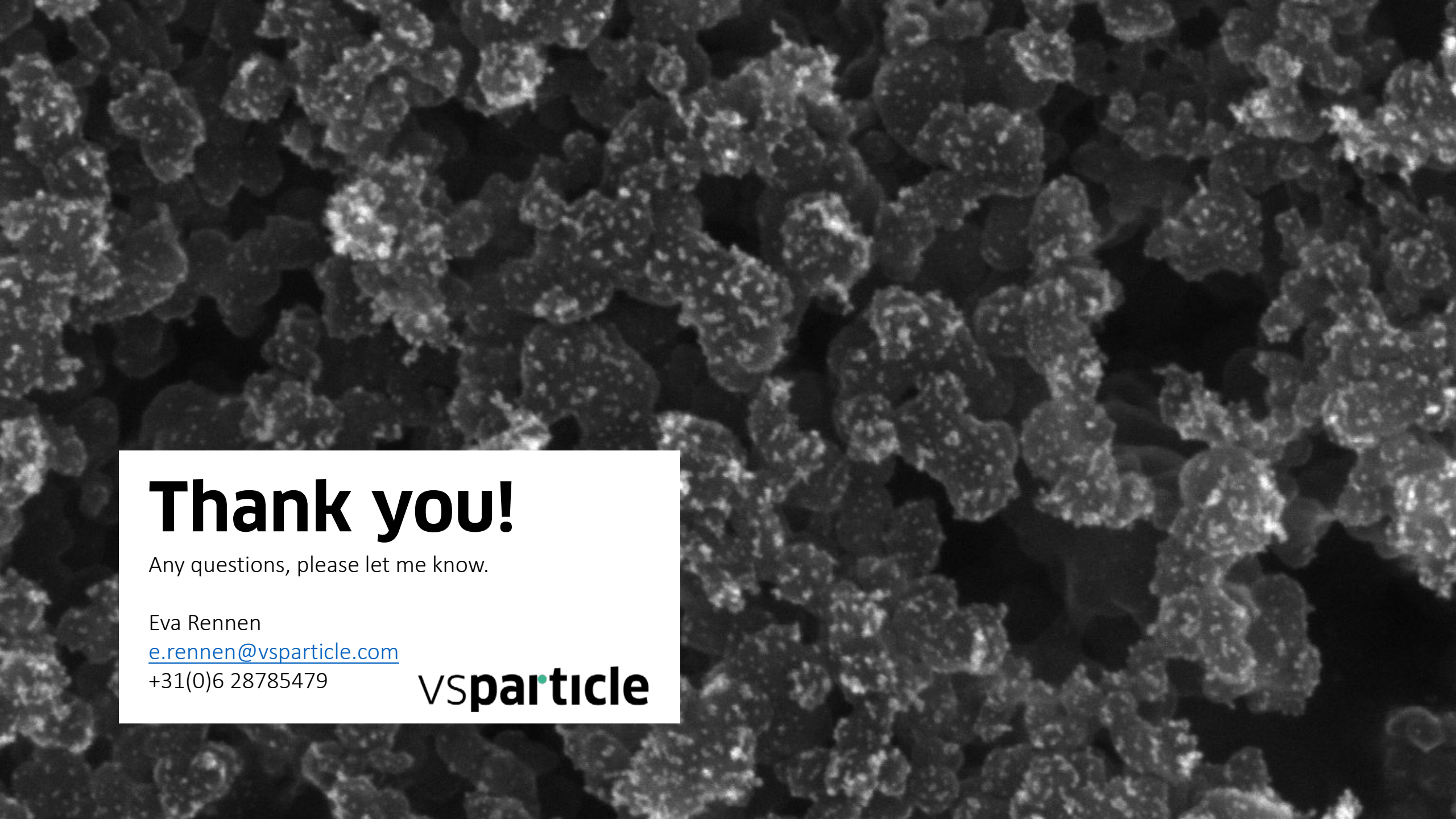
We need the capability to make physical manufacturing into a digital layer: exploring, discovering and applying machine learning to create a huge dataset of properties

Low worth use – to – optimized use

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




See the abundance



Thank you!

