



Universität Paderborn



Chemie und Technologie  
der Beschichtungstoffe

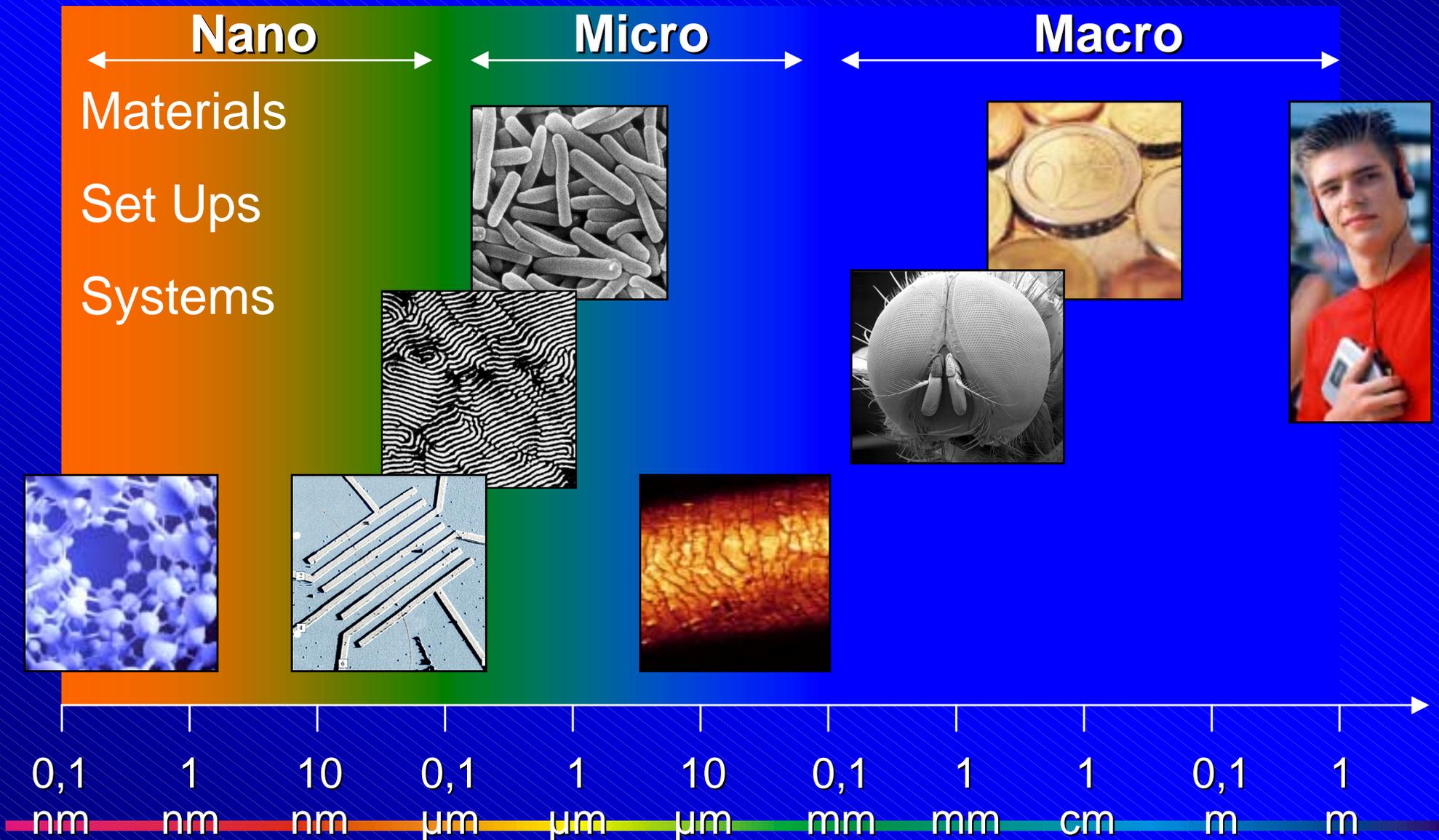
# *Nanotechnologie in Beschichtungen*

Wolfgang Bremser  
Coatings Science  
University Paderborn





# Scales





# The Coatings Industry at the Forefront

Zwischen 4 und 20 Millimikron  
bewegt sich die Teilchengröße von



dem neuen Hilfsmittel  
für die Lackindustrie

Bitte, fordern Sie den neuen Prospekt an

**DEGUSSA**  
ABT. RUSS · FRANKFURT/M.

**Farbe und Lack**

...EN- UND LACK-INDUSTRIE

...liche Leitung: Prof. Dr. Joh. S

... AM SCHIFFGRÄBEN 41. POSTFACH PO

APRIL 1949

**DEGUSSA**

*Russ*

*das Güteerzeugnis für*

FARBEN · DRUCKFARBEN · LACKE



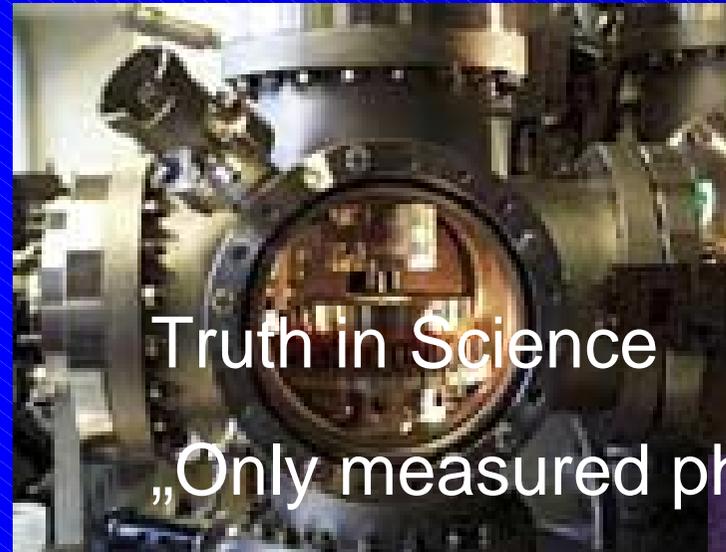
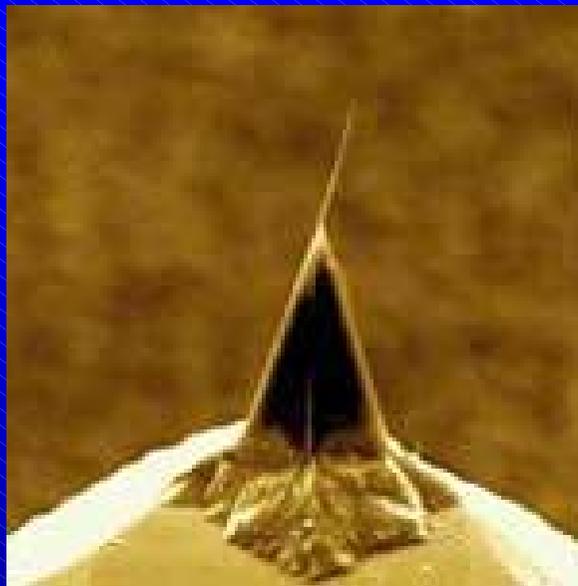
DEUTSCHE GOLD- UND SILBER-SCHIEDANSTALT  
VORMALS ROESSLER · FRANKFURT/MAIN

