



Universität Paderborn



Chemie und Technologie
der Beschichtungstoffe

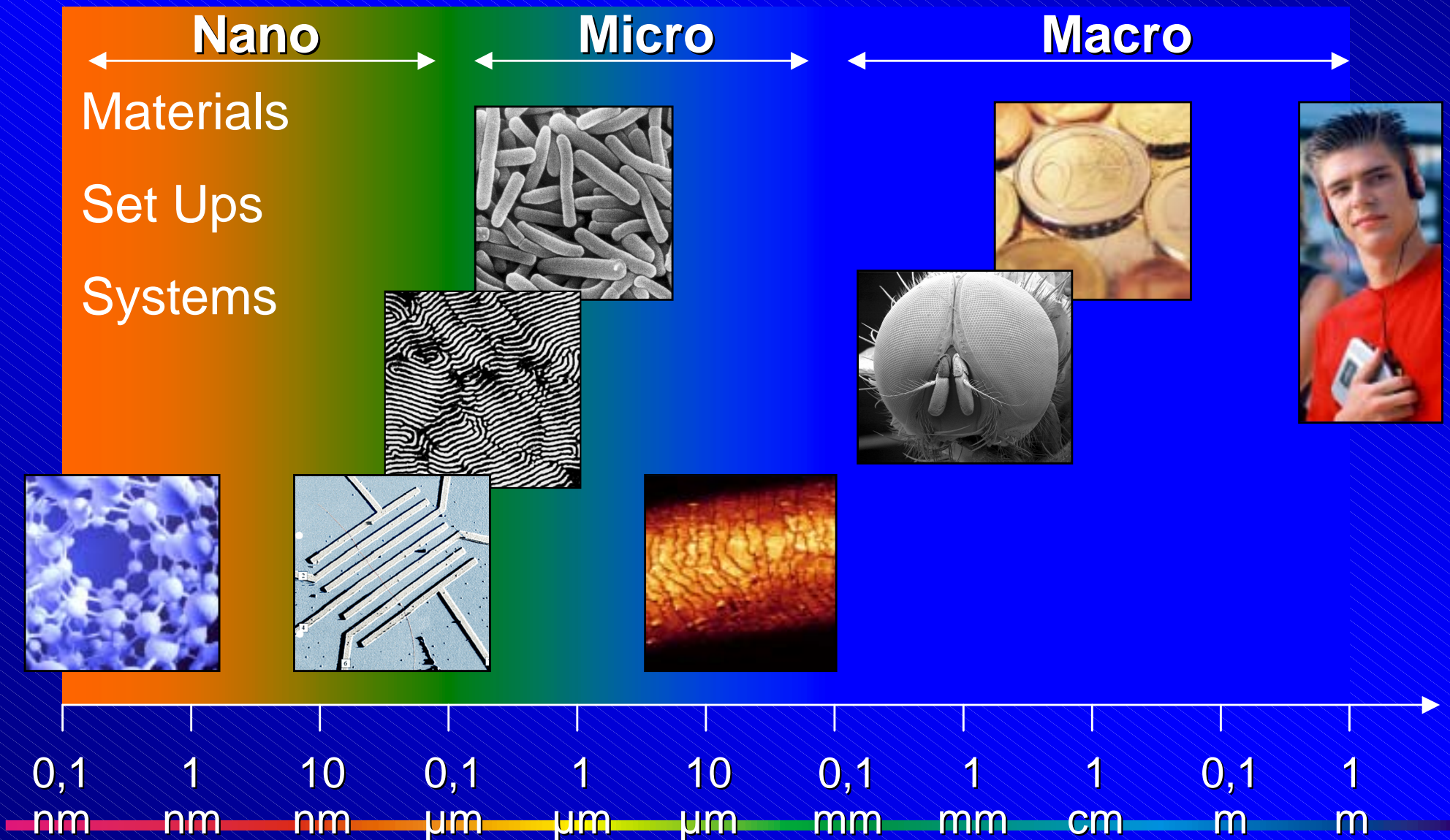
Nanotechnologie in Beschichtungen

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



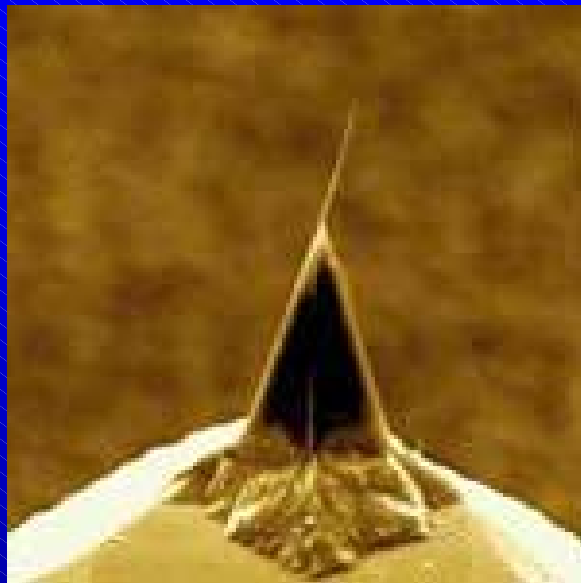
DEUTSCHE GOLD- UND SILBER-SCHIEDANSTALT
VORMALS ROESSLER · FRANKFURT/MAIN

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



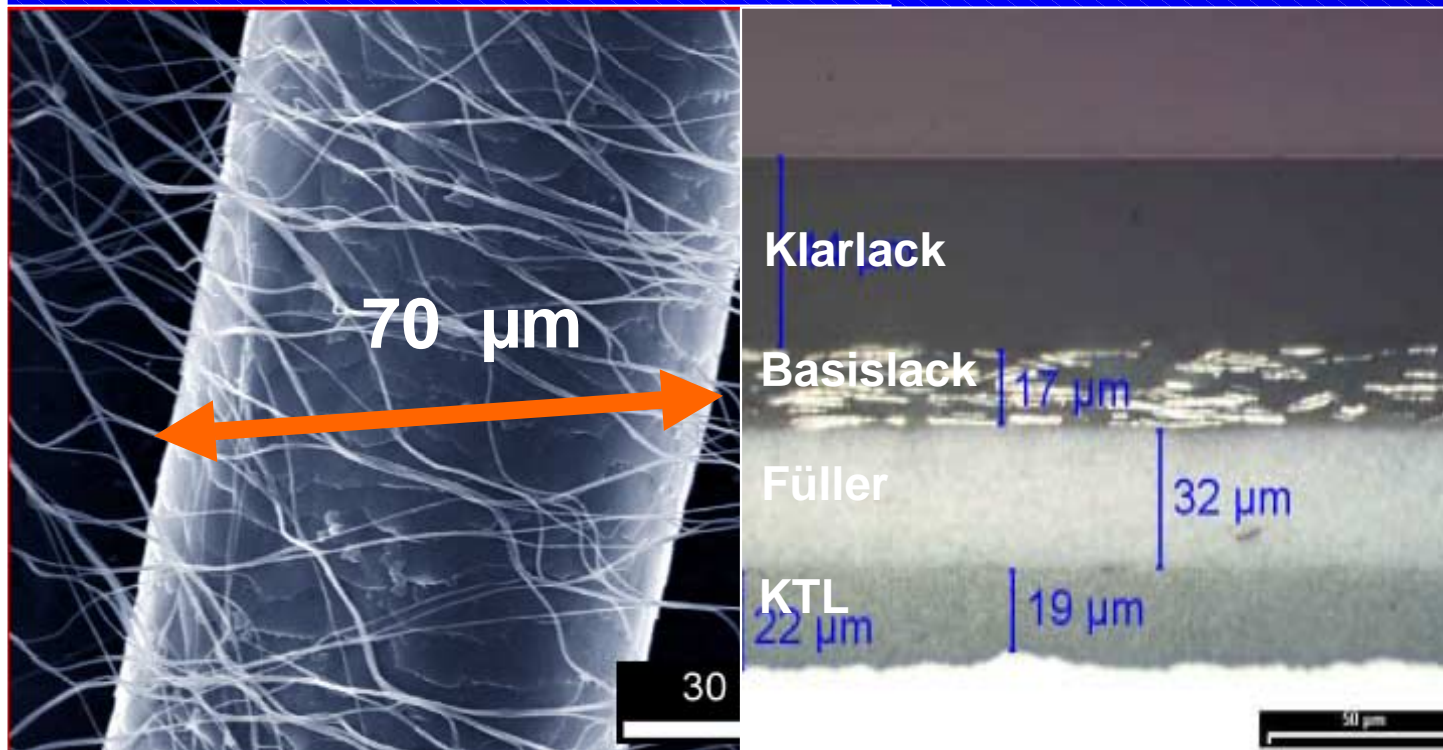


Synonyms for Nanotechnology

- 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 matrices the use of inorganic fillers becomes more and more important. Incomprehensibly low prices (less than 10 € kg⁻¹, 100 µm quartz, carbon black) are used to reduce material costs of inorganic or polymeric. Additions to the end entering effect, self-healing, etc. can provide an improvement of material properties like tensile strength, hardness, abrasion resistance, etc. 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.

