Innovation Challenges & Nanotechnology Opportunities in Tyre Development

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1872 – 2016: PIRELLI'S WORLD

Founded in **1872** in Milan

37,000 employees globally

A great commitment to **research** and **innovation**

Leader in the **Premium** segment

Participating in sports competitions **since 1907**

2015 Ebit margin: **14.6%**

2015 Revenues: **6.3 €/bln**

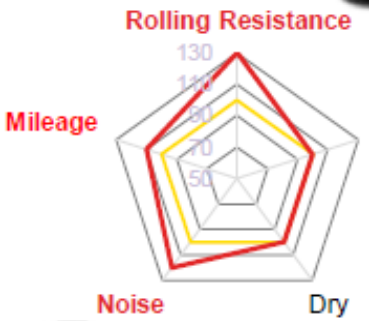
Exclusive supplier to the **Formula 1®** Championship for the three-year period **2016-2019**

Drivers of Tyre Innovation: Performance Space vs Products

Market requirements

- Rolling resistance
- Mileage
- Retreadability
- Acoustic comfort

CAR HP/SUV

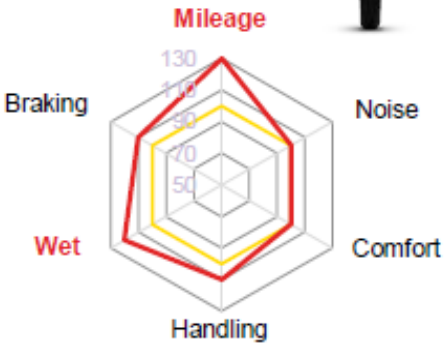


Environment & Legislation

- Aromatic oil-free compounds
- Vehicle gas emissions
- Noise

TRUCK

MOTO



The Tyre is an engineered product which needs to evolve more and more in a predictable way, not just trial and error

Other variables

- Competition
- Fuel cost
- Raw material prices

Environmental Sustainability plays a major role in shaping the future of tyre through legislation and market forces