Rheology

Color



# Nanotechnology in Science



Truth in Science

„Only measured phenomena are true“

„Only written things are true“



Truth in Industry

„Only tested phenomena are true“

„Only what I know is true“

- Scanning Tunnel Microscopy
- Scanning Probe Microscopy
- Beginning of 80s





## ***Nanotechnology in Material Science***

- What's new about it?
  - Quantum size effects?
    - Not used in Coatings
  - New Physical Properties?
    - There is no other or new physics
    - Described by Colloid and Interface Science
  - Everything can be achieved by Nanotechnology?
    - Deus ex machina
  - Nanoparticles offering any desired Solution?
    - Even more powerfull Deus ex machina
-



# ***Nanotechnology in Material Science***

## ○ Nanotechnology as a selling argument?

- Works in industry
- Works in the scientific community
- Works in politics

## ○ Nanotechnology as a tool?

- Necessary to control materials on the nano scale
- Necessary to control all other levels



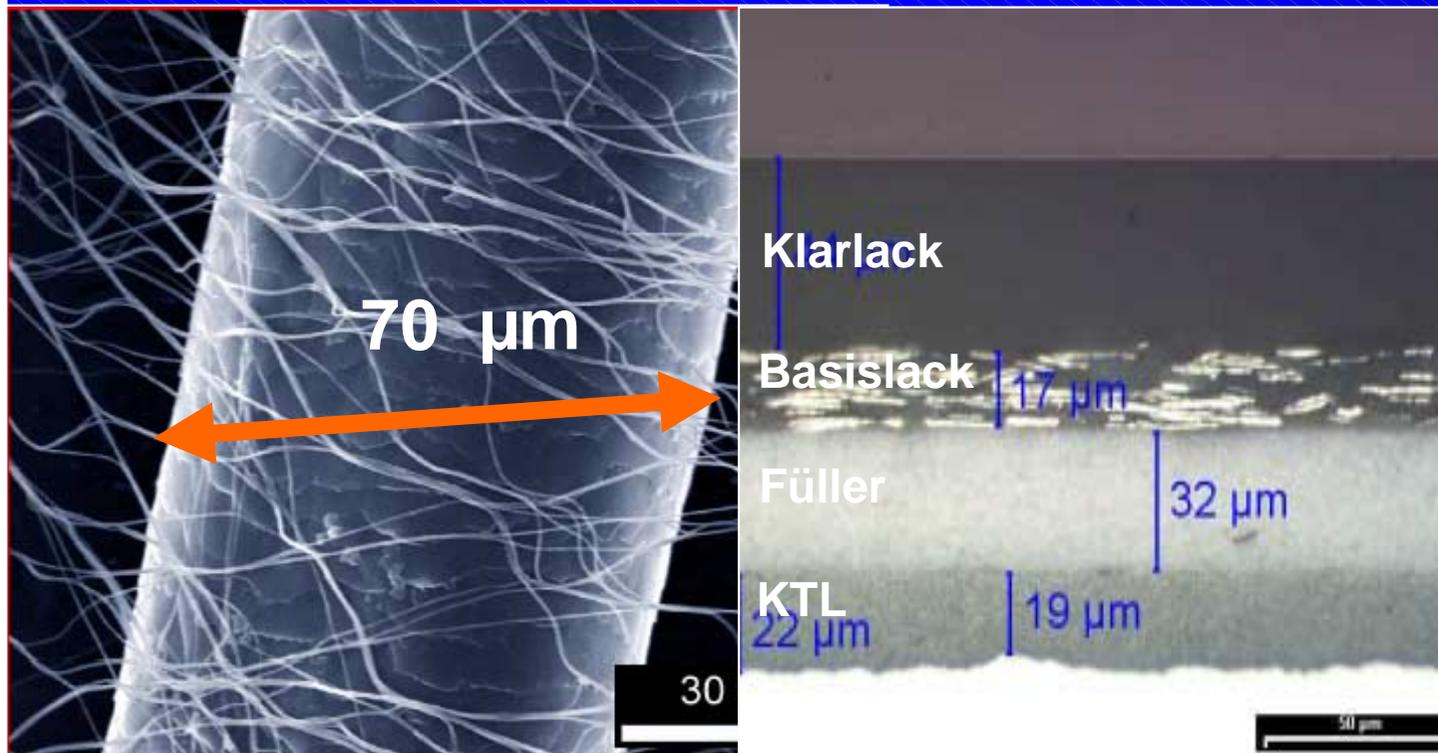


## *Synonyms for Nanotechnology*

- Coatings
  - Pigments, Effect Pigments
  - Fillers, functional Fillers
  - Colloid and Interface Science
  - Molecular Control
  - Hierarchical Materials
  - Hybrid-Materials
  - Polymer Science
  - ...
  - Everything that is not a simple molecule or a crystal
    - Real Material
  - Every New Property
-

# Nanoelements in Automotive Coatings

## 4-Layer System



**Crosslinking  
Topologie**

**Colloidal System**

**Mechanical  
Properties**

**Gradient  
system**

- Complex Heterophase System with Suprastructures on different length scales



## Lotus Effect

# Illusion

In nature...

... In technical materials



# Everything is Fine with Nanoparticles?

## Tiny particles, huge effect

### Radiation curable silica nanocomposites for scratch and abrasion resistant coatings

**Christof Rescher**

Nanotechnology reinforced composites consisting of monodisperse, non-agglomerated  $SiO_2$ -particles and radiation-curing acrylic resins show a great enhancement of scratch and abrasion resistance and hardness without possessing the disadvantages known from other inorganic additives. Even with loads of silica up to 50 %, water-clear products with low viscosities and no sediment-formation are realized, making these nanocomposites a useful and versatile raw-material source suitable for all kinds of high performance applications.

**Figure 1:** DLS distribution of a DCC derived from G400.

In polymer matrices as well as in mineral inorganic fillers, the use of inorganic fillers becomes more and more important. Inorganic fillers like quartz, carbon black or TiO<sub>2</sub>, pigments, carbon black can be used to reduce material costs of inorganic or polymer. Addition to the cost reducing effect, inorganic fillers can provide an improvement of material properties like tensile strength, hardness, abrasion resistance, thermal stability, and electrical properties and gas barrier of fillers. However, the applicability of such fillers, particularly in coatings, is restricted because of their high hydrophobicity, which is counterproductive. A solution for this problem can be the use of monodisperse nanosized  $SiO_2$ -particles which do not show these drawbacks.