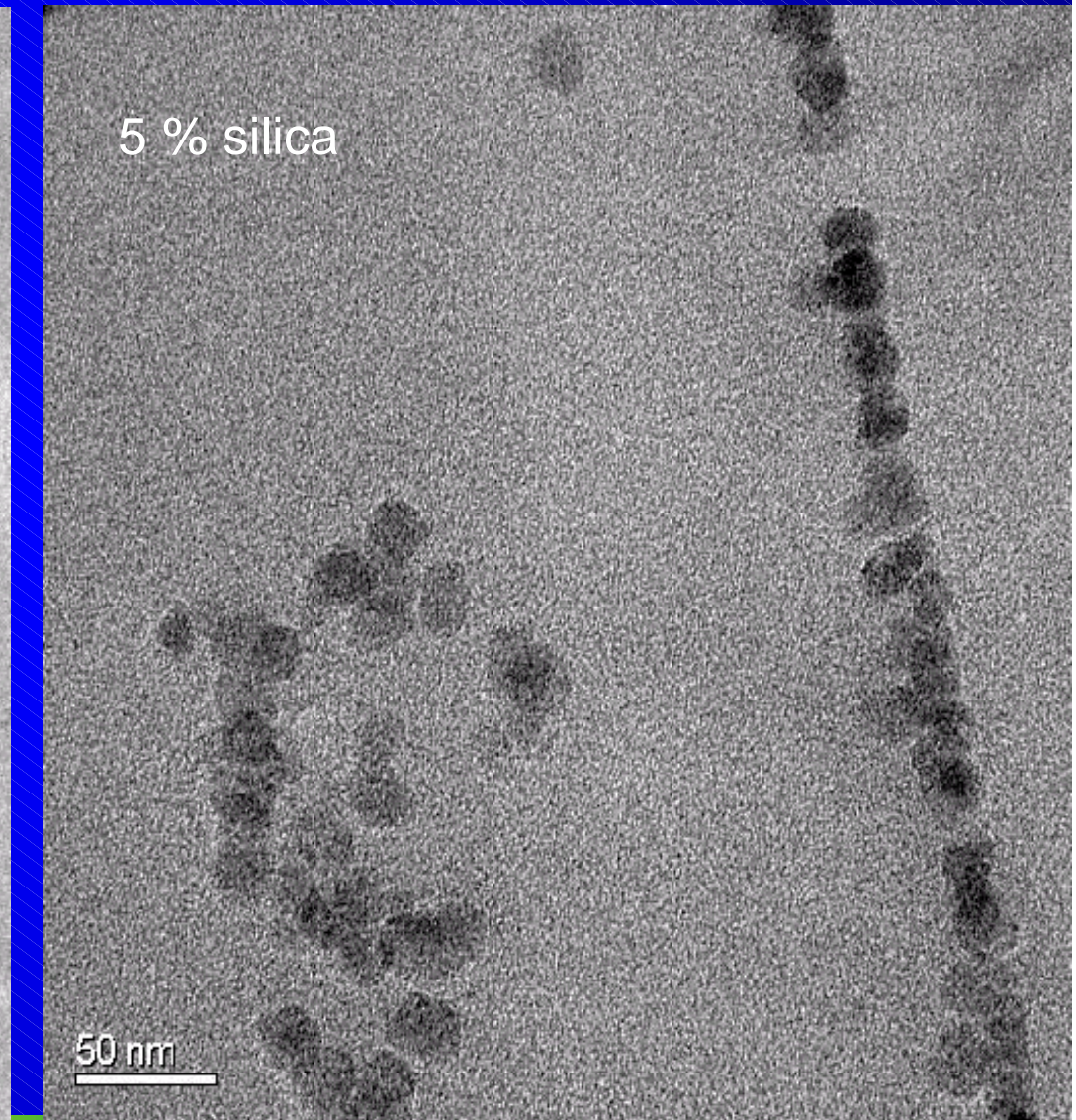
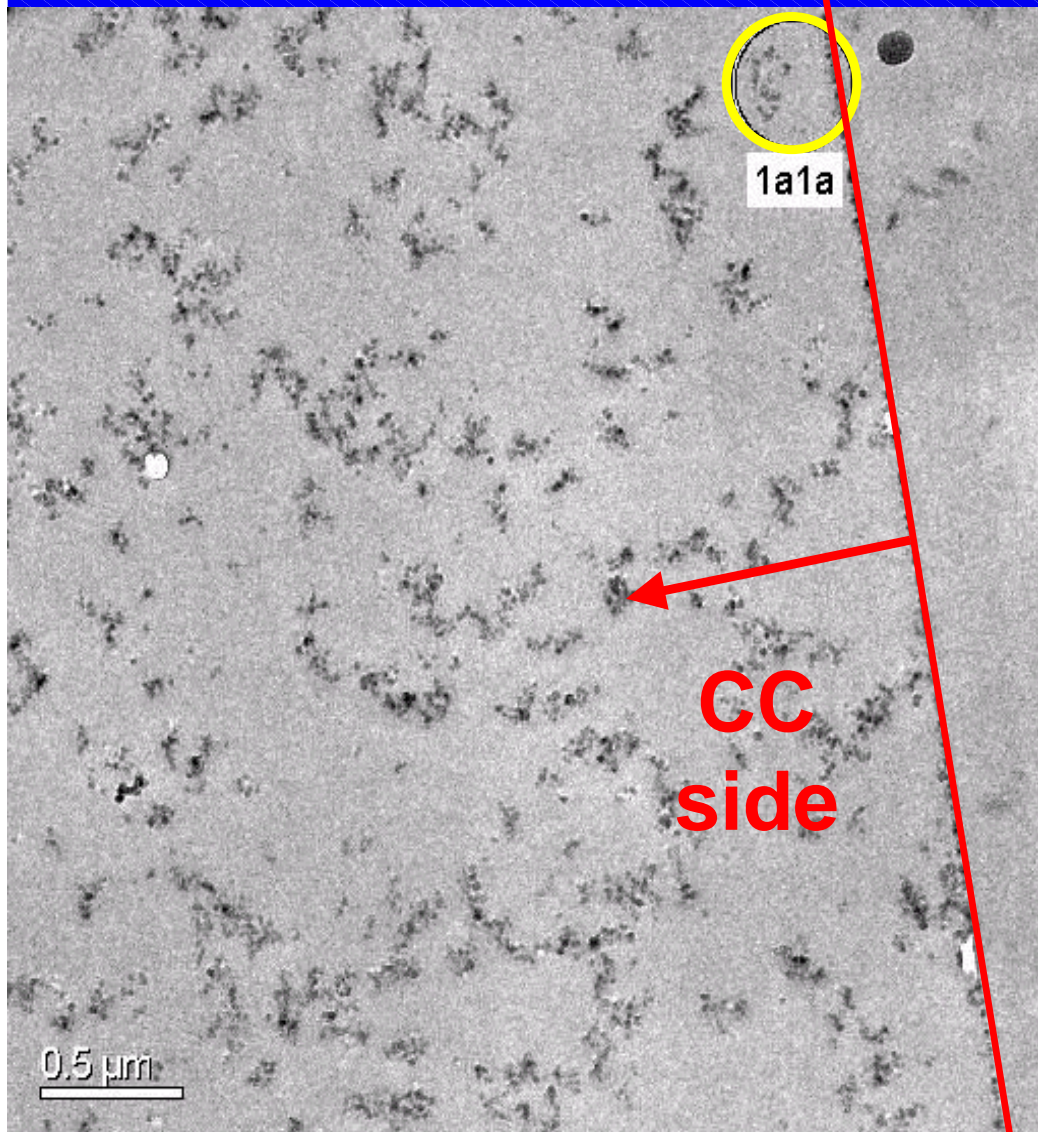
They not only perfectly fit themselves into the matrix, viscosity increases and (due to low of most abrasives containing, but not silica) is amount of more than a few percent. However, the abrasion resistance is usually defined below the level desirable from a performance standpoint. Further modification of the fillers with organofunctional groups (e.g. hydroxyl) together with mechanical effects (e.g. abrasion) may help up to a certain level and show promising results [1,2] but at the expense of the efficiency to control sand and certain processing inconveniences.

Figure 2: TEM of an ultra-thin film of cured silica nanocomposites.

