

Hier steckt Nano drin

für intelligente Lösungen
im Alltag.



**Forschung zur Zelladhäsion
und deren Beeinflussung
durch nanostrukturierte
Oberflächen**

The New World of chemical Nano Technology

by Michael Veith

www.inm-gmbh.de

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Leibniz-Institut für
Neue Materialien

» Klassifizierung

- > Natürlich vorkommende Nanopartikel
(Bsp. durch Verbrennungsprozesse)
 - ⇒ unvermeidbar
 - Konzentration auf andere Bereiche
- > Nanomaterialien
(In Matrix eingebettete Nanopartikel
oder -strukturen)
 - ⇒ unkritisch in der Verwendung.
 - Verbleib in der Umwelt?
- > Künstlich hergestellte Nanoobjekte
(Freie Nanopartikel, Fullerene, CNTs)
 - ⇒ häufig bioaktiv
 - deutliches Gefährdungspotenzial
- > Autonom agierende Nanosysteme
(Nanoroboter, aktive Nanostrukturen)
 - ⇒ uninteressant
 - solange Realisierbarkeit nicht geklärt

» Beispiele

- > Photokatalytisch aktive Fensterscheiben
(TiO₂-Nanopartikel in transparenter Matrix auf Glas)
- > Kratzfestlack
(Künstliche Nanopartikel in Suspension)

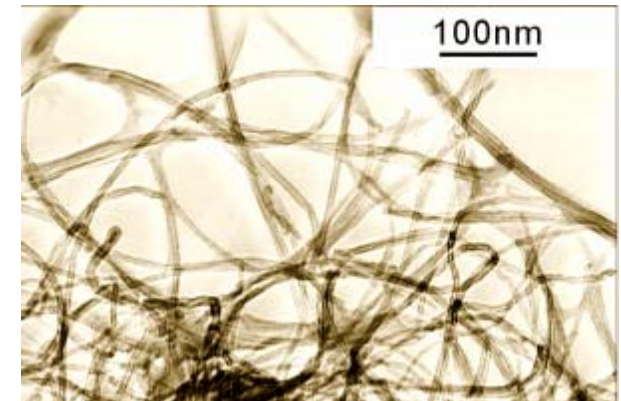


» Lebenszyklus

- > Herstellung nasschemisch, geschlossene Prozesstechnik
 - ⇒ unkritisch
keine Freisetzung beobachtbar
- > Nutzungsdauer: nicht verbrauchend, kein Austritt gebundener Nanopartikel
 - ⇒ unkritisch
keine Freisetzung beobachtbar
- > Bearbeitung / Entsorgung
 - > Sägen, Bohren, ...
 - ⇒ Nanopartikel bleiben eingebettet
 - > Schleifen
 - ⇒ Forschungsbedarf
 - > Verbrennung
 - ⇒ Verbrennung erzeugt ohnehin Nanopartikel
 - Forschungsbedarf:
Werden auch die eingebetteten frei?

» Beispiele

- › Kohlenstoffnanostrukturen
(ein- und mehrwandige Kohlenstoffnanoröhrchen,
Fullerene)
- › Pyrogene Kieselsäure
(Bsp. Degussa Aeorasil)



» Problematik

- › Aufnahmewege in die Zelle ⇒ Bisher nicht eindeutig identifiziert
- › Wirkmechanismen in Zellen und Zellkernen ⇒ Forschungsbedarf
- › Abhängigkeiten von Form und Oberflächenmodifizierung ⇒ Nur exemplarische Untersuchungen möglich, Modelle erforderlich
- › Biologische Effekte ⇔ Nanoeffekte ⇒ Nanoeffekte unter 50 nm
Biologische Effekte schon im Sub- μ -Bereich



» Beispiele

- › Mikrobizide Beschichtung von Hörgeräten (Im-Ohr-Hörgerät, Fa. Audio Service GmbH)
- › Schwammtücher (*Vileda Fresh* "mit antibakteriellen *Silber*-Ionen")