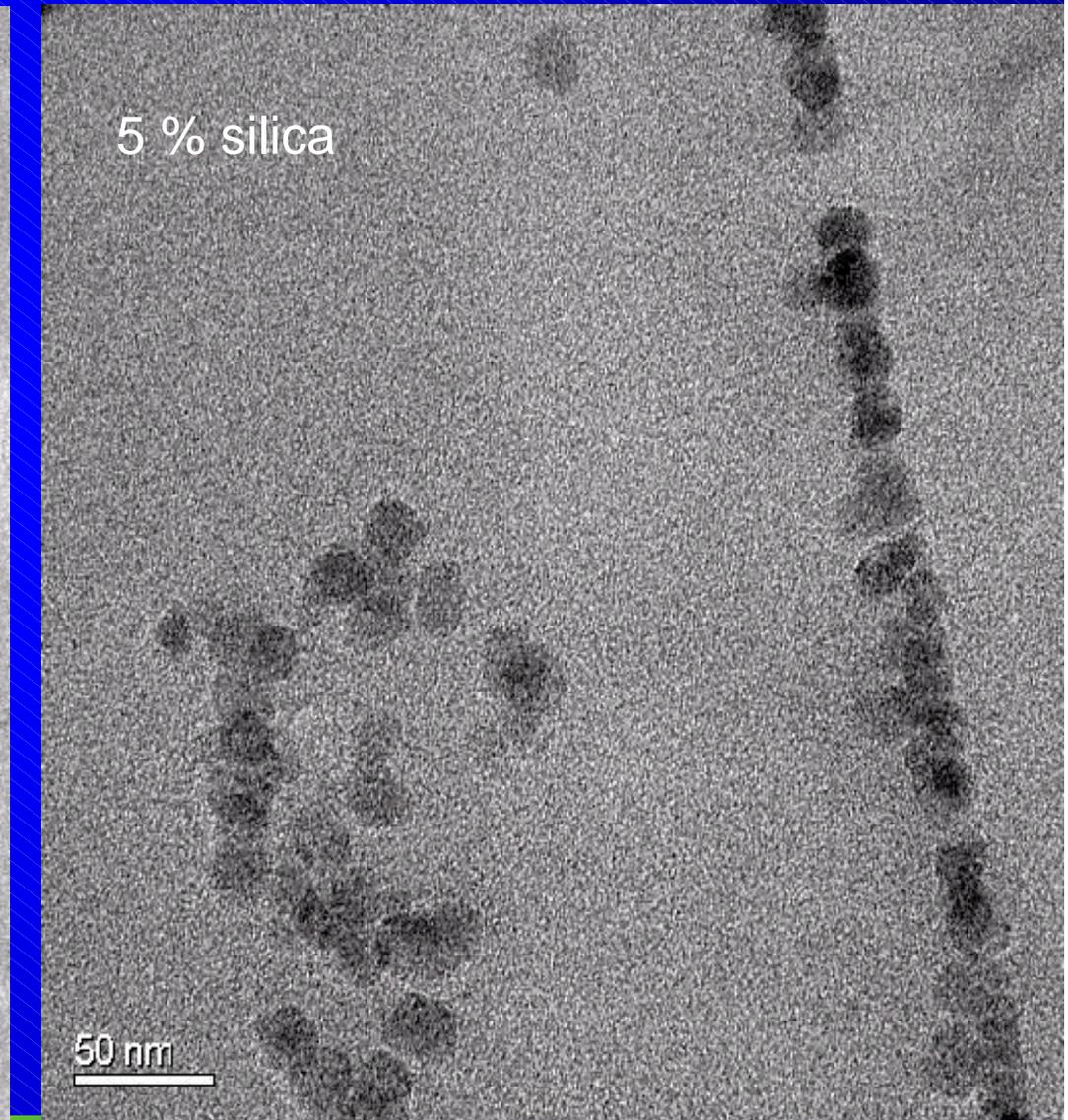
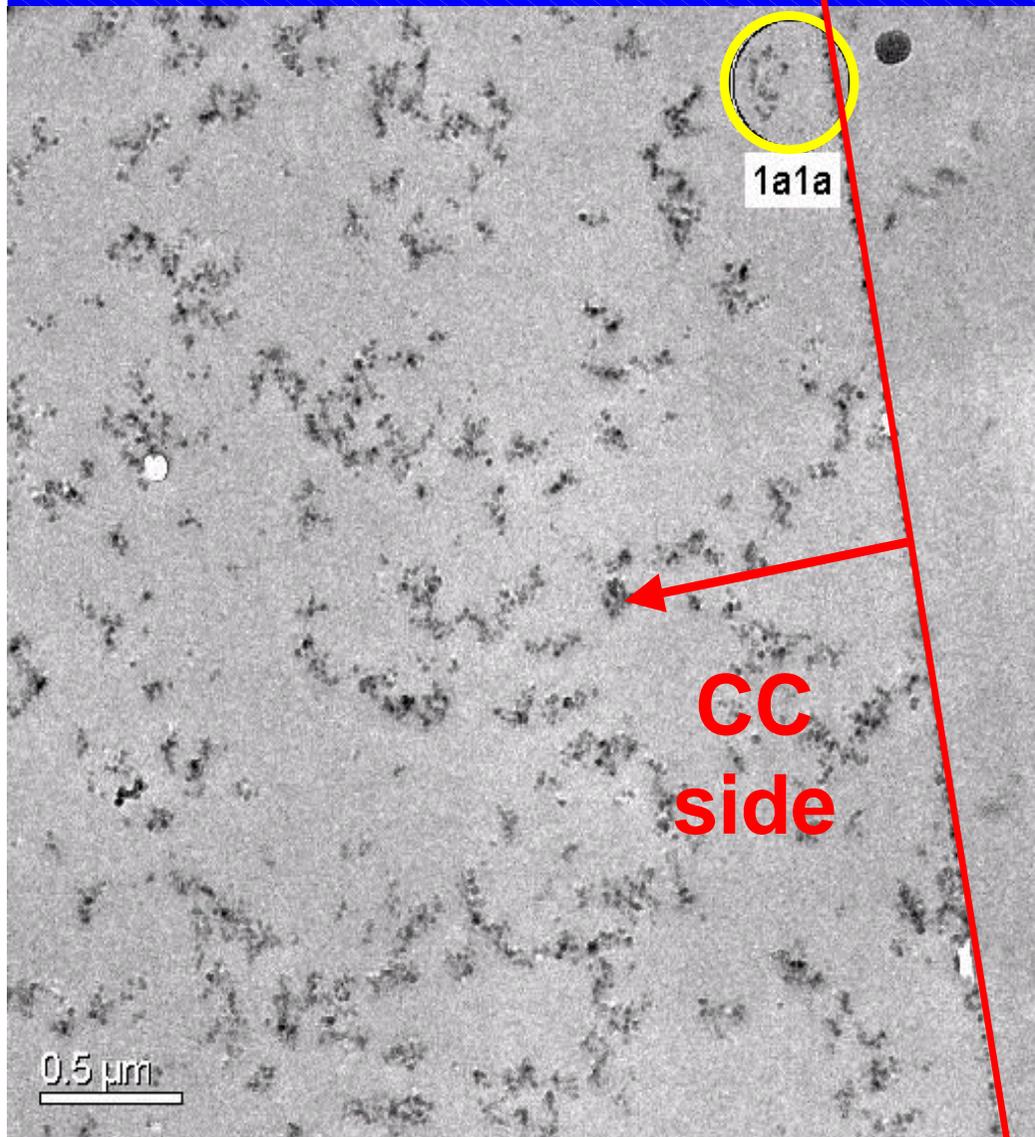
Formerly silica nanoparticles suitable for inclusion in an acrylic matrix formulation (by a hydrolysis from hydrolysis process) followed it many cases by a silica treatment of the  $SiO_2$ -surface [1]. The size of the primary particles of hydrolysis silica in the range of 100 nm, but during the silica hydrolysis much larger agglomerates are formed. These agglomerates are not fully dispersible into acrylic matrix particles, which is the reason for the observed viscosity increase and (due to loss of resin) abrasives containing formulation is amounts of more than a few percent. However, the introduction into coating is usually limited below the level due to the low dispersibility.