Pirelli Life Cycle Environmental Strategy & Materials

MAIN CONTRIBUTIONS TO CARBON FOOTPRINT

The EU medium car Carbon footprint

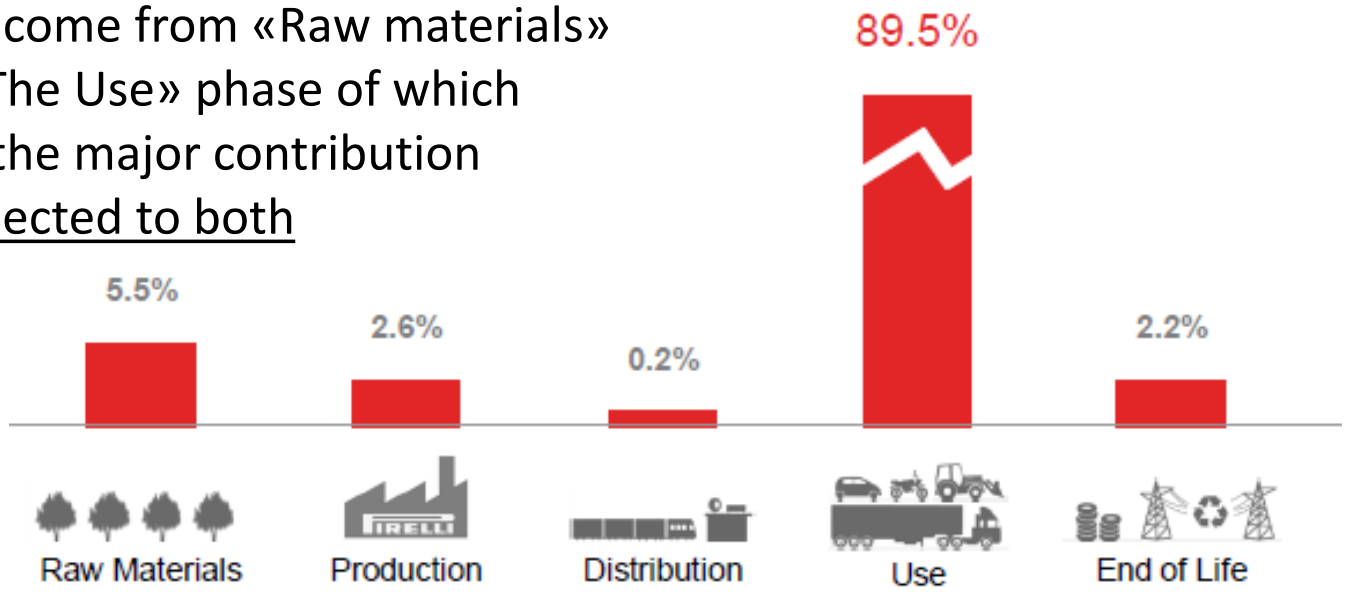
of which

~20-30% is the average contribution of FOUR TYRES

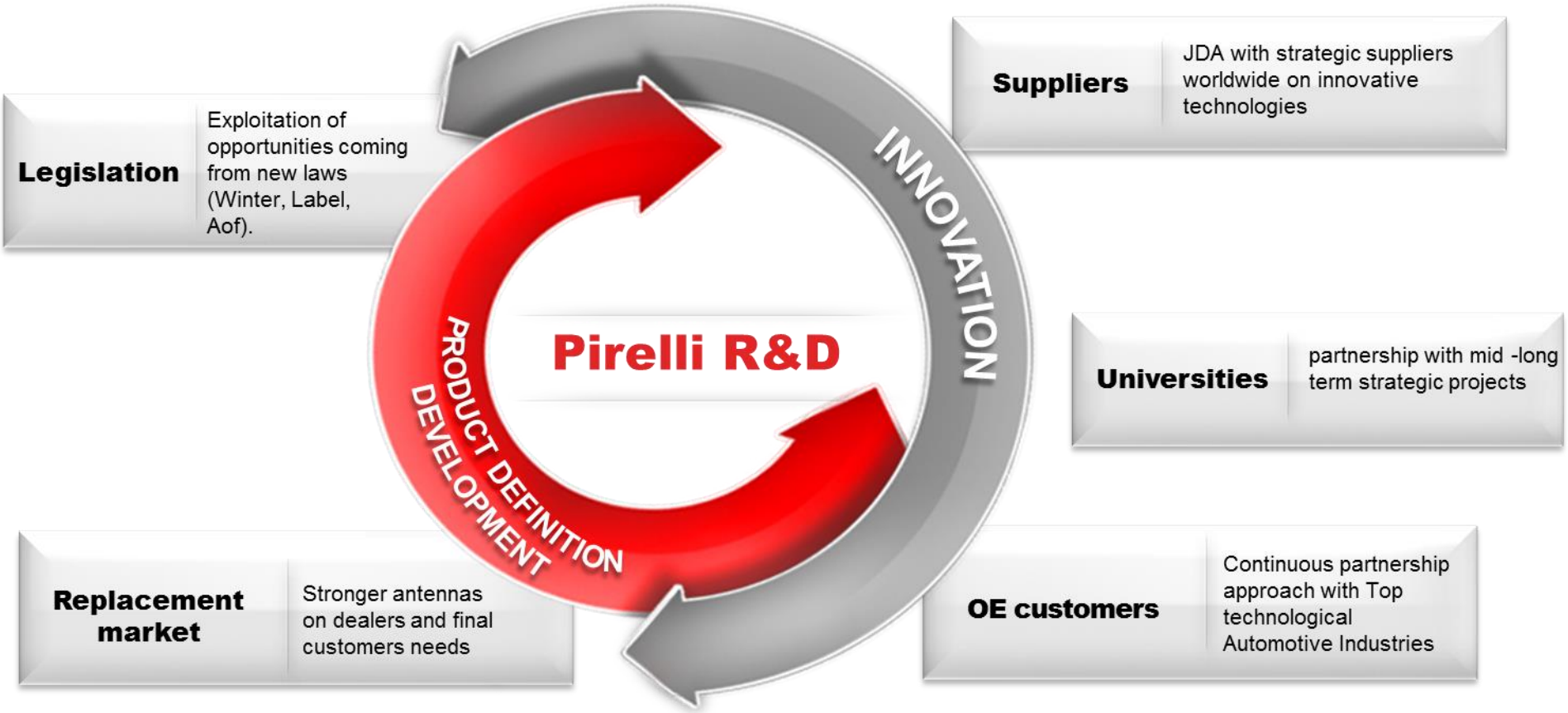
GLOBAL WARMING POTENTIAL OF OUR MODEL TYRE