Formerly silica nanoparticles suitable for inclusion in an acrylic matrix (available in the market) have been synthesized by a sol-gel process. However, it may come by pulsed treatment of the SiO_2 -surface [1], the size of the primary particles of the inorganic silica in the range of 100 nm, but during the flame hydrolysis much larger agglomerates are formed. These agglomer-



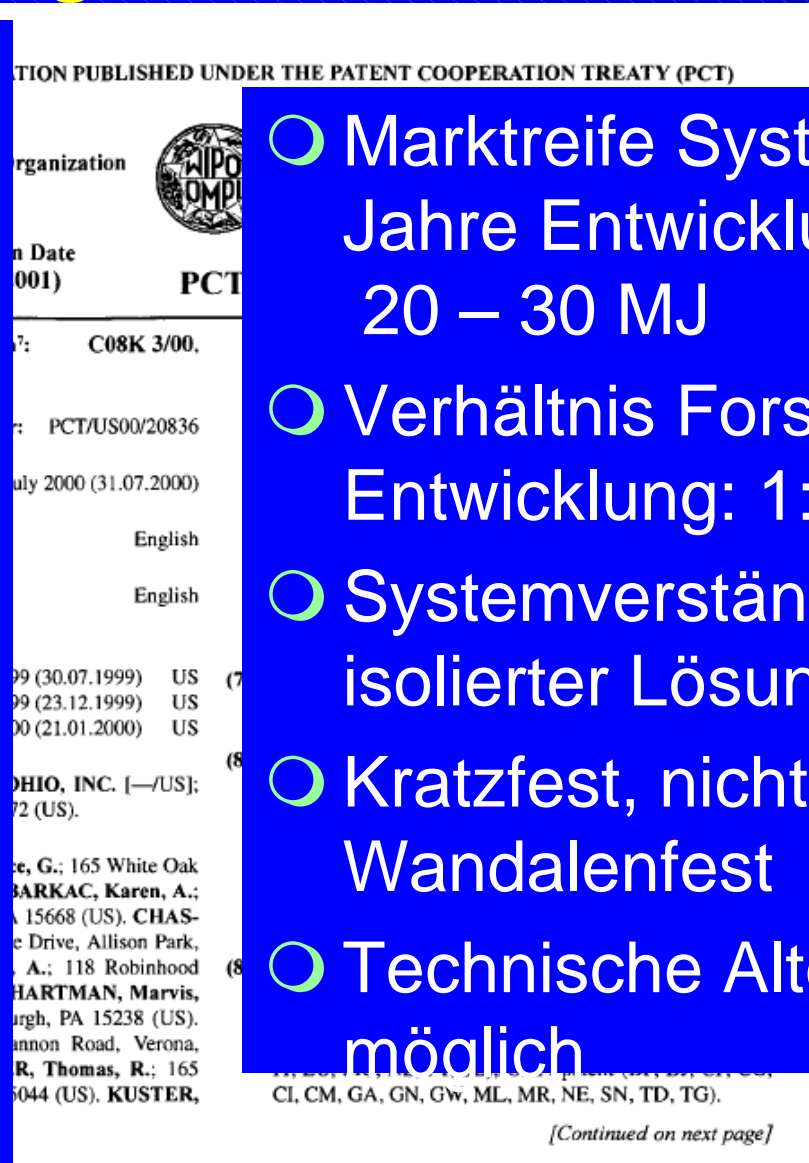
Verteilung der Nanopartikel





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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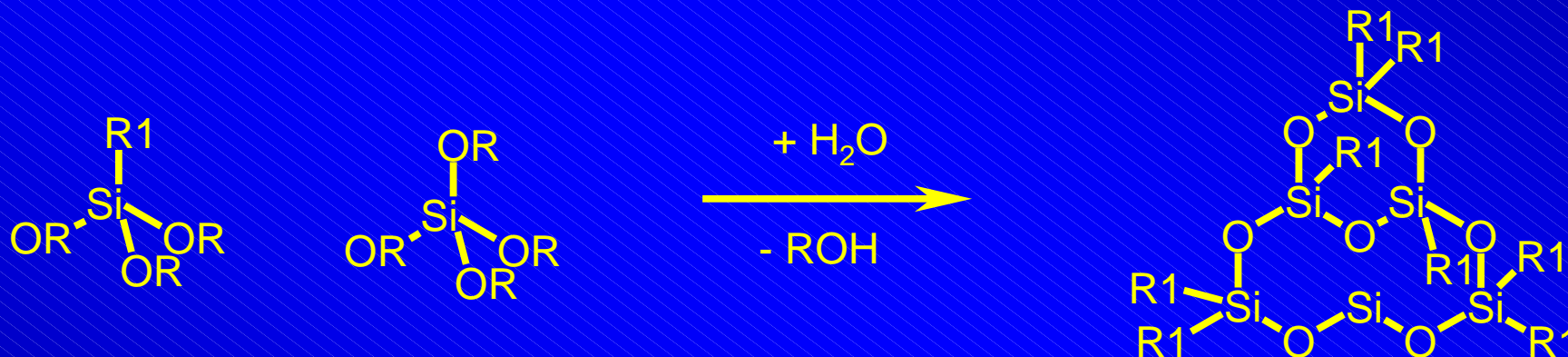


Chemie und Technologie
der Beschichtungstoffe

Nanolacke - Siloxanbasis



Siloxan-Lacke, „Nanolacke“

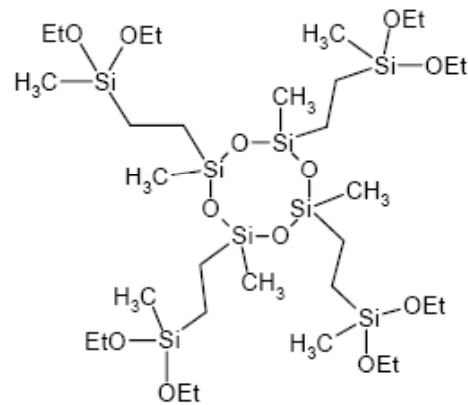


- Organisch-Anorganische Kompositwerkstoffe
- „Ormocere“, „Sol-Gel“, „Nanolacke“
- Polysiloxane als Bindemittel anstatt „normaler Polymere“
- „Übliche Rezeptierung“: Additive, Füllstoffe usw