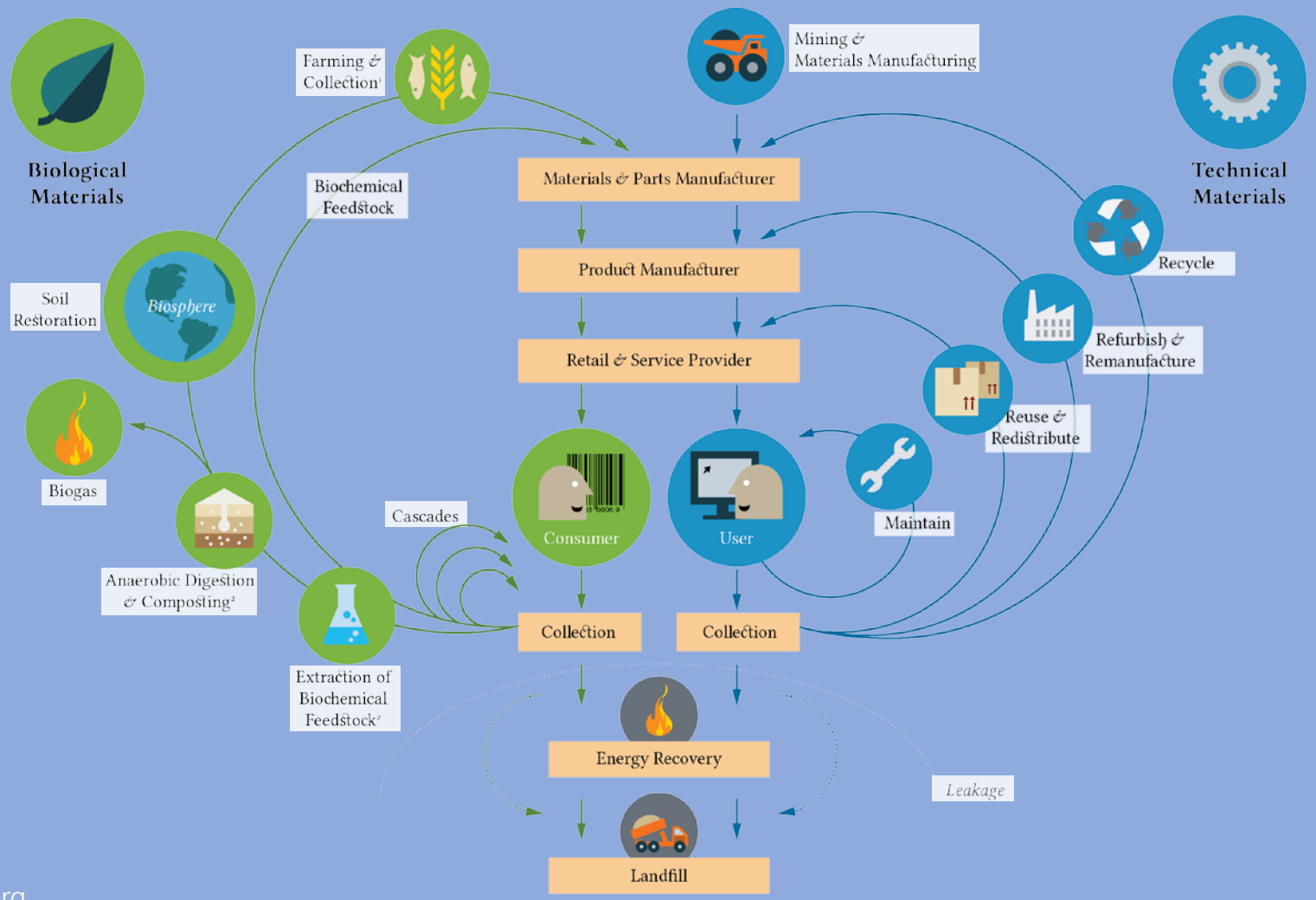
Any questions, please let me know.