Higher contributions come from «Raw materials» but above all from «The Use» phase of which Rolling Resistance is the major contribution

MATERIALS are connected to both



R&D Innovation Loop



OPEN INNOVATION MODEL

- **22 Universities partner with us**
- **35 R&D projects with Partners & Suppliers (JDA, NDA)**
- **109 cooperations with Premium OEMs projects on cutting edge technology**

Over 150

external projects

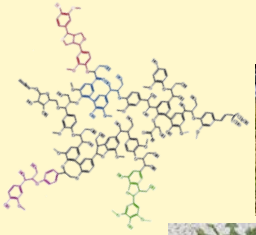
Key Enabling Technologies in Tyre Innovation

Micro-Nano Electronics

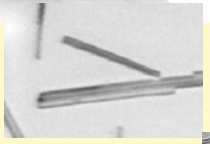
Cyber Tyre

Advanced Manufacturing Systems

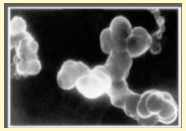
New processes of mixing and tyre building

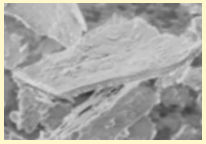


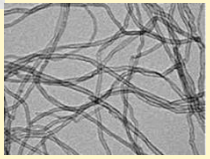
New polymers and Additives



Renewable Materials







New Nano Fillers

Advanced Materials

Industrial Biotechnology

Nanotechnology

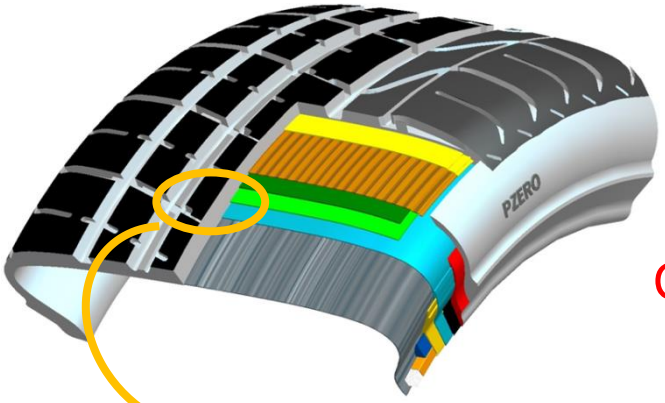
Tyre Insight

Tyre looks just black and round....

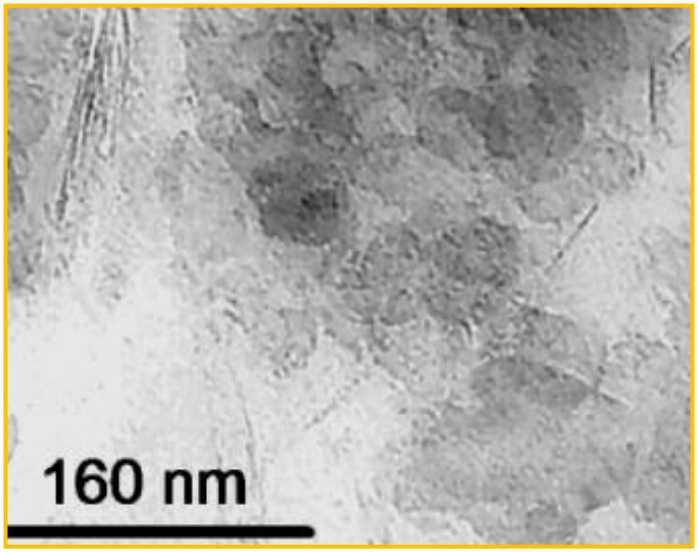
...but hides significant complexity in macro-components and in materials, down to the nano-scale