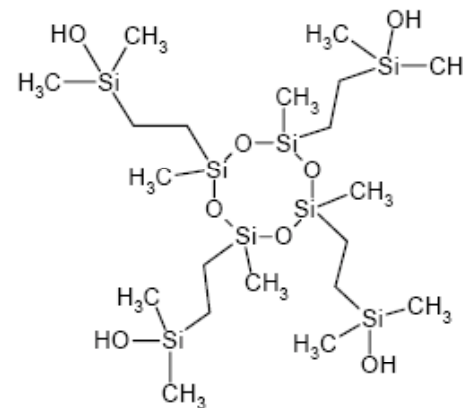


Siloxan Bausteine

„D4-Diethoxide“

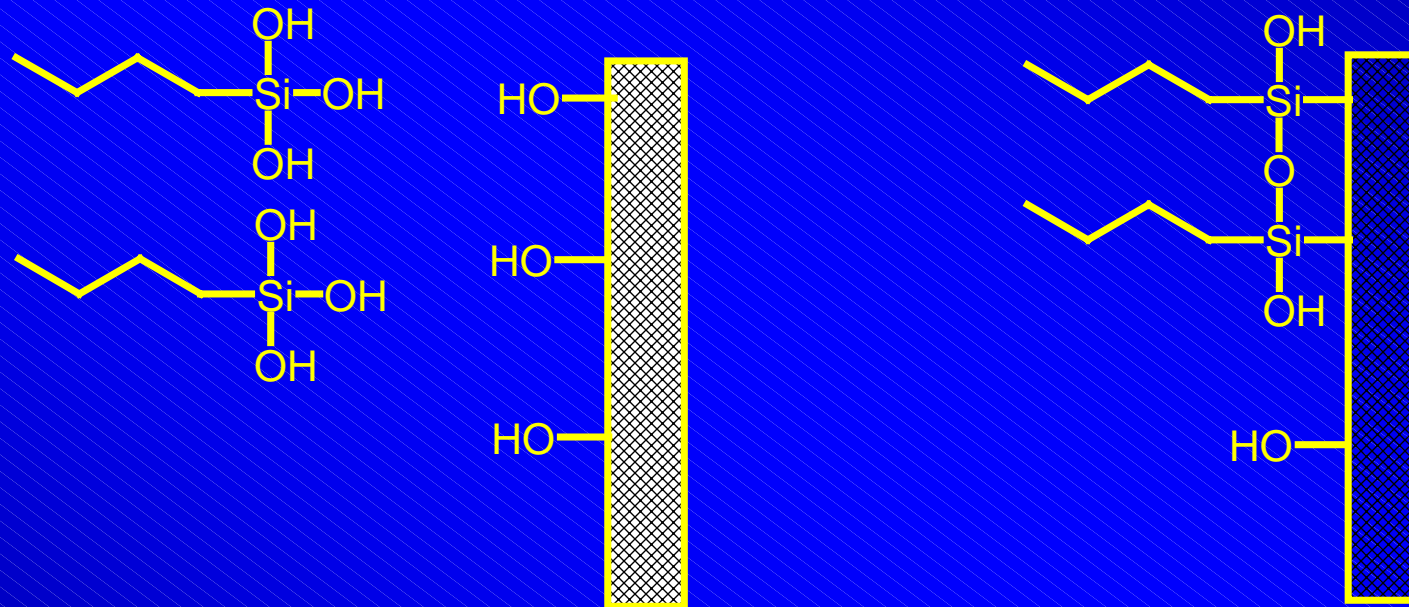


„D4-Silanol“



Bayer AG

Siloxan-Lacke - Korrosion



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



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Chemie und Technologie
der Beschichtungstoffe

„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
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- Hobo- und Senkmechanismus
- Stoffe auswändig mit verbesserter Wasserabweisung
- Einfarbiges Design
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- Abtropfblech mit abgerundeten Ecken
- Spritzen
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(siehe auch Seite 19)