Eva Rennen
e.rennen@vsparticle.com
+31(0)6 28785479

vsparticle

The Circular Economy

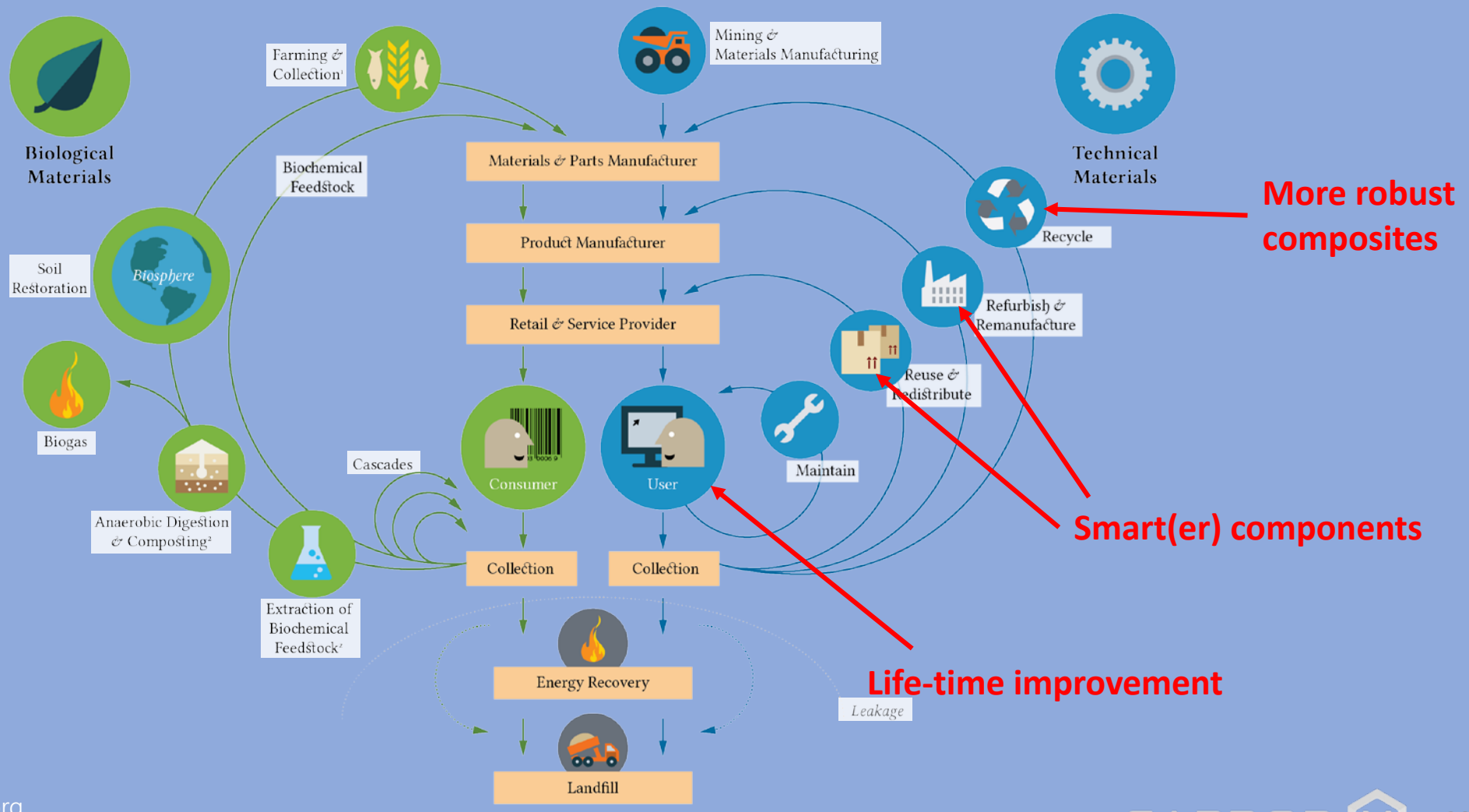
System diagram



Ellen MacArthur Foundation
www.ellenmacarthurfoundation.org