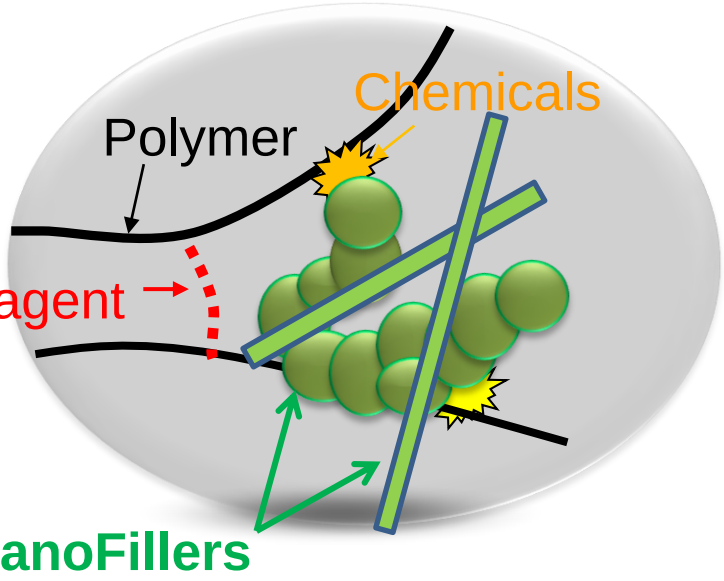
Tyre macroscopic performance depends critically on compounds properties at lengthscales spanning 7 orders of magnitude from cm to nm