» Verbleib des Wirkstoffs

- › Partikel eingebunden, nur Abgabe von Silberionen
 - › Wachsender Markt → Mengenabschätzung
 - › Wirkung auf (biologische) Kläranlagen
 - › Klärschlamm Entsorgung
- ⇒ keine Partikelproblematik
 - ⇒ Abschätzung von FFD (Freudenberg): Weniger als Eintragsrückgang durch Fotolabore
 - ⇒ Vermutlich Komplexierung und Ausfällung durch hohen Gehalt an Salzen im Abwasser
 - ⇒ Ausbringung auf Ackerflächen
Forschungsbedarf



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Thanks to my coworkers

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Cenk Aktas

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Eva Sow

Special thanks for cooperation to

- Dr. Metzger, Klinikum Homburg
- Dr. Narz, Quiagen
- Prof. Schäfer,
Zweibrücken/Stanford

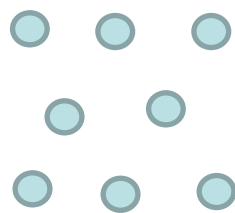






„Tastensensitivität biologischer Zellen auf der Nanometerskala“

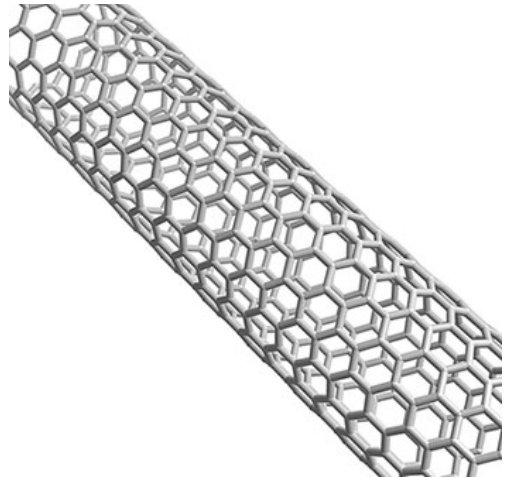
Zellen messen mit großer Empfindlichkeit die chemische, topographische und mechanische Beschaffenheit der Materialien, die sie umgeben und mit denen sie wechselwirken...



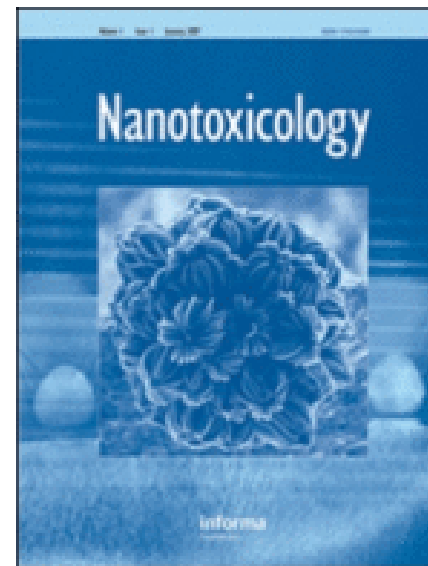
Goldpartikel mit Integrin

Abstand zwischen den Partikeln
zwischen 40 und 70 nm

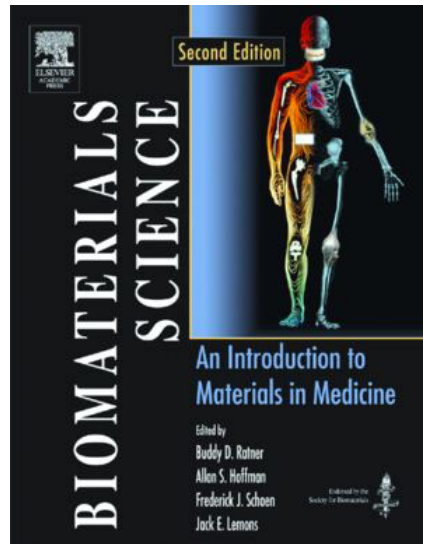
Nanoballs, nanotubes, nanorods, nanowires...