The Circular Economy

The role of advanced nano-materials



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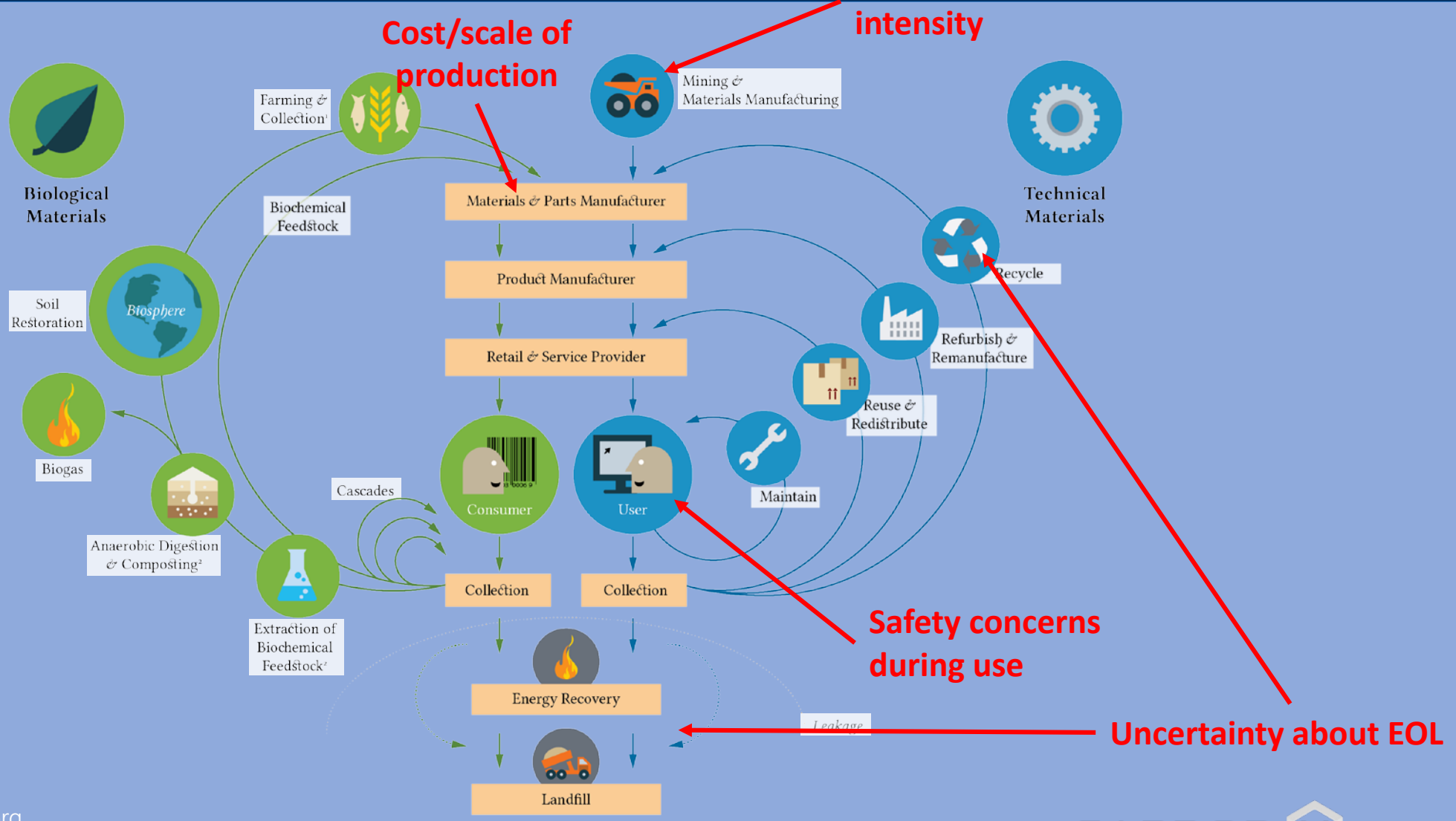
The Circular Economy

