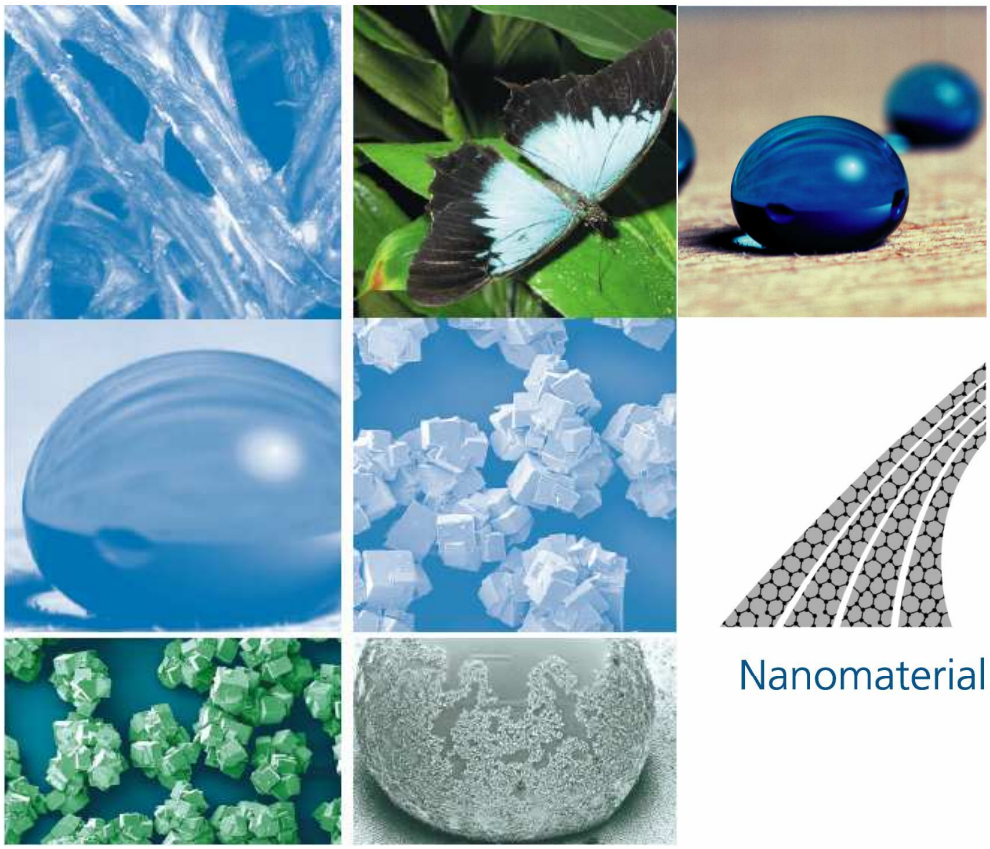

SIXTH FRAMEWORK PROGRAMME

nanoRoad sme

Nanomaterial Roadmap 2015

SWOT Analysis Concerning the Use of Nanomaterials in the Automotive Sector

STEINBEIS-EUROPA-ZENTRUM

FFG

funded by the European Commission

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I. Introduction

I.1. Objectives of the SWOT analysis

This study has the objective to give an overview on the use of nanomaterials in the automotive sector and has not the goal to be exhaustive. It will give to small and medium sized enterprises (SMEs) the possibility to have a concise description of the development in this sector. For this reason no scientific detail and technological explanation are presented.

Four main aspects of the industrial branch will be described in the SWOT analysis. The "*Strengths*" and "*Weaknesses*" will give information on the actual *State of the Art* concerning the use of nanomaterials and the "*Opportunities*" and "*Threats*" will describe *future Trends and Vision* in the industrial sector.

In order to give precision about the definition of the terms "*Strengths*", "*Weaknesses*" "*Opportunities*" and "*Threats*" in relation to the project NanoRoadSME, specific questions were defined for each of the four aspects.