Forming standards, but also modification of the silica with organofunctional groups together with mechanical effects (abrasion) may help up to a certain level and show promising results [2,3] but at the expense of the efficiency to control sand and certain processing inconveniences.

**Figure 2:** TEM of an ultra-fine line of cured silica nanocomposites.



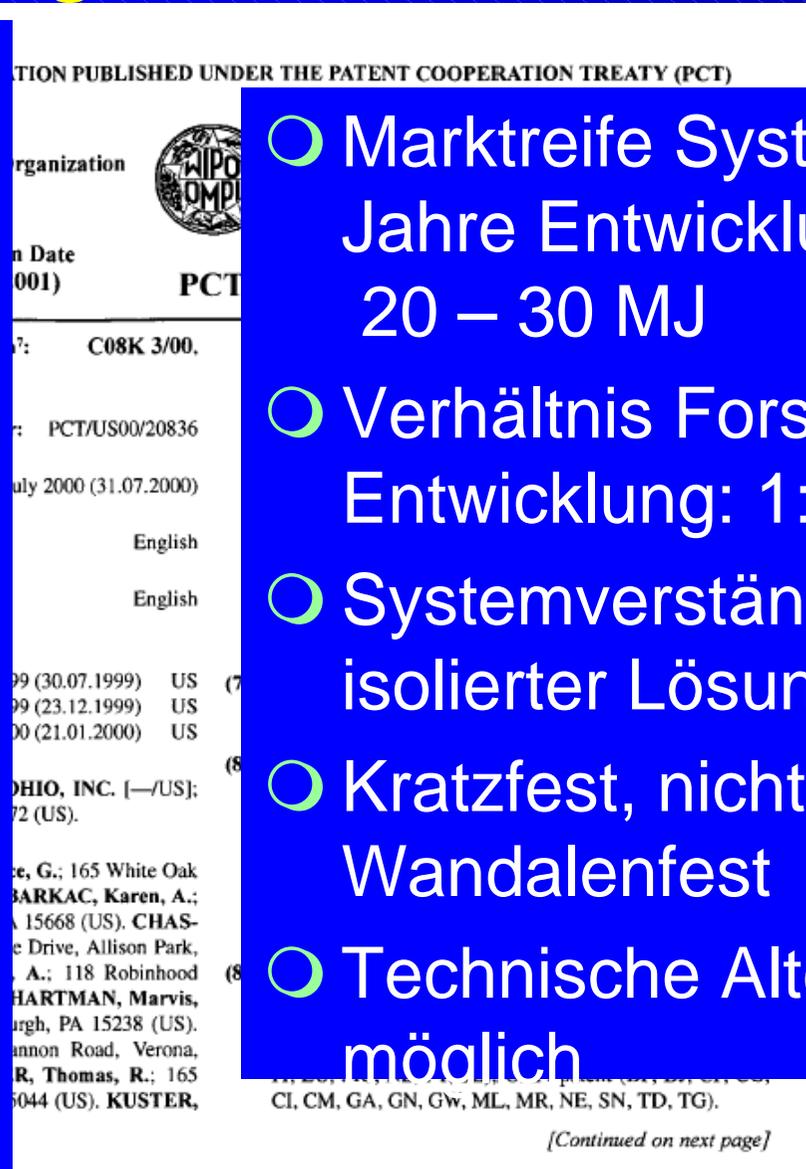
# Verteilung der Nanopartikel





# Patents are Revealing Efforts

- Nano Particles
- (Gradient Structure)
- Pentasiloxane
- Melamine Resins
- Isocyanate
- 3-4 Levels of Crosslinking
- Suprastructure
- Brittle
- Unsufficient Adhesion
- Internal Stress
- Costs



- Marktreife Systeme: 4-5 Jahre Entwicklungsarbeit, 20 – 30 MJ
- Verhältnis Forschung zu Entwicklung: 1:10
- Systemverständnis anstatt isolierter Lösungen
- Kratzfest, nicht Wandalenfest
- Technische Alternativen möglich



# ***Nanotechnology Environmental Hazards and Toxicity***

- Nanoparticles
  - Permanent Association with Asbestos
  - Covered by existing legislation
  
  - Free Nanoparticles?
    - Aerosol
    - Dispersion
    - Material
  
  - Toxic Effect observed
  - Defined Conditions?
-



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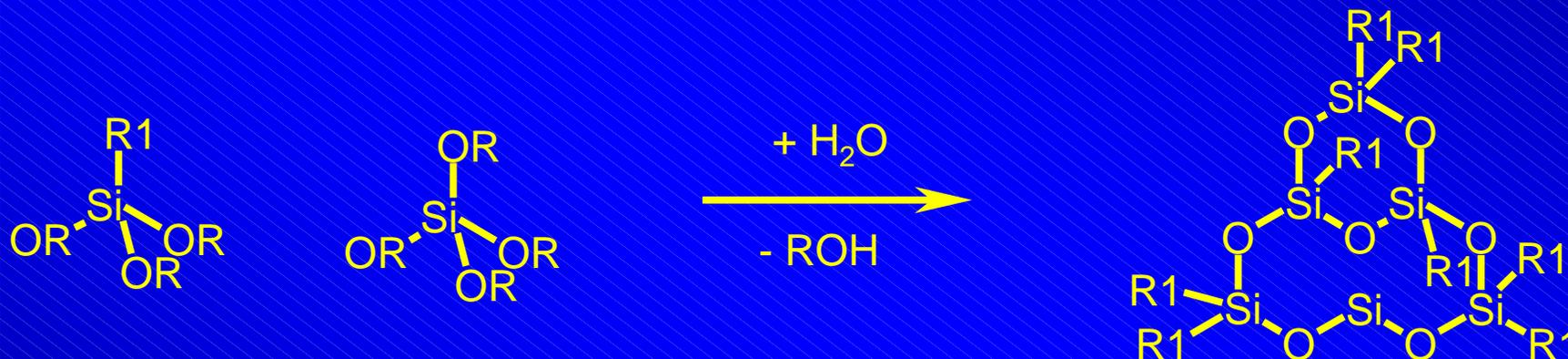


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# *Nanolacke - Siloxanbasis*