The challenges of advanced nano-materials



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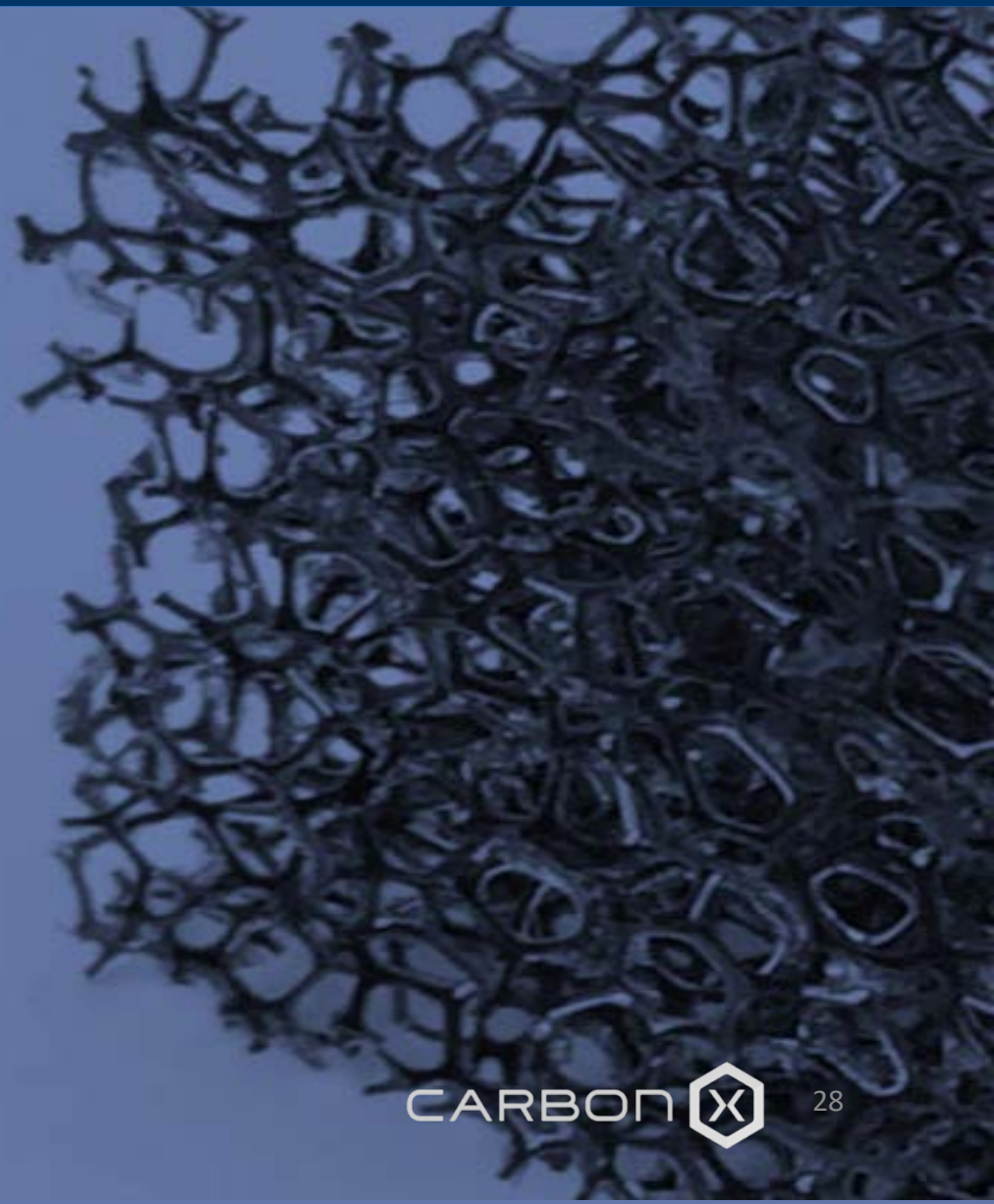
CarbonX