- Actual industrial state of the art

"Strengths"
Which nanomaterials are presently industrially used in the corresponding sector? What are their technological and socio-economic advantages?

"Weaknesses"
What are the actual technological and socio-economic barriers to be overcome concerning products and applications in the corresponding sector?

- Trends and vision in the sector

"*Opportunities*"
How can **R&D opportunities** in nanomaterials (new development of nanomaterials, scientific breakthroughs) solve the existing problems and improve the existing weaknesses of products?

"*Threats*"
What are the **threats/risks** linked with the new opportunities; technological, market and socio-economic risks?

I.2. Overview on the automotive sector

The automotive industry is torn between trying to reduce costs on the one hand and, on the other, dealing with the high price of performance-enhancing technology and environmental compliance. Key drivers in the automotive industry are:

- Reduced air pollution
- Reduction of weight
- Recyclability
- Safety
- Better performance and engine efficiency (fuel saving)
- Aesthetics
- Longer service life

Future Applications in the Automotive Industry

Through nanotechnology, the automotive industry can get its new growth potential and development momentum. The design and manufacturing of cars, trucks and buses can be affected by nanotechnology and the related technologies up to 60% in 10 years.

The dominating trends of science and technology go to the nanoscale. The automotive industry will benefit from this trend by getting e.g. advanced powertrain, using new energy, reducing car weight, enhancing material functions, increasing comfort degree & flexibility, raising cost efficiency. Almost all the automobile components can be improved by nanotechnology (Figure 1). The nanotechnology provides the automotive industry with huge space for innovations and enormous chance for new markets. The competition in 10 years could well depend on the development and application of nanotechnology by manufacturers in their automobiles.

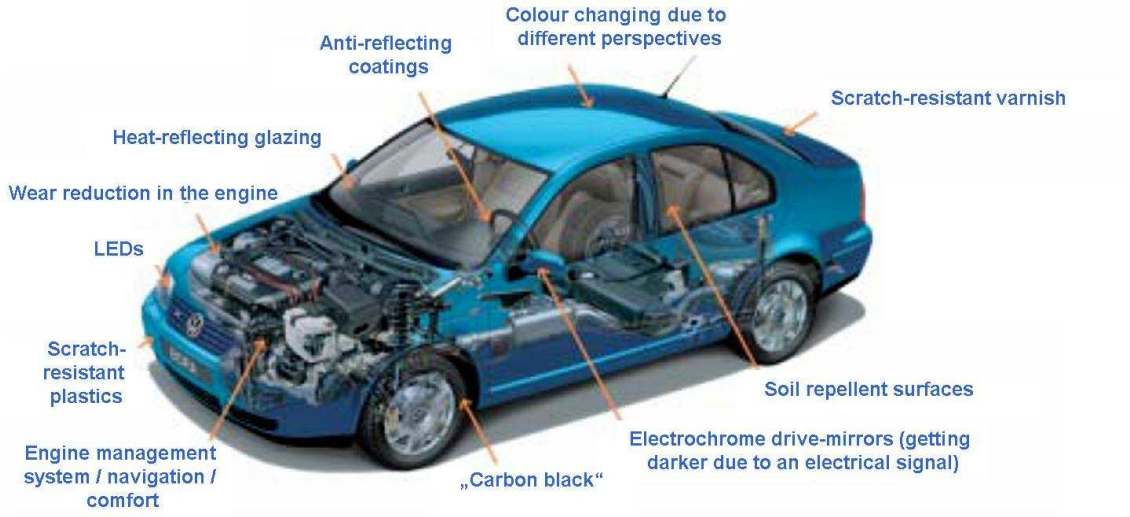

Figure 1: Fields of application of nanotechnology in the automotive industry [1]

[1] Nanomobility initiative of the German Ministry for Education and Research (BMBF, www.nanotruck.net)

In order to give a clear overview of the industrial sector, three different levels have been defined in the project:

Level 1: Domains of application
Level 2: Products in these domains of application
Level 3: Nanomaterials used in these products or having the potential to improve the weaknesses of existing products

The automotive industry can benefit from nanomaterials in several domains (Figure 2):

- Frames and body parts
- Engines and powertrain
- Paints and coatings
- Suspension and breaking systems
- Lubrication
- Tires
- Exhaust systems and catalytic converters
- Electric and electronic equipment

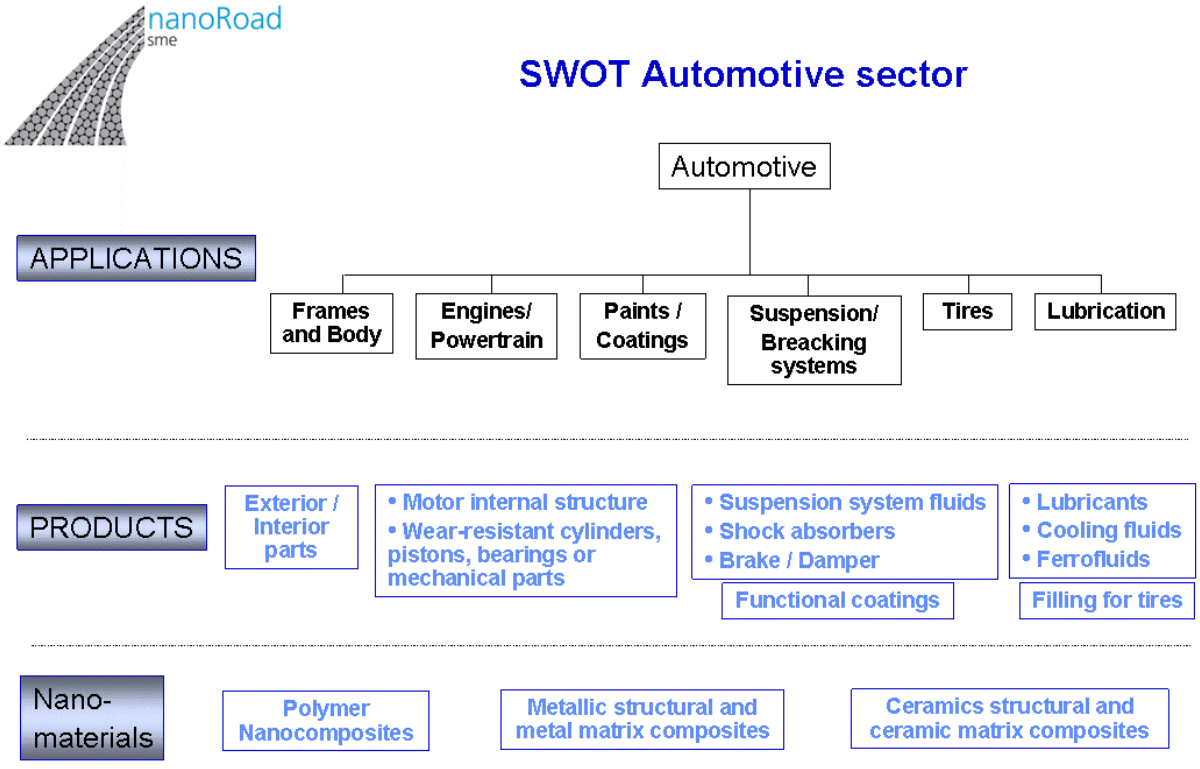

Figure 2: Applications and products in the domain of automotive industry

II. SWOT analysis on the automotive sector

II.1. Frames and body

(1) Nanomaterials presently industrially used

Concerning the materials used for frames and body, polymer nanocomposites play an essential role.