## Siloxan-Lacke, „Nanolacke“

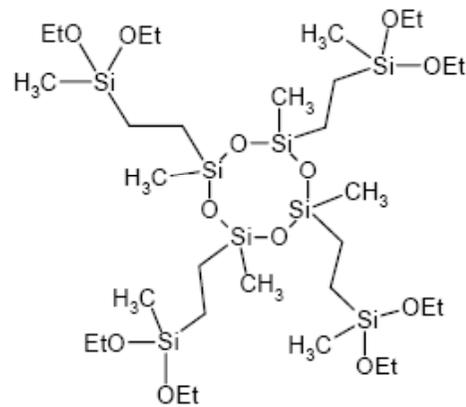


- Organisch-Anorganische Kompositwerkstoffe
- „Ormocere“, „Sol-Gel“, „Nanolacke“
- Polysiloxane als Bindemittel anstatt „normaler Polymere“
- „Übliche Rezeptierung“: Additive, Füllstoffe usw

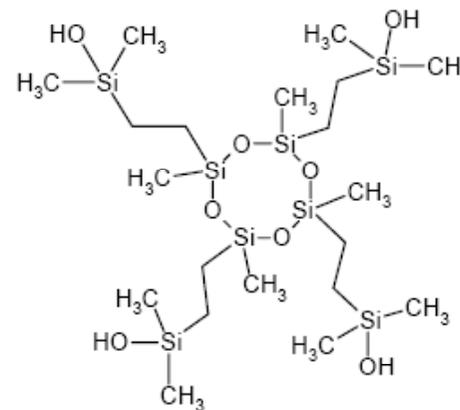


# Siloxan Bausteine

„D4-Diethoxide“

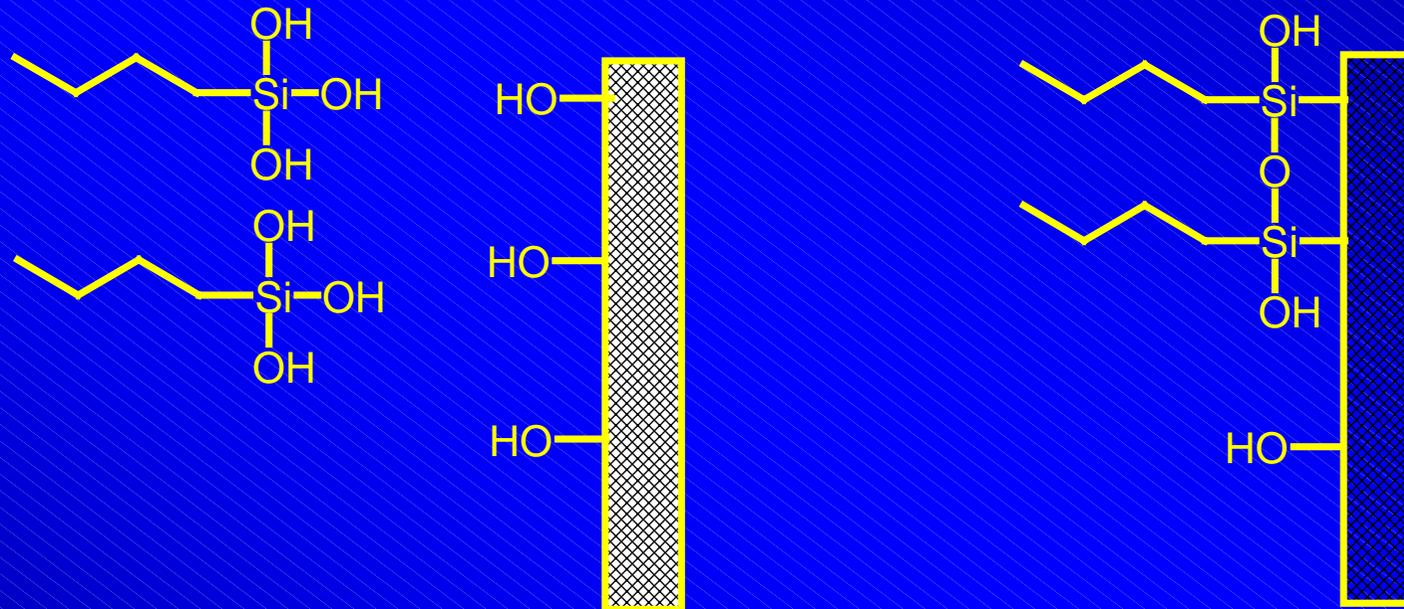


„D4-Silanol“



Bayer AG

## Siloxan-Lacke - Korrosion



- Anbindung an OH-Gruppen
- Stabil verankerte Oxide notwendig (Aluminium)
- „Nanolack“ = Siloxanbindemittel



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# ***„Nanolacke“ im Alltag***





# Easy to Clean - Sanitär



**3 Teile = 1 Preis**

**Runddusche GLASS 5**

Bestehend aus:

**Runddusche GLASS 5**

- 5mm Sicherheitsglas klar
- DUSART PLUS Glasbeschichtung auf der Innenseite, Anhaftung von Schmutz und Kalk wird reduziert
- Höhe 1.850 mm oder 2.000 mm
- Türen mit Magnetverschluss
- Hobo- und Senkmechanismus
- Stoffe aus hochwertigem beschichtetem Polyester
- Einfarbiges Design
- Made in Germany

**Passende Duschtasse DOMO**

- Becken und Schürze aus einem Stück
- angeschliffener Wannenränder, dadurch perfekte Passgenauigkeit von Wanne und Träger und optimale Geräusch- und Wärmeeinsparung
- Abtropfblech mit abgerundeten Ecken
- Spritzen
- Made in Germany

**Kopfbrause RAINY**  
(siehe auch Seite 19)

- große Regenschauerdüse mit über 90 Düsen aus Softmaterial (Antical)
- Armatur nicht im Lieferumfang enthalten
- Made in Germany

**DUSAR**  
LIFE LINE

## DUSCHKABINEN



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\*DUSART PLUS Glasbeschichtung auf der Innenseite  
Anhaftung von Schmutz und Kalk wird reduziert