Tyre Materials: Nanoscale Structure



Tyre Compunds = Nanocomposites

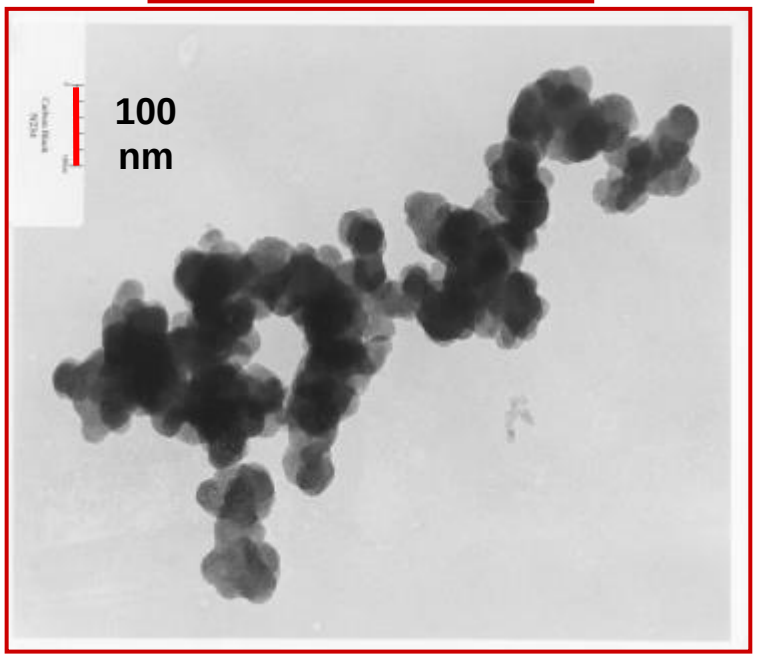




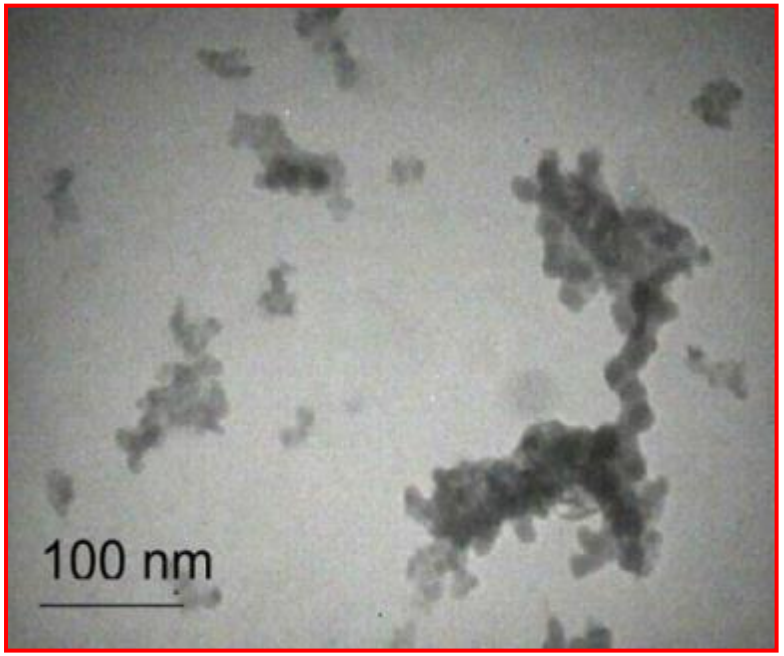
- Polymers and Nanofillers are essential part of all Rubber Compounds
- Fractal “bulk” interfaces make up most of the volume of rubber compounds
- Understanding fundamental aspects of Nanofillersand their interaction with Polymers is the key to improved Compounds

Tyre Materials: [nano]Fillers

Carbon Black (CB)



Silica (SiO_2)

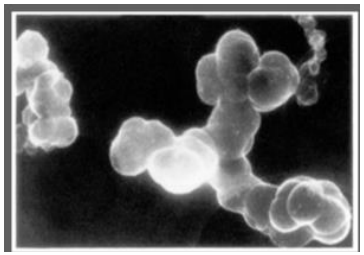


- Standard Rubber Fillers CB and SiO_2 are Nano(structured)materials
- Rubber Technology has always been based on «Nanocomposites» of CB and SiO_2 !

☺ Rubber Technologists are all «Nanotechnologists»!!

Tyre Materials: New Nanomaterials as Fillers

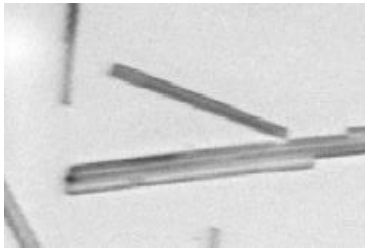
[new] NANO MATERIALS (FILLERS)



SILICA (NEW STRUCTURE)