Example of applications/products:

- Polypropylene and TPO-based automotive exterior claddings.
- Clay nanocomposite olefin plastics for exterior parts.
- Nanoscale clay minerals for use in lightweight plastic nanocomposites.
- All parts of the car can theoretically be concerned e.g. nanocomposites (nanoparticles in a polymer matrix) are being recommended for use to produce interior trim items like door pillars, dash mats, dashboards, airbag covers, filters for air control.

(2) Barriers

- Cost effectiveness
- Reducing weight
- Recyclability
- Safety
- Aesthetics
- Many current polymers meet the strict mechanical needs for frame and body applications but do not fit with current electrostatic painting techniques. The development of conductive-insulant polymers will resolve this obstacle.

(3) Possible solutions through nanomaterials and risks linked

- Economical **lightweight** parts that enhance fuel efficiency and vehicle durability. The advantage of using a nanocomposite for automotive applications is **that less filler material** is required to provide the **same or better performance characteristics** when compared to conventional materials, **transparency**, less **permeability** and increased **strength** (clay nanoparticles), **safety** for example flame-retardant materials.
- The fire retardancy properties demonstrated by nanocomposites promise to create a whole new class of polymers for use in the interior of the automobile. The weatherability of nanoplatelet-reinforced composites offer extended useful life for exterior components
- Green nanocomposites, based on carbohydrate chemistry, promise to provide a new definition for recyclability and bio-decomposition.
- Amenities like cup holders that can absorb or produce heat and keep beverages at the perfect temperature.
- Shape memory alloys
- Active interior tissues

(4) Some companies active in this field

- General Motors
- Toyota
- GE Plastics (Noryl GTX) (Nanocomposite Supplier for Automotive painted parts)

- Nanocor Inc.
- 3D Systems Corporation nano-composite resin for SLA® (stereolithography) systems - Bluestone™)
- Blackhawk Automotive Plastics Incorporated
- Bayer AG

II.2. Engines and powertrain

The new development in engine and powertrain technologies has the objectives to improve thermal and mechanical efficiency, performance, drivability and reliability as well as to reduce emissions and costs.

(1) Nanomaterials presently industrially used

- Requirements for increased fuel economy in motor vehicles demand the use of new, lightweight materials — typically plastics — that can replace metal. The best of these plastics are expensive. **Nanocomposites** consist of traditional **polymers reinforced** by nanometer-scale particles dispersed throughout. These reinforced polymers may present an economical solution to metal replacement. In theory, the nanocomposite can be easily extruded or moulded to near-final shape, provide stiffness and strength approaching that of metals, and reduce weight. Corrosion resistance, noise dampening, parts consolidation, and recyclability all would be improved.
- In the internal combustion engine there are opportunities conferred by nanocrystalline structures (greater strength and temperature tolerance). E.g. future fuel injector for diesel engine will integrate thin diamond like carbon coatings for an increased wear resistance.

Figure 3: Future fuel injector for diesel engine with nanometer thin diamond like coatings[2]

(2) Barriers

- Thermal and mechanical efficiency
- Performance and drivability
- Emissions (pollution and noise)
- Reliability and durability

[2] Brochure „Nanotechnologie – Innovationen für die Welt von morgen“ - German Ministry for Eduction and Research (BMBF) – Picture credits Robert-Bosch GmbH, Stuttgart

- Speed to market and cost
- Weight and size

- However, producing nanocomposites requires the **development of methods for dispersing the particles throughout the plastic**, as well as means to **efficiently manufacture parts** from such composites.

(3) Possible solutions through nanomaterials and risks linked:

- Nanoceramic materials offer an opportunity to rethink the internal structure of the internal combustion engine and its component coatings
- Wear-resistant cylinders, pistons, bearings or mechanical parts

(4) Some companies active in this field

- Magna International
- Centro Ricerche Fiat (CRF)
- Electrovac
- Ford Motor Co.
- Aveka Group
- GE Plastics
- Synkera
- Emil Bröll GmbH

II.3. Paints and coatings

(1) Nanomaterials presently industrially used

- Properties of traditional materials change and the behaviour of surfaces start to dominate the behaviour of bulk materials. Such effects include ultraviolet (UV) blocking, anti-static, and conductive capabilities. Paints and coatings industries were among the first to take advantage of these capabilities three years ago. Companies also found that with the incorporation of nanoparticles, thin film coatings have stronger bonds and better flexibility, with little cost differences. These coatings are smoother, stronger, and more durable. When used on products, the results range from scratch-resistant and self-cleaning surfaces to moisture-absorbing clothing. Many companies from around the world are using the properties of nanoparticles and are incorporating them within their coatings.