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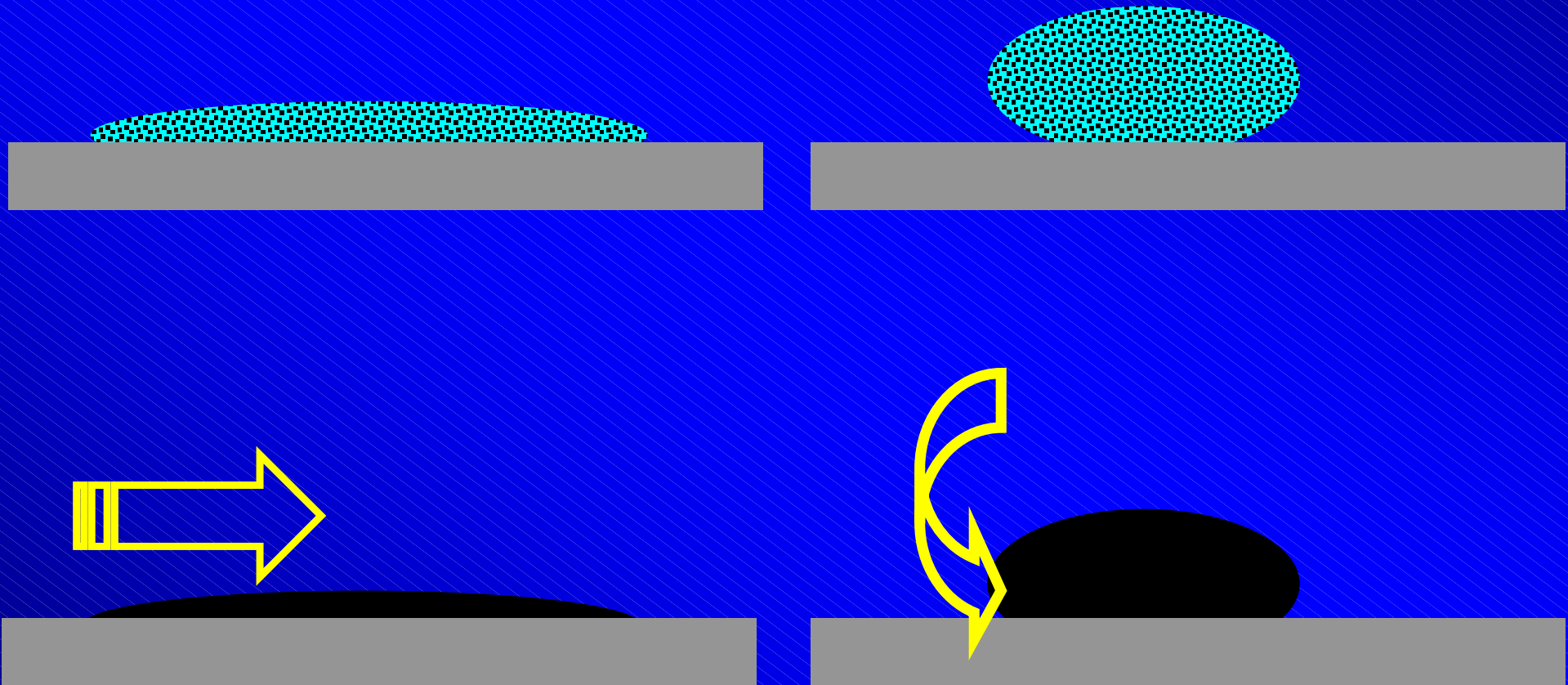
Easy to Clean - Sanitär



- Abperlende Tropfen auf Hydrophober Oberfläche
- Abperleffekt
- Schmutzform



Easy to Clean - Dusche





Anti-Fingerprint



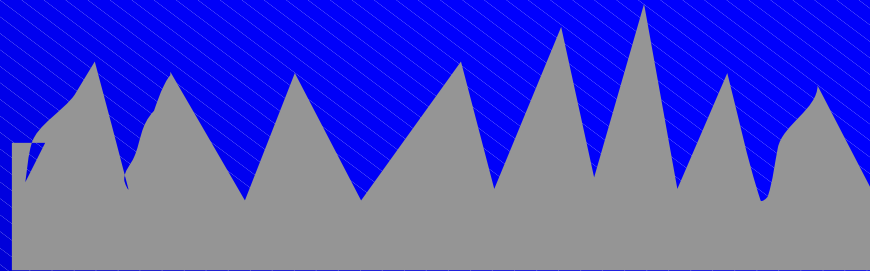
270-Liter-Kühl-/Gefrierkombination Edelstahl

Designergerät. Der Blickfang für Ihre Küche.

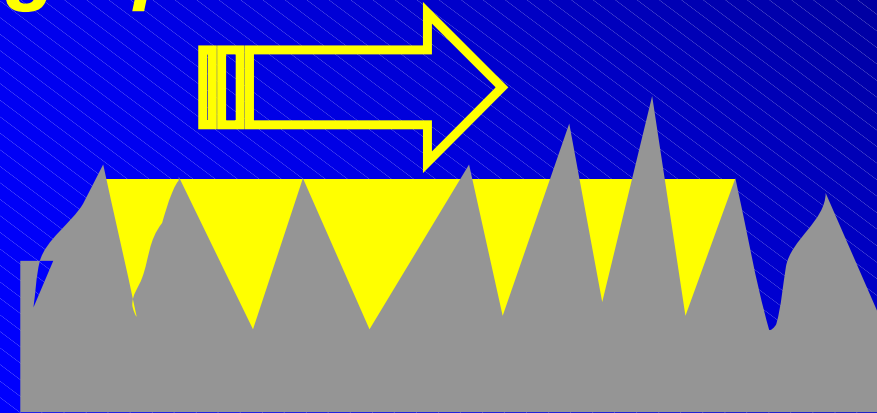
Matte Oberfläche mit Anti Fingerprint Beschichtung



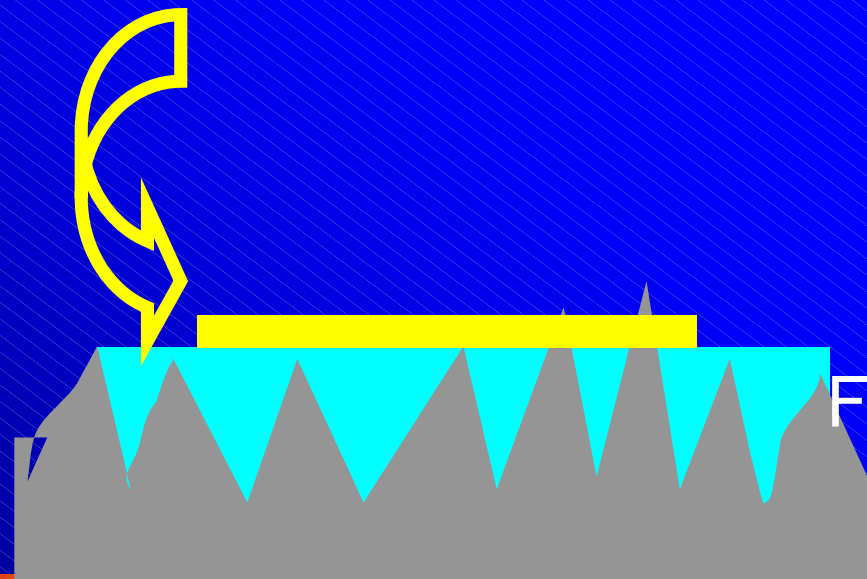
Anti-Fingerprint



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.