Carbon nano tube



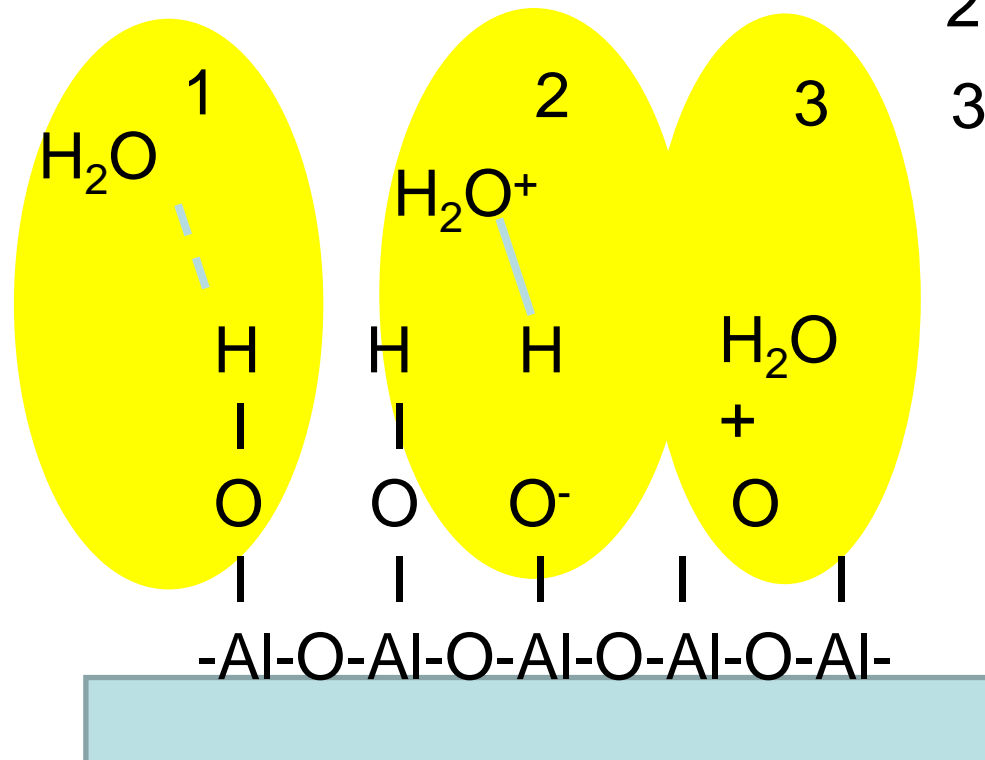
Toxic?



Biocompatible?

Surface of alumina in contact with water

- 1 hydrogen bridge
- 2 O-H dissociation
- 3 equilibrium

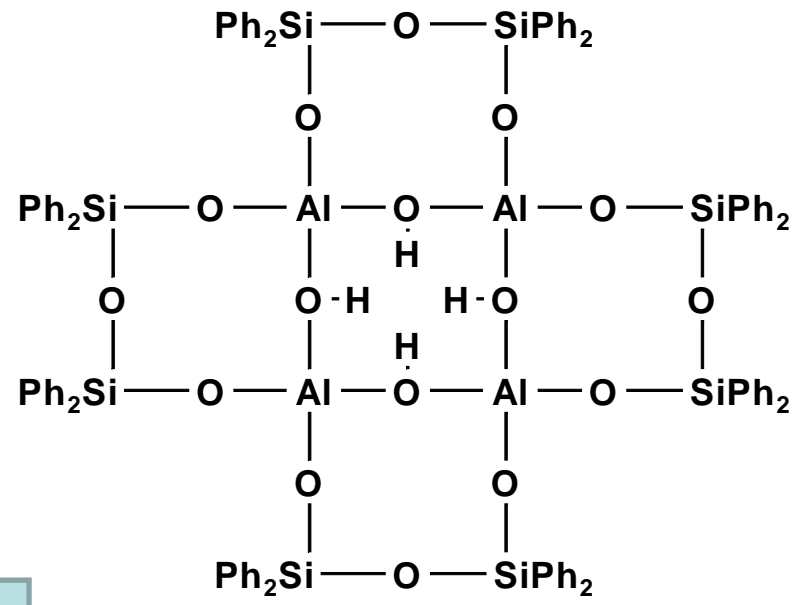
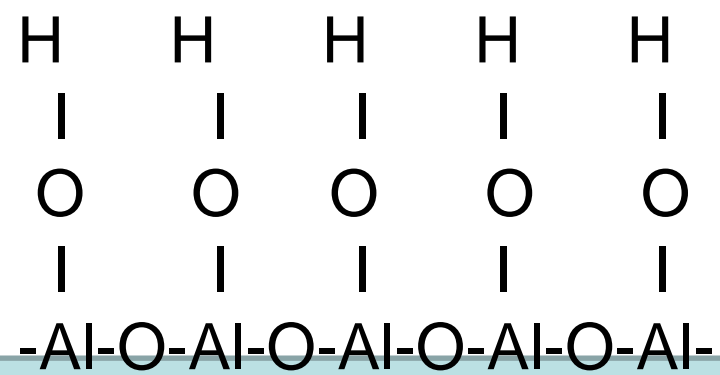