Some examples of nanocoating applications:

- Iridescent coatings
- Carbon nanotube based paints
- Corrosion protection coatings
- Ultraprecise polishing of surfaces
- Scratch-proof, transparent coatings
- Fluoropolymer composites allowing water- and dirt-repellent effect
- Photochromic and electrochromic window coatings (allowing glass to change color at will)
- Chemo-mechanical polishing (CMP) and abrasive slurries for precision finishing
- Coatings and Adhesives
- Nanoparticles are being used as abrasives, and in paints, and in electrochromic coatings for windscreens, or windows
- Surface Disinfectants

- Thermal Spray Coatings
- Nano-particle clearcoat offering greater scratch resistance
- Electroconductive polymers (with dispersion of carbon nanotubes) for exterior body panel applications, in which the body panel can follow the same electrostatic paint line as the steel components they replace, e.g. for electrostatically painted moulded parts to avoid electrostatic build-up.

(2) Barriers

- Recyclability
- Environmental friendly
- Aesthetics
- Specific functionality's (electrostatic, colour, self cleaning effect, etc...)

(3) Possible solutions through nanomaterials

- The coatings themselves, and the surfaces they are applied to, are subject to damage from environmental elements such as rain, snow, salts, acid precipitation, ultraviolet part of sunlight and humidity. These coatings can also get scratched, chipped or otherwise damaged during use or during manufacturing and shipping. There is a constant effort to identify ways to prevent such damage from the elements and from chipping, spotting or scratching. The discovery of new functionality offered by the use of nanomaterials allows development of new applications.

(4) Some companies active in this field

- DaimlerChrysler (e.g. using nano-particle clearcoat paint nano-particle clearcoat on metallic and non-metallic paint finishes offers significantly greater scratch resistance and improved gloss on some of its Mercedes model series of cars)
- BMW (e.g. Nanoparticle based coatings as self cleaning material)
- PPG Industries Inc.
- BASF
- DuPont
- Hyperion Catalysis International (e.g. Static-dissipative applications)
- Sustech GmbH
- Robert Weitzer Glaszubehör GmbH (Nano-Coating)
- Nanoproofed Austria (Nano-Coating)
- Tiger Coatings (Paints)
- Asix GmbH (Surface Coatings with Nano-Scale Particles)
- Gabriel-Chemie GmbH (Colour and additive concentrates)
- Benda Lutz Werke GmbH (Paints, powder coatings)
- VoestAlpine Stahl GmbH (Coatings)

II.4. Lubrication

(1) Nanomaterials presently industrially used

- Nanotechnology-based solid lubricants reduce friction between moving parts and minimise wear, save maintenance costs and greatly improve overall machine performance. In addition, it reduces energy consumption and decreases air pollution.

Example of nanocoating applications/products:

- New cooling fluids and ferrofluids

(2) Barriers
- Improvement of Tribological properties with use of nanomaterials to increase the lifespan of mechanical components.
- Cost effectiveness

(3) Possible solutions through nanomaterials and risks linked:
- The development of lubricants in the automobile industry depends on the adhesion of nanometer layers (mono layers) to a material surface. Assembly of components can depend critically on the adhesion of materials at the nanometer length scale.
- Lubricant-free bearings

(4) Some companies active in this field
- ARC Seibersdorf research GmbH
- ApNano Materials Inc.
- Hatco Corp.
- IAVF Antriebstechnik AG
- Etc...