LOW HYSTERESIS

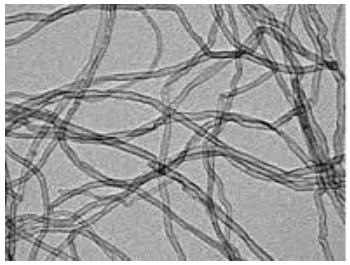
REDUCED ROLLING RESISTANCE



NEEDLE-SHAPED FILLER

HIGH MODULUS

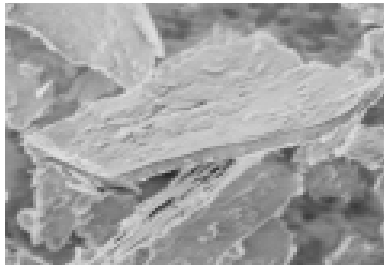
BETTER DRY HANDLING



CARBON NANOTUBES

ELECTRICAL CONDUCTIVITY

ELECTRICAL DISSIPATION COMPLIANCE



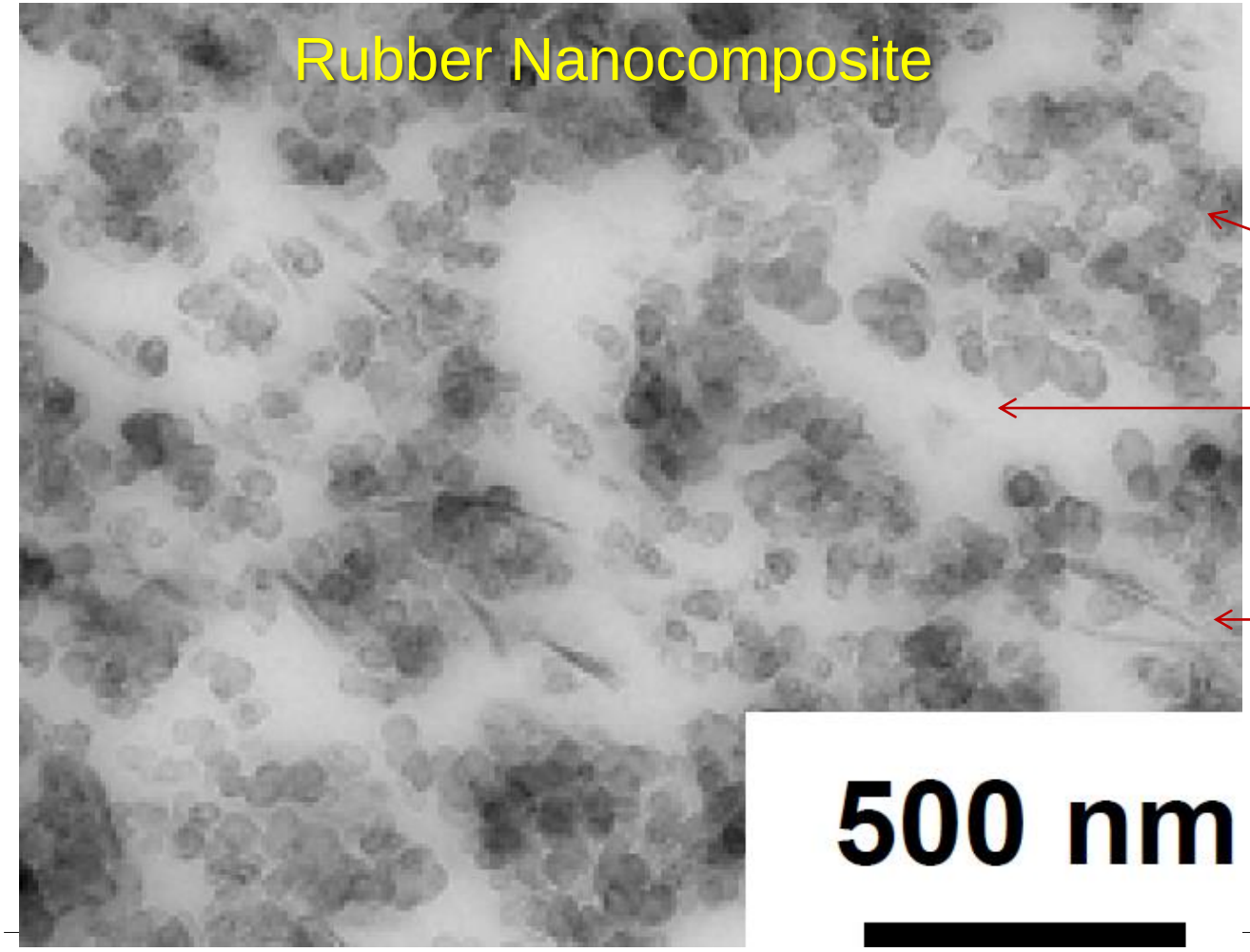
PLATY-SHAPED FILLER

HIGH IMPERMEABILITY

HIGH DURABILITY REDUCED WEIGHT

Tyre Materials: [nano]Composites – ideal view

- **Nanocomposites are MADE OF INTERFACES**
  very few areas free of filler (polymer appears white, having lowest density)
- **«Old» and «New» Nanofillers can coexist giving «Hybrid Systems»**