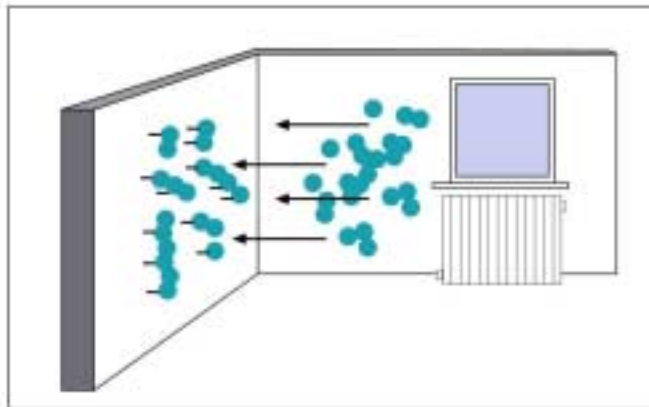


Photokatalyse – Wellness-Farben

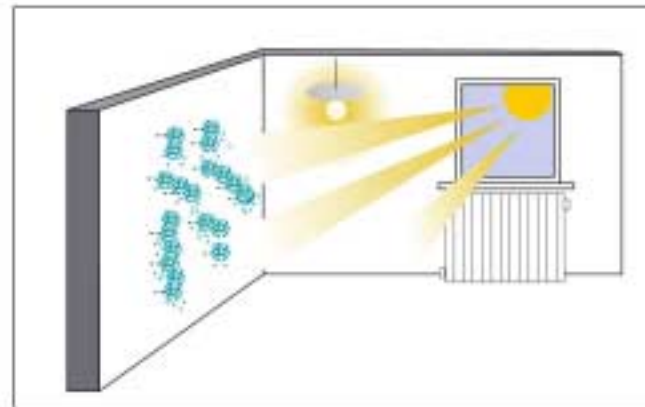
Verbessertes Raumklima



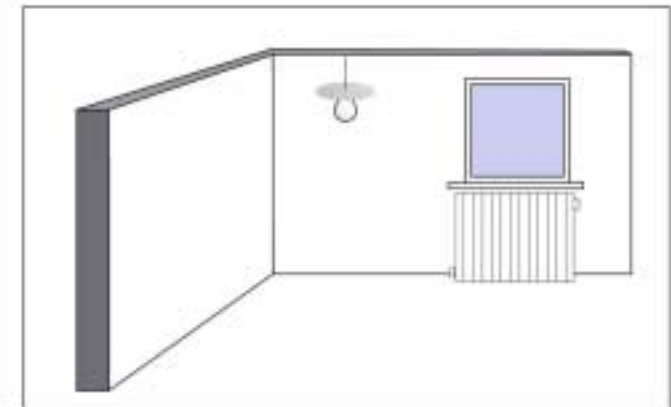
CapaSan. Innenfarbe mit photokatalytischem Effekt



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

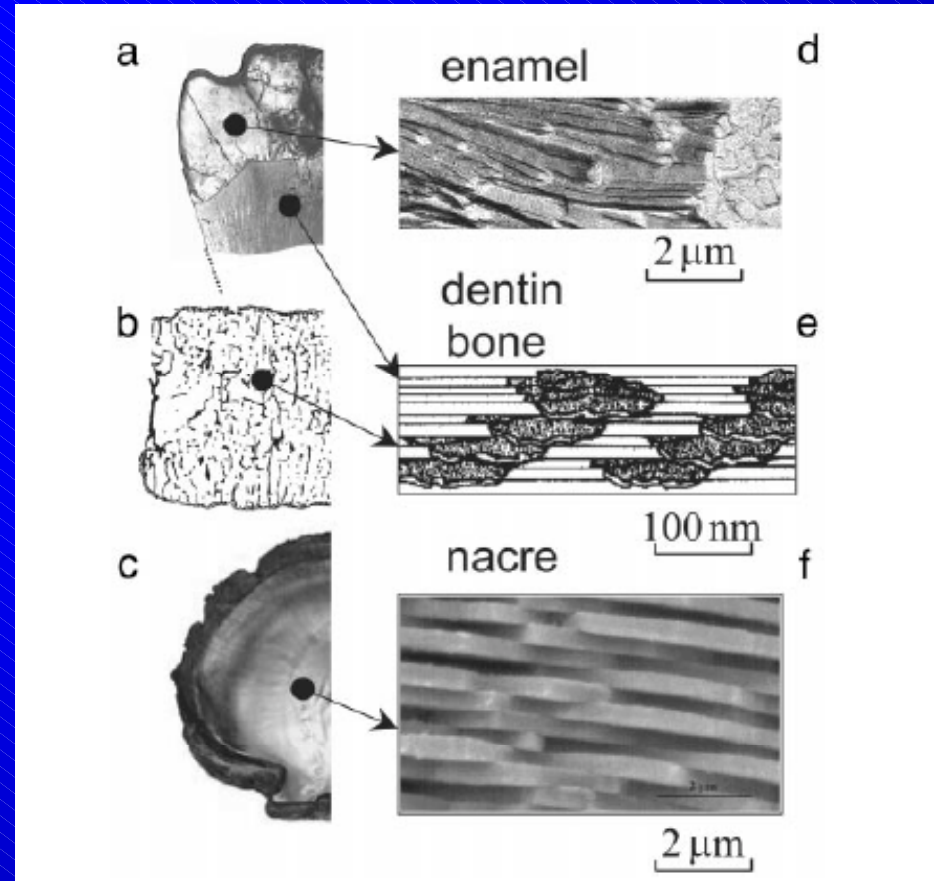
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○ Korrosionsschutz