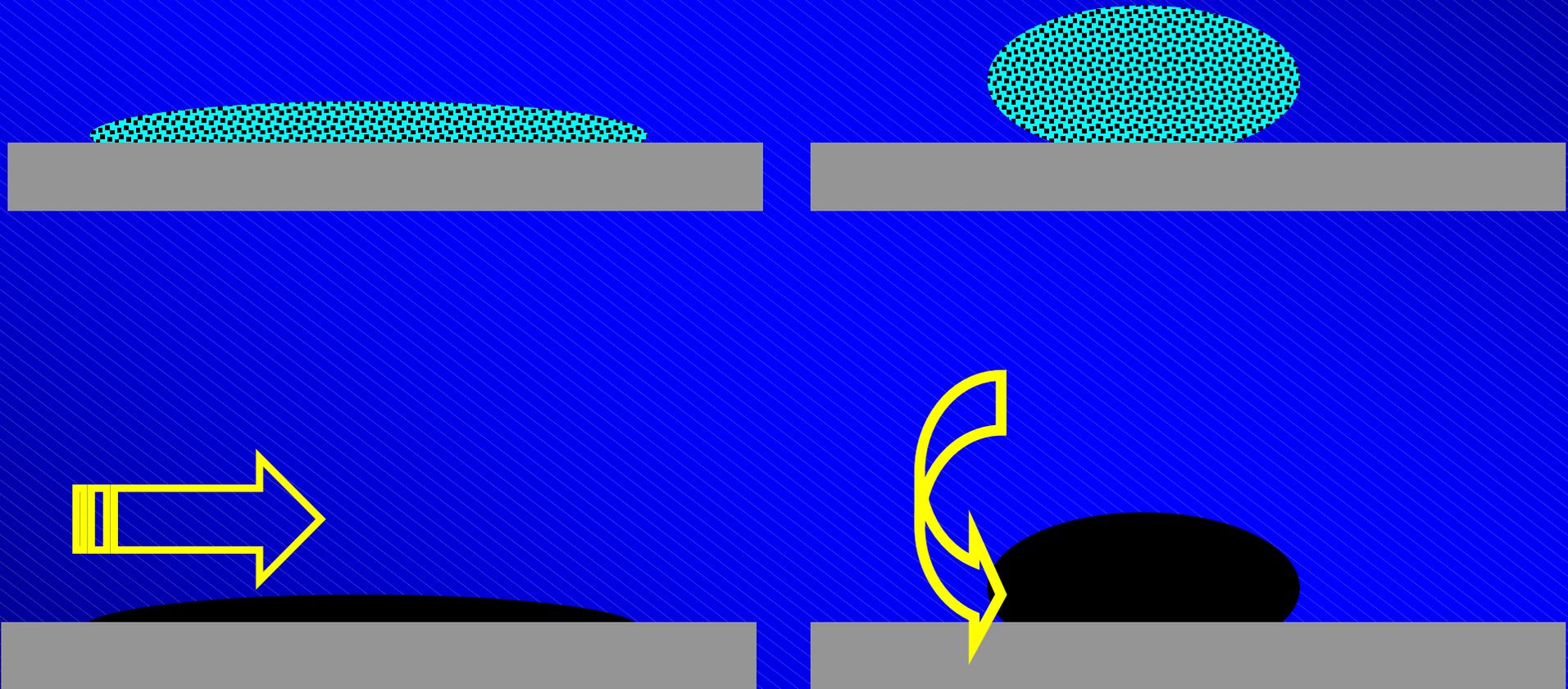
## *Easy to Clean - Sanitär*



- Abperlende Tropfen auf Hydrophober Oberfläche
- Abperleffekt
- Schmutzform



# Easy to Clean - Dusche





## *Anti-Fingerprint*



**270-Liter-Kühl-/Gefrierkombination Edelstahl**

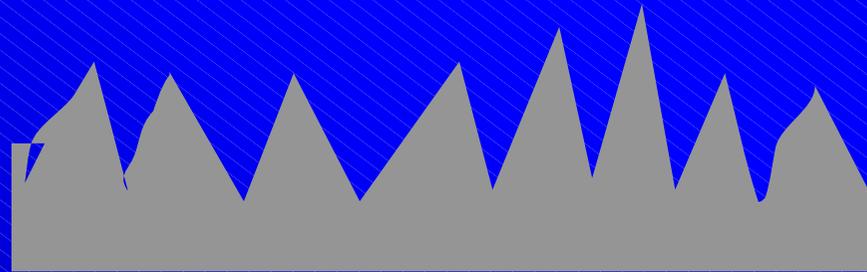
**Designergerät. Der Blickfang für Ihre Küche.**

**Matte Oberfläche mit Anti Fingerprint Beschichtung**

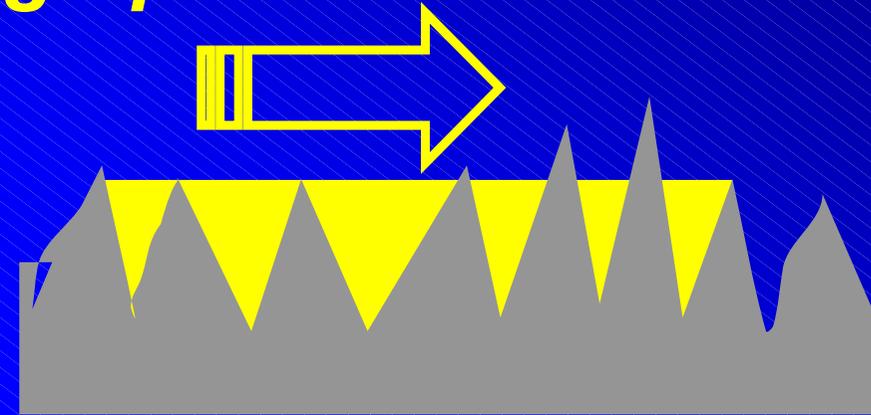
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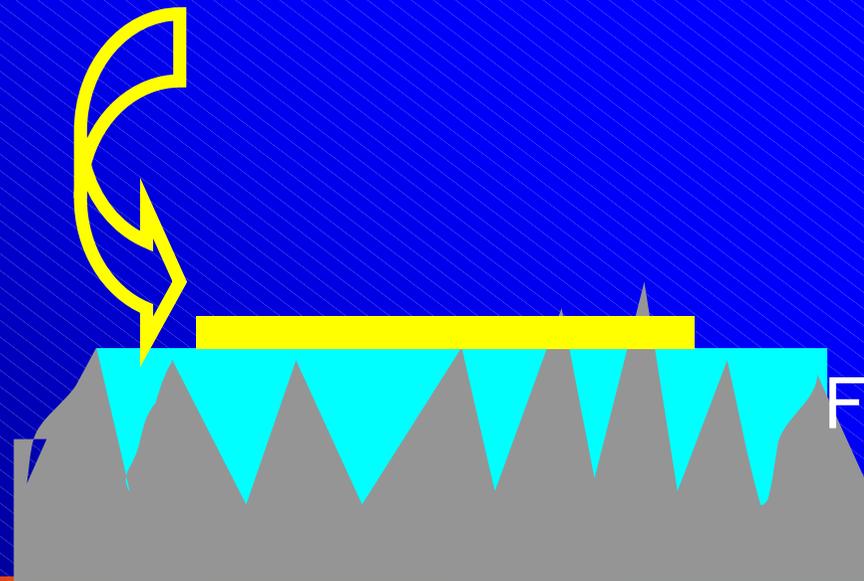
# Anti-Fingerprint



Matte Edelstahloberfläche



Fingerabdruck



Füllung der Vertiefungen



## **Anti-Mikrobiell**

Nutzhalt Kühlraum 346, Gefrierraum 186 l Elektronische  
Temperaturreglung **Silver Nano: Antibakterielle Beschichtung**  
No-Frost-Technik Twin Cooling System Superfros & Supercool  
Abtau-Automatik Cool Select für Temperaturen von +2  
über 15,5 Grad) Abstellfläche Kühl- und Gefrierteil aus  
stabilem Sicherheitsglas Wassereiswürfel und Eisspender für Würfel und  
"Crushed Ice" (Frischwasser) Innen liegender  
Wasserfilter Hausbar, Wasserdampfsicherung Tür-offen-  
Warnsystem (akustisch) Energieverbrauch 525 kWh/Jahr Farbe  
silber





## *Antimikrobielle Wirkung von Silber*

- (Fast) unsichtbare Silbernanopartikel
- Freisetzung von Spuren an Silberionen
- Bakterientoxische Wirkung
- Analog: Silber und Kupfergefäße

100 nm

\* Uncountable Ag nanoparticles is dispersion in dark field as like galaxy.