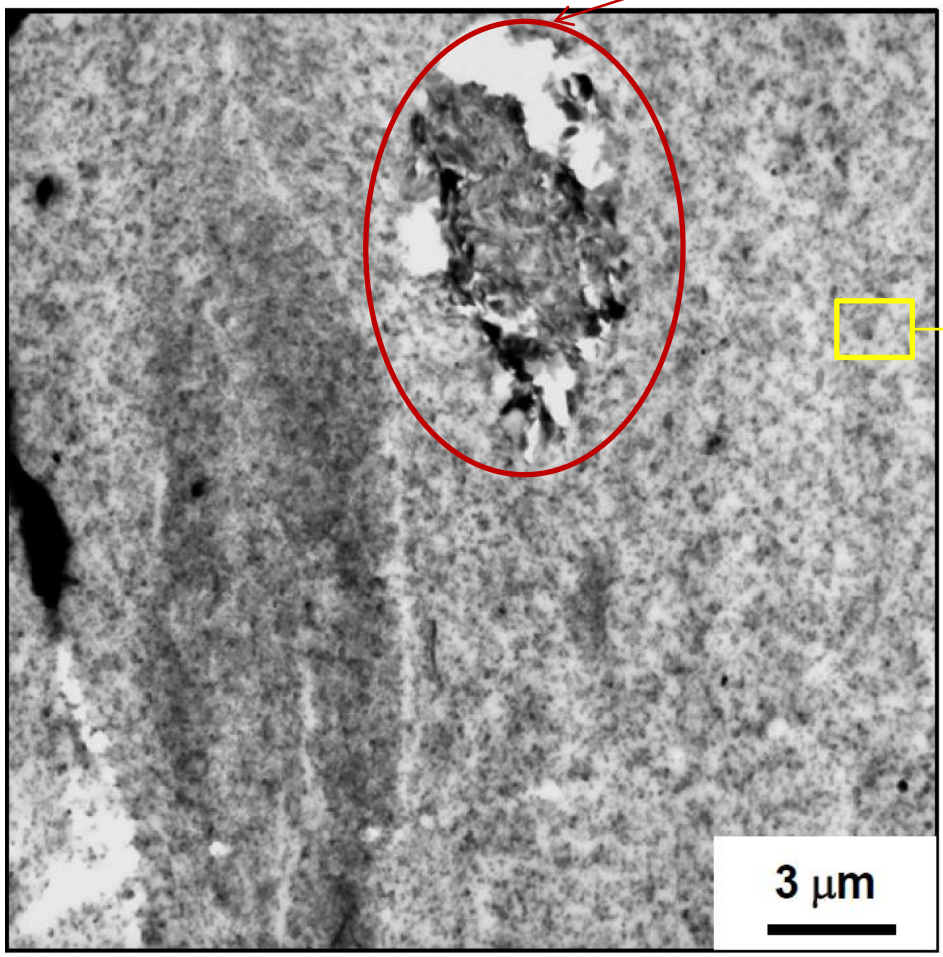
Carbon Black
(active «old» Nanofiller)

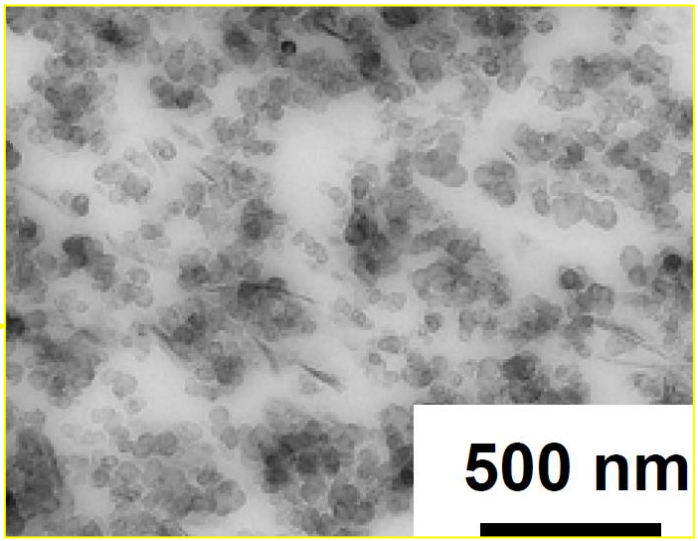
Polymer (IR)