II.5. Suspension and breaking systems

(1) Nanomaterials presently industrially used
- Suspension systems. Injecting nano iron-based particles into certain fluids creates a magnetic field that changes the viscosity from a thin liquid to a solid. This allows a vehicle to instantly alter its suspension system based on the conditions it senses.

(2) Barriers
- Security
- Comfort
- Faster response time
- Better road-holding qualities of a vehicle.

(3) Possible solutions through nanomaterials and risks linked:
- Electro-rheological fluids for shock absorbers
- Brake and active rotative damper based on Nano MR-Fluids (nano Magnet over micro particles)

(4) Some companies active in this field
- Continental Teves
- TWR
- Bridgestone
- Lord Corporation

II.6. Tires

(1) Nanomaterials presently industrially used

- Replacement of carbon black in tyres with nanoparticles of inorganic clays and polymers, leading to tyres that are environmentally friendly and wear-resistant
- New nano coating reduce weight, improve pressure retention and reduce recycling and incineration costs.
- Nanostructured soot as an additive to increase tire life, reduce friction and fuel consumption.
- In the past few years European elastomer and inorganic oxide producers have teamed to produce, using an empirical approach, the green tire which is based on nano-structured silica reinforced hydrocarbon elastomers.

(2) Barriers

- Greater safety and efficiency: reduce weight
- Improve fuel efficiency
- Improve pressure retention and reduce recycling
- Reduce incineration costs.

(3) Possible solutions through nanomaterials and risks linked

- Better grip
- Less filling
- Nano coating

(4) Some companies active in this field

- Degussa
- Cabot
- Electrovac GmbH
- Bridgestone (BFS)
- Michelin
- Goodyear
- Dana Corp.
- Federal-Mogul
- Continental AG

II.7. Electric and electronic equipment

The automotive industry is a major user of sensors and components for new integrated miniaturised systems, and MEMS have been a key driver in many of today's advanced safety systems. MEMS are currently used in two standard automotive applications: the air bag accelerometer, which first went small tech in the early 1990's, and the manifold air pressure sensor, or MAP sensor, first used in the late 1970's.

- Night Vision Systems
  - High transmittance IR polymers embedded with nanoparticles
  - High sensitivity IR sensors
- Sensors
  - Cabin air quality monitoring
  - Exhaust emissions detection
  - Advanced functionalised textiles
- On Board Information
  - Thin film display
  - Interactive glasses (IPI)
  - Micro-shutter displays based on carbon nanotubes
- Lighting
  - Electro-optical films
  - New lighting sources
  - Optical switches

<u>Some companies active in this field</u>

- CISC Semiconductor Design & Consulting GmbH (microelectronic activities)
- Astron Electronic GmbH (microelectronic activities)
- Infineon Technologies Austria AG
- Siemens AG
- Robert Bosch GmbH
- BEI Technologies Inc.
- Motorola Inc.
- SensoNor ASA
- Volvo
- Ford Motor Co.
- NASA
- Fujitsu
- IBM
- AB Mikroelektronik GmbH

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EXPERTS:

- Dr. Humbert Noll, Head of Department Microsystems, FH Wiener Neustadt
- Dipl. Ing. Roland Pichler, AWS, Technologie & Innovation
- Ing. Thomas Zischinsky, Automotive Cluster Vienna Region

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Authors:
Marcus Bidmon, Hélène Valadon, Dr. Rita Ebner
(FFG - Österreichische Forschungsförderungsgesellschaft, Austria)

Dr. Jonathan Loeffler
(Steinbeis-Europa-Zentrum, Karlsruhe, Germany)

Contact of project co-ordinator:
Dr. Jonathan Loeffler
e-mail: loeffler@steinbeis-europa.de
Steinbeis-Europa-Zentrum
Erbprinzenstraße 4-12, 76133 Karlsruhe
Germany

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