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

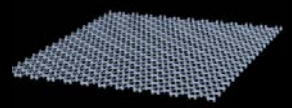
Graphite

Diamond

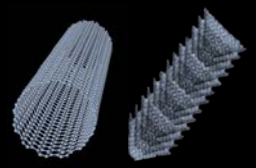
Charcoal

Soot

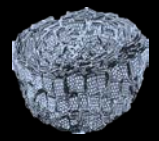
Graphene
0,1nm



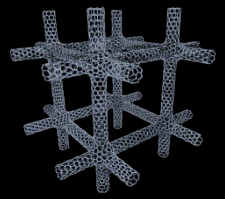
Carbon nanofiber/tube
3nm – 100nm



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

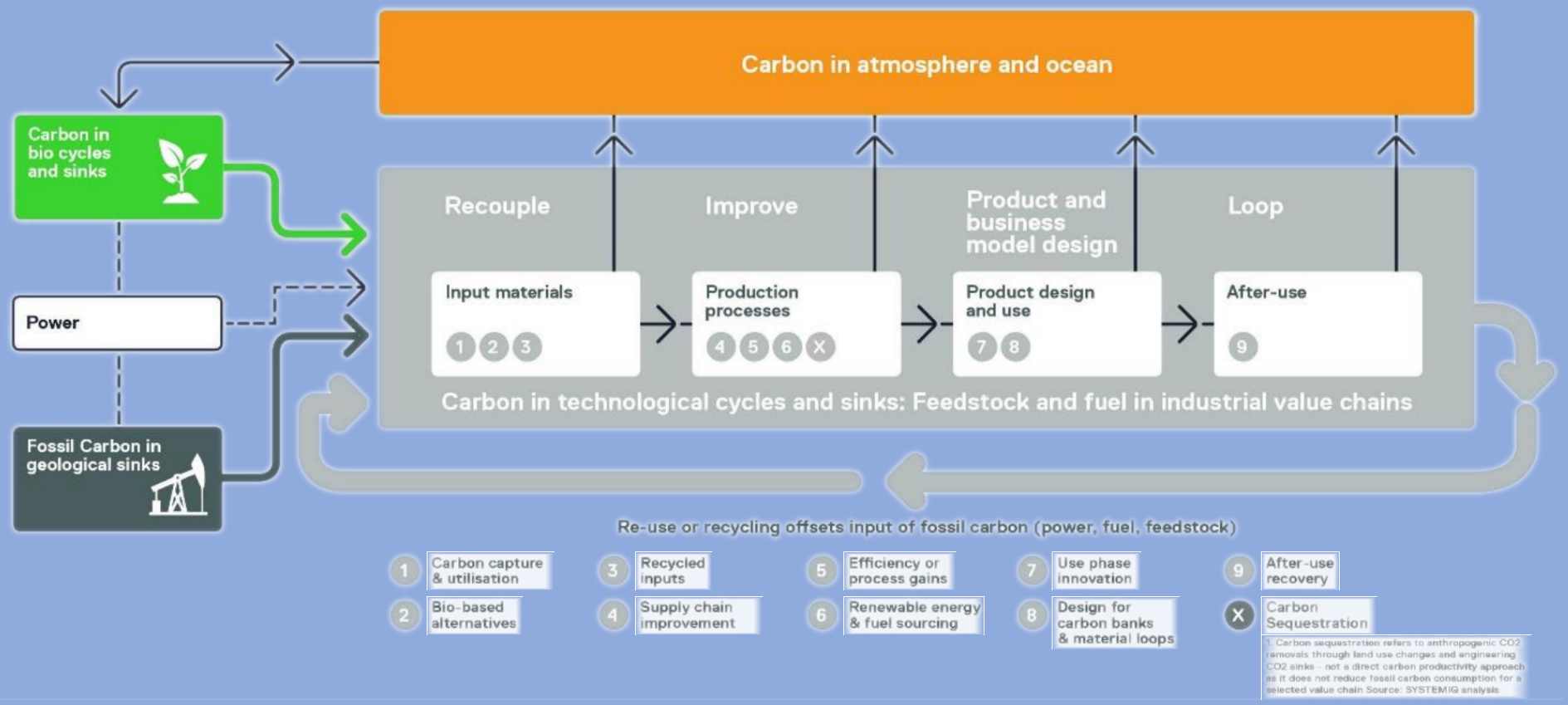
- **CarbonX is produced in Carbon Black reactors and plants**
- Production is efficient and comparatively inexpensive
- Most of the feedstock is a by-product

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



Carbon Productivity Consortium
www.carbonproductivity.com