Montmorillonite
(2D «new» Nanofiller)

Tyre Materials: Nanocomposites - Challenge

- Nanocomposites are MADE OF INTERFACES: very few areas free of filler (polymer white)
- «Old» and «New» Nanofillers can coexist giving «Hybrid Systems»
- NANOcomposites ofter coexist with **MICRO-composites**, due to NOT complete nano-particles dispersion





Real Materials in engineered products present a range of situations: Quantification of nanostructures and microstructures occurrence is currently very difficult to obtain and control

Tyre Materials

Innovative Compound Materials Overview

Polymer

Advanced Materials

Industrial Biotechnology

- **Joint Developments** with Best in Class Suppliers lead to «**TAILOR-MADE**» **IMPROVEMENTS** AND **INNOVATIVE Exclusive Solutions** for resolving trade-offs between **RR**, Wet, Winter, Mileage and Grip and Performance Enhancement
- Synthesis of **Innovative Polymers** in **Research collaborations**
- Research Activities with Universities **on NR Alternatives cultivated in Europe**
- PhD Projects on **«End of life tires» for selective Devulcanization** technology

Filler

Nanotechnology

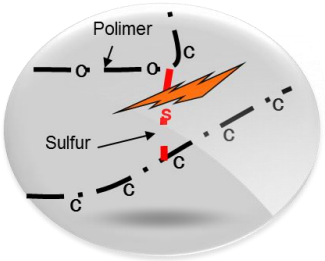
Industrial Biotechnology

- **University Research Collaborations on Nanofillers** to support lighter structures, higher impermeability and Product Trade-offs
- **Development of** new Fillers of **Mineral origin** to improve Wet, RR , Mileage and Processability
- **Biofiller Research** as partial substitution of CB
- **Rice Husk Silica** (EDS – HDS) produced in our Brasilian Plant

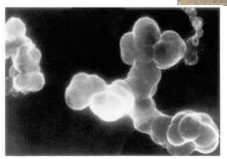
Chemical

Advanced Materials

Industrial Biotechnology



- **Development of innovative Chemicals** to resolve trade-offs between **RR**, and driving performance
- Development of **Natural based oils and resins**
- New more sustainable **Vulcanization agents**
- **Innovative** Systems to enhance the resistance against environmental attacks



Innovation Challenges & Nanotechnology Opportunities in Tyre Development

- Pirelli is a leader tyre producer in the **Premium segment**, strongly committed to the development of high performance products, according to its “green performance” strategy **“safe for People, safe for the Planet”**
- Tyre performance evolution [macro-scale] is driven by **Customer’s requirements, legislation and economics**
- Pirelli manages Innovation adopting an **Open Innovation Model**, including over 150 projects involving external partners, leveraging on **Key Enabling Technologies** including Micro-Nano Electronics, Advanced Manifacturing Systems, Industrial Biotechnology, Advanced Materials and Nanotechnology
- The Tyre is a **composite of different semi-finished materials**: Tyre macro behaviour is determined by material properties at **lengthscales from cm to nm**
- While engineering at the macro-scale is standard, engineering at the nanoscale is still in its infancy: **Polymers, Nanofillers and Chemicals need to be engineered also at the Nanoscale to deliver best performances.** Pirelli is engaged, in collaboration with Research Institutes and Selected Suppliers, in the development of new and more sustainable Materials, Nanocomposites and Tyres.

Thank you!

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