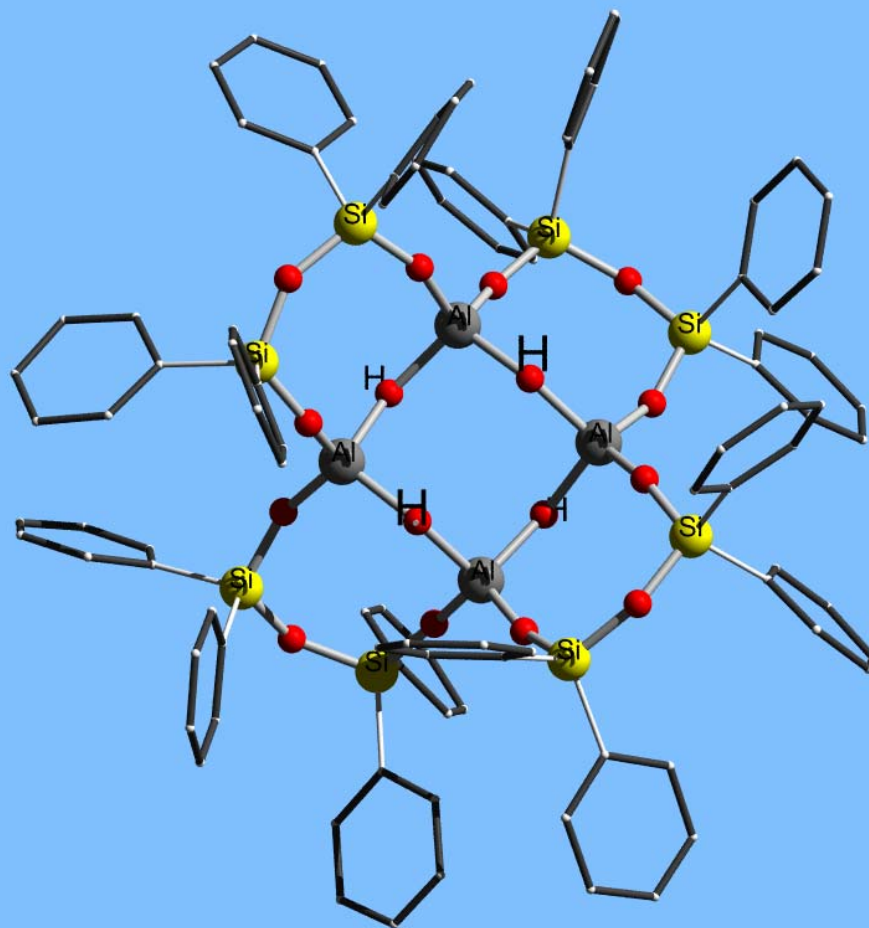
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Surface of alumina in a molecular cut-out