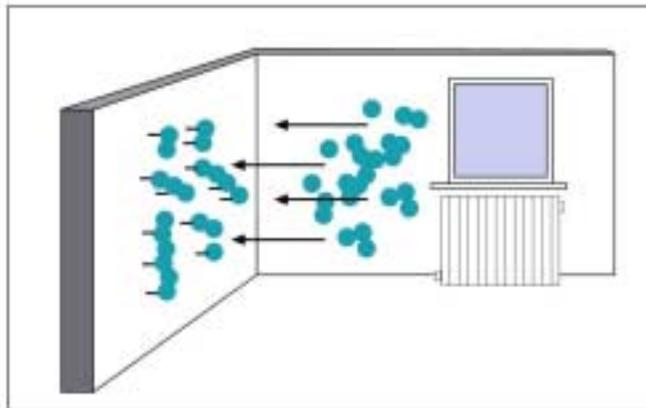


# Photokatalyse – Wellness-Farben

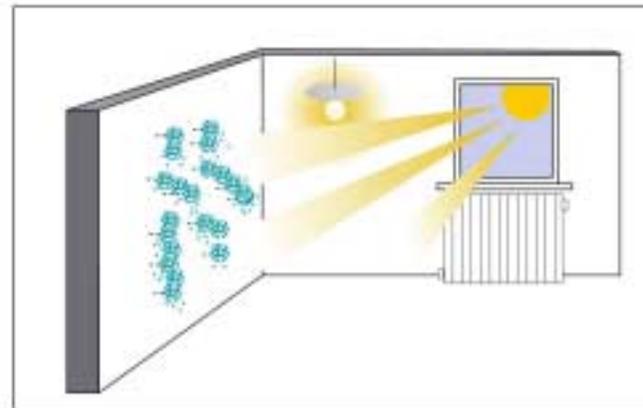
## Verbessertes Raumklima



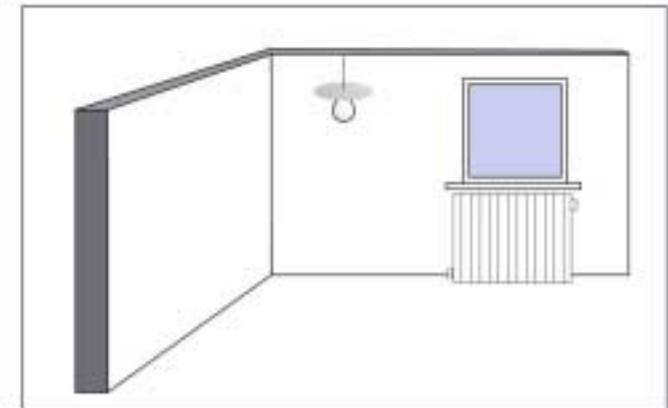
### CapaSan. Innenfarbe mit photokatalytischem Effekt



Organische Bestandteile in der Raumluft lagern sich an der Wandfläche ab.



Auf Basis von Weißpigmenten und Lichtenergie werden organische Substanzen abgebaut.



Das Resultat:

Durch den photokatalytischen Effekt werden Schadstoffe in der Raumluft reduziert.



## Conclusion

- Coatings are Nanotechnology
  - Nanotechnology in Coatings is more than Siloxanes or Nanoparticles
  - Nanotechnology is an Enabling Technology, but is No Innovation by itself
  - Changing Focus from Molecules to Structure
  - From Bricks to Architecture
  
  - Hierarchical Structure on all Length Scales
  - Control and Understanding
  - Integrated Systems instead of Isolated Solutions
  - Properties Instead of Isolated Nano Elements
  - Be Inspired, See the Challenge!
-



# *Visionäres*

Be Inspired





## **Lack als**

- Leuchte
  - Reflektor /Reflektorstreifen
  - Warnleuchte, Unfallsignal
  - Display
  
  - Solarzelle
  
  - Sensor
-



## *Lack mit neuen Effekten*

### ○ Schaltbarem Farbton

- /Nutzer
- Reversibel irreversibel
- automatisch
  - durch Energieeintrag
  - durch Pigmentausrichtung
  - durch chem. Reaktion
  - **irreversibel**

### ○ Schaltbarer Struktur

- Lotuseffekt
  - Benetzbarkeit
  - Muster/Maserung
  - Oberflächenspannung
  - Glanz
-



## ***Lack mit neuen Eigenschaften***

○ selbst reparierend (Bionik)

○ regnerierbar

○ Struktur

- Lotuseffekt
- Benetzbarkeit
- Muster/Maserung
- Oberflächenspannung
- Glanz

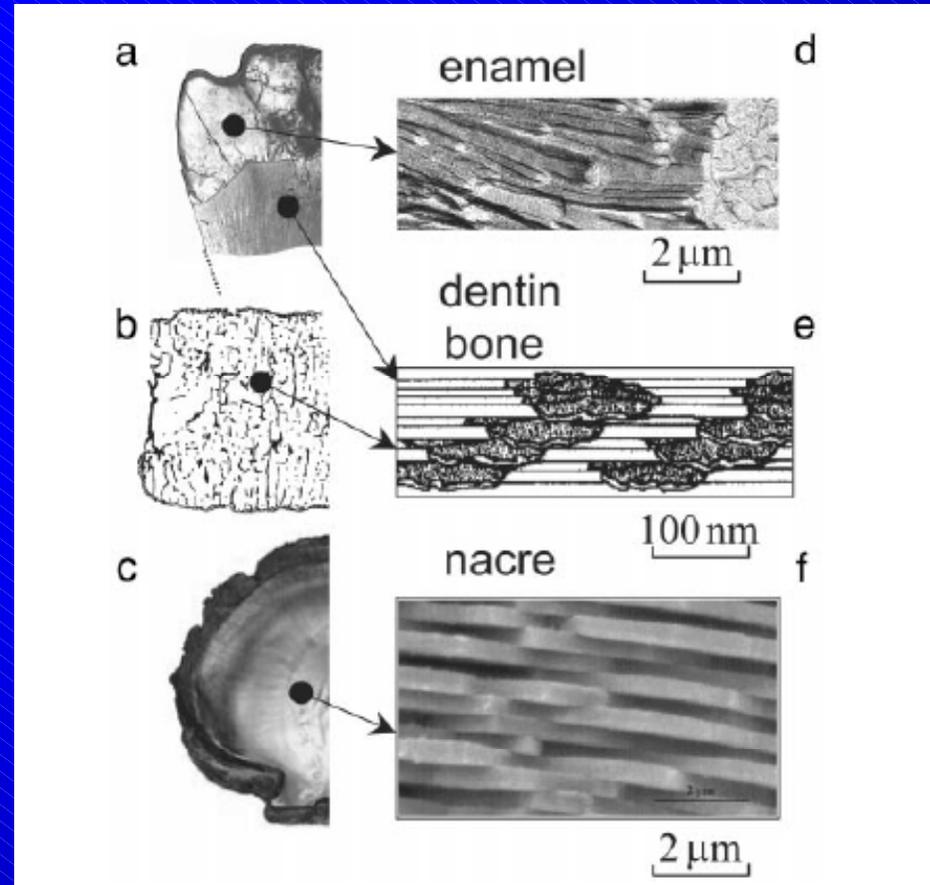
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○ Korrosionsschutz