○ Härtung



Bioinspired Materials

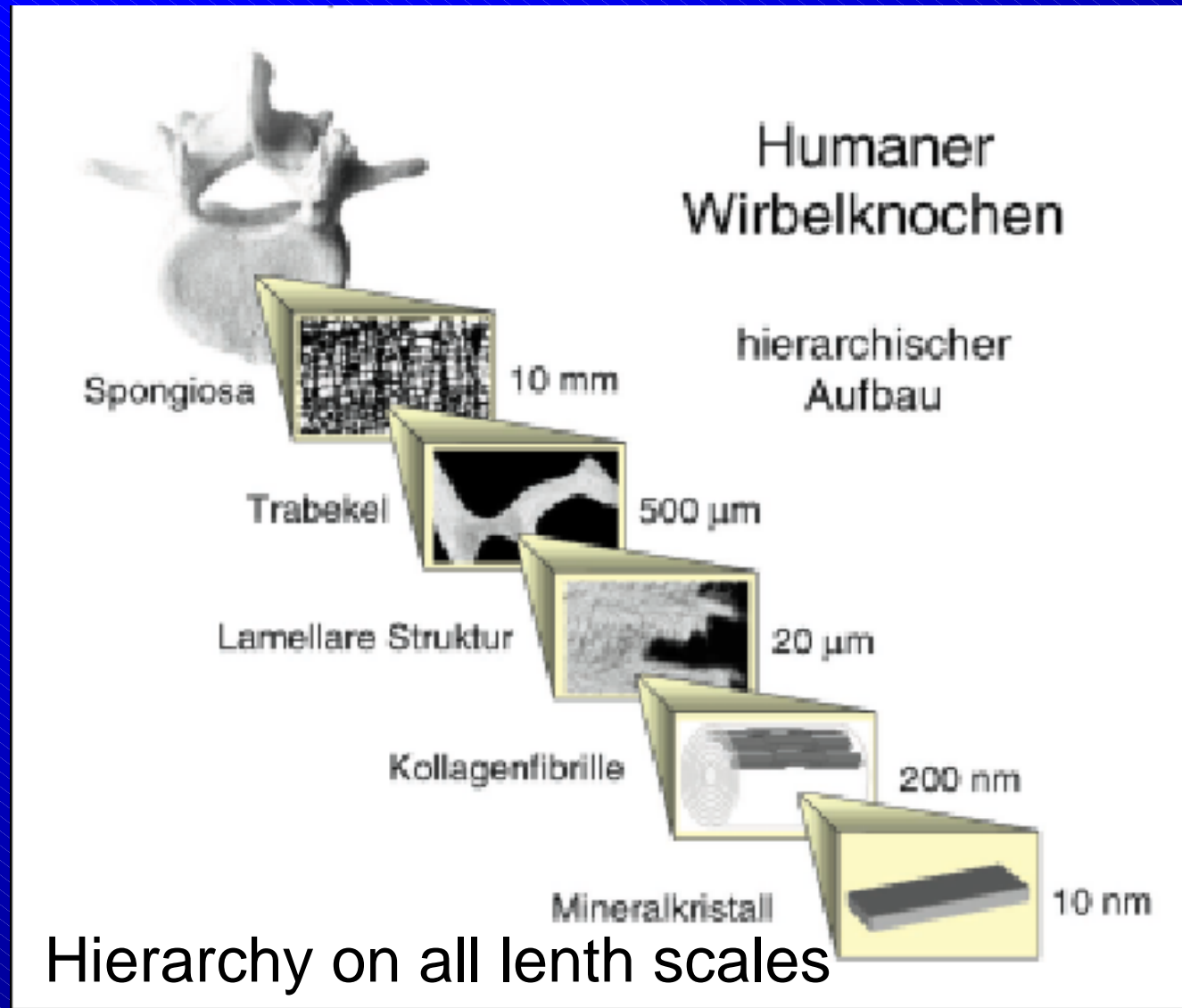


Integrated Systems

Hierarchy on all length scales



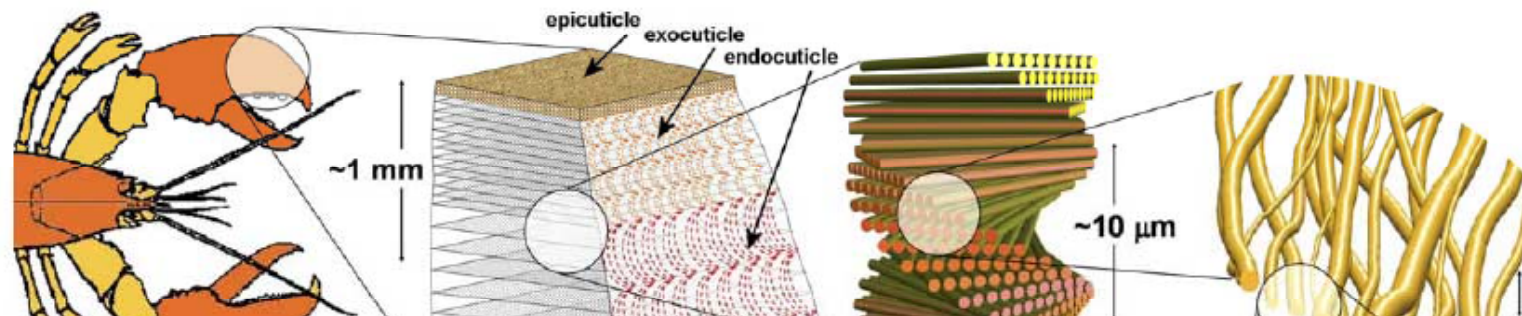
Human Vertebral Bone



Visionäres

4282

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



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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.