Crystal Structure of $(\text{Ph}_2\text{SiO})_8[\text{Al}(\text{O})\text{OH}]_4$

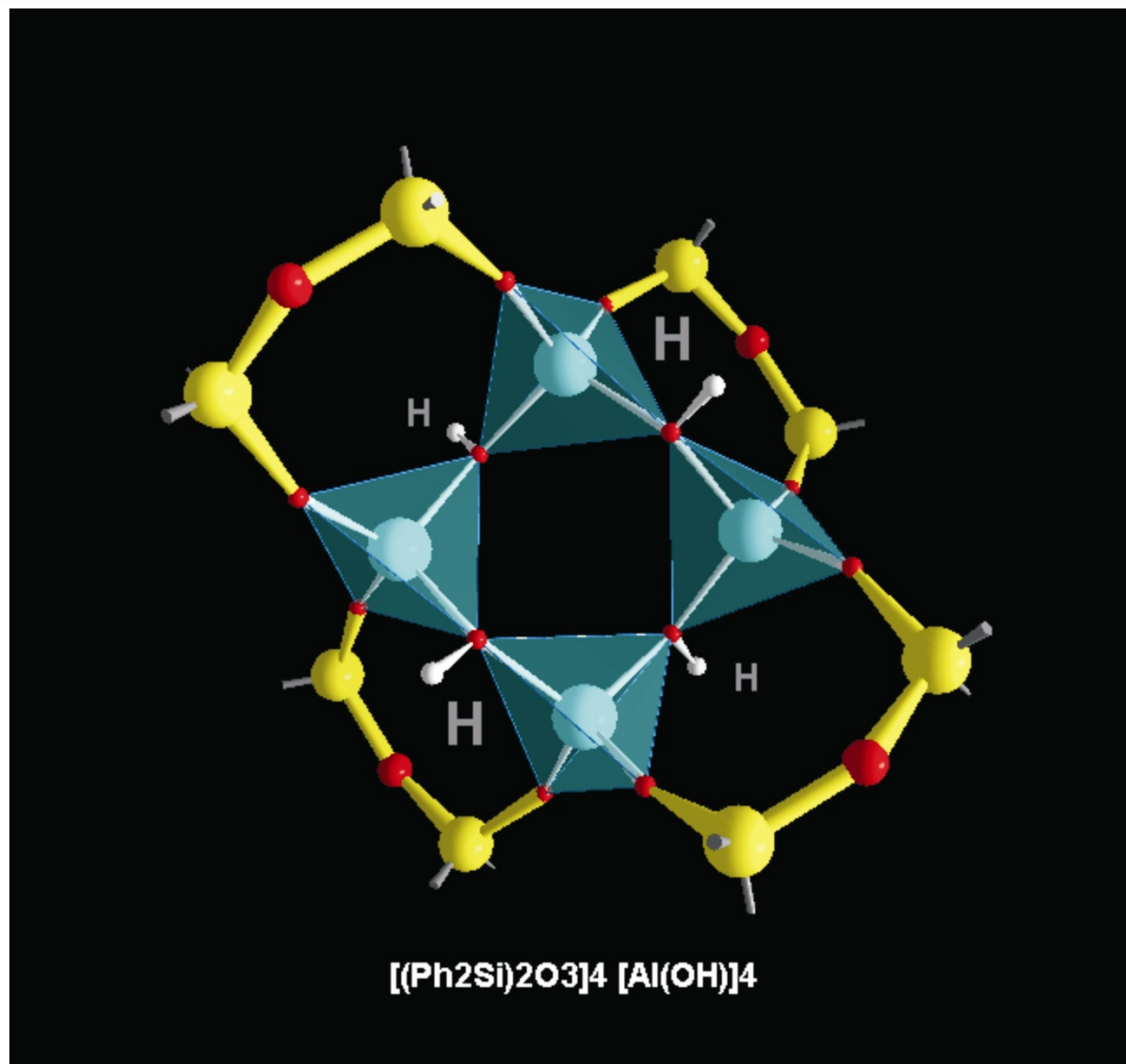




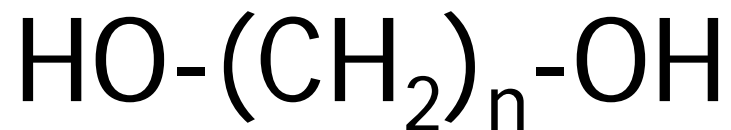
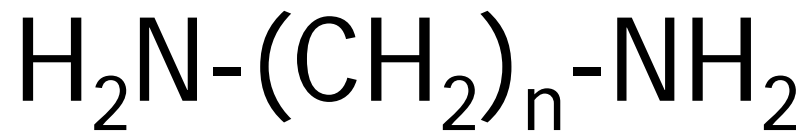
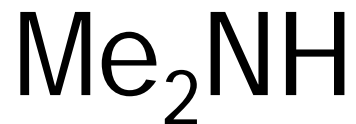
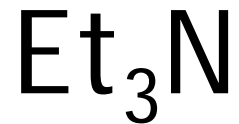
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Another view of $(\text{Ph}_2\text{SiO})_8[\text{Al}(\text{O})\text{OH}]_4$