○ Härtung



# Bioinspired Materials

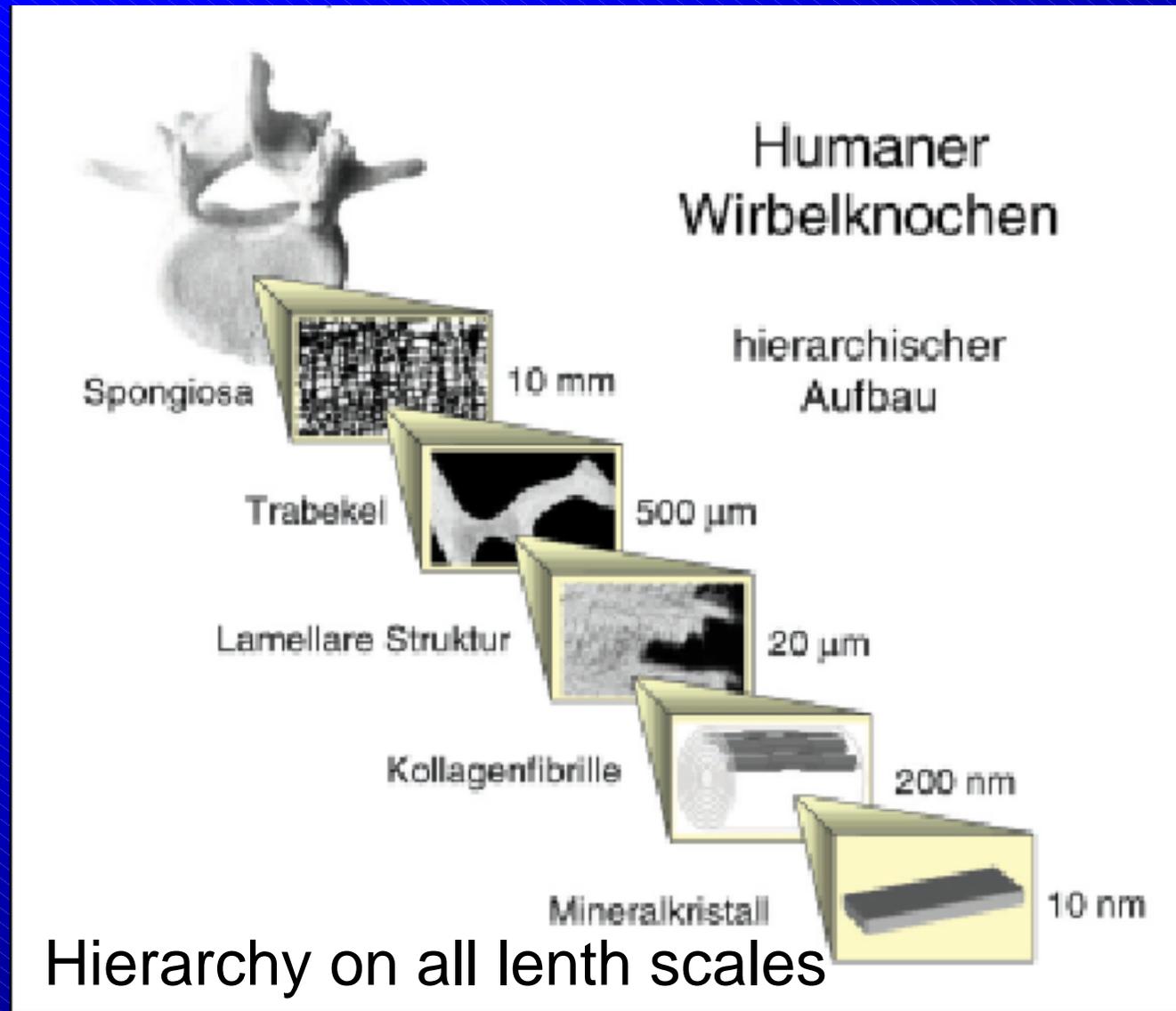


Integrated Systems

Hierarchy on all length scales



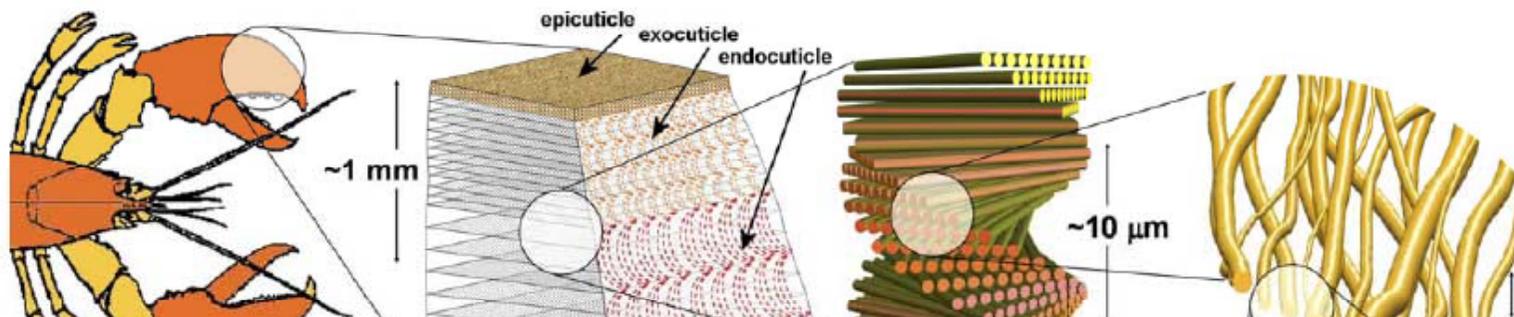
# Human Vertebral Bone



# Visionäres

4282

*D. Raabe et al. / Acta Materialia 53 (2005) 4281–4292*



**Genießen Sie Ihren Hummer  
und**

**Vielen Dank für Ihre Aufmerksamkeit**

Fig. 1. Hierarchy of the main structural levels and microstructure elements of the exoskeleton material (referring to the exocuticle and endocuticle layers) of *H. americanus* (American lobster). The first structure level (Bouligand or respectively twisted plywood pattern) is presented as a cross section through the thickness of the cuticle.