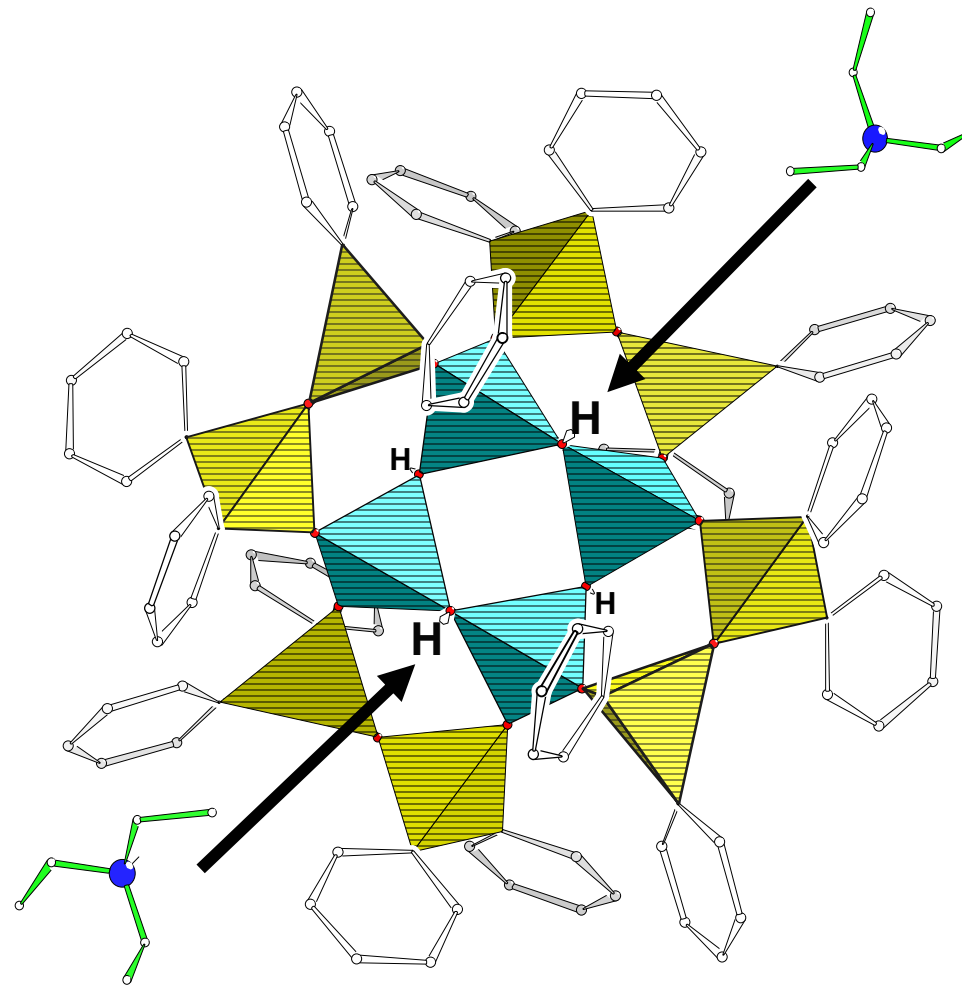


From simple bases and acids to
amino-acids

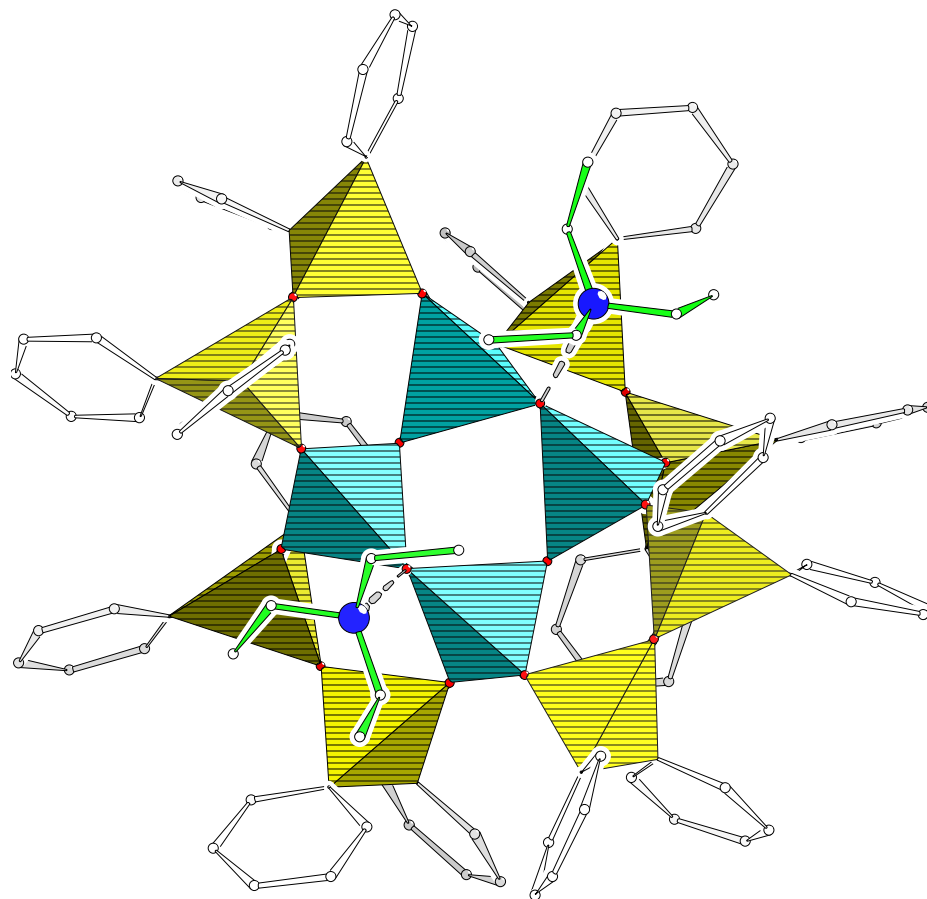


Amino-acids

Attack of $\text{N}(\text{Et})_3$



Adduct of 2 NEt_3 to $[(\text{Ph}_2\text{Si})_2\text{O}_3]_4[\text{Al}(\text{OH})]_4$



Biphasic Composites and their mutual
arrangements

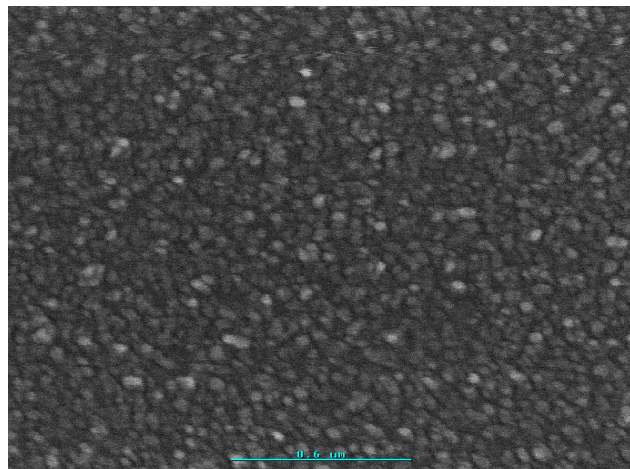
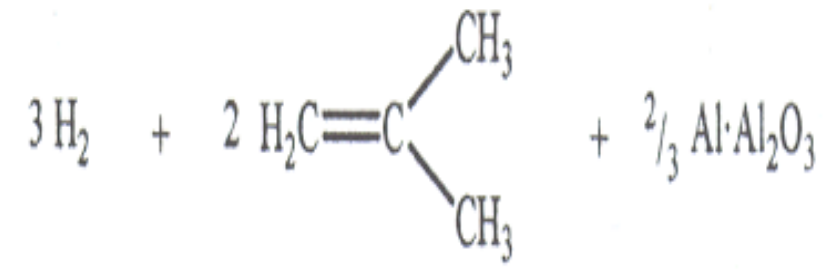
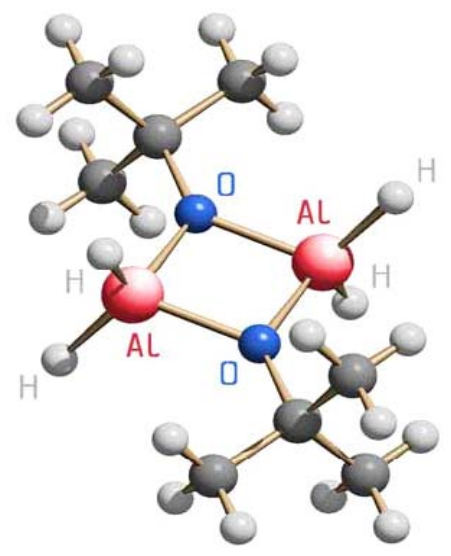
Dependance of properties on the particle sizes and
geometries



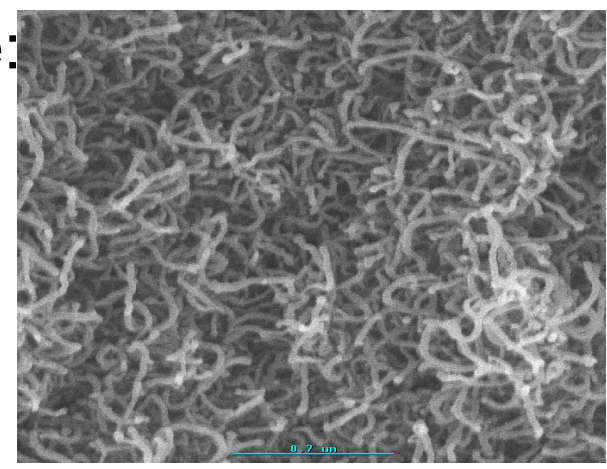
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Nanostructured surfaces by CVD



Temperature:
550 °C

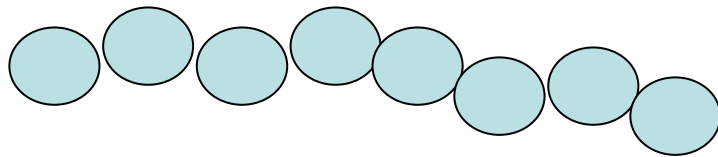


Temperature
:
400°C

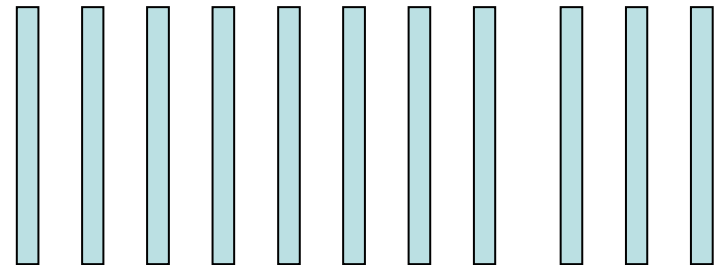
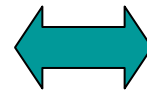
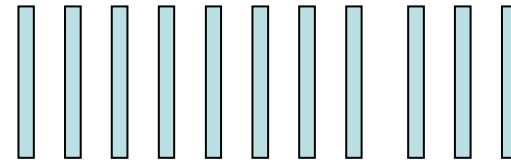


Temperature/
Pressure

Globular Structures:



Brush-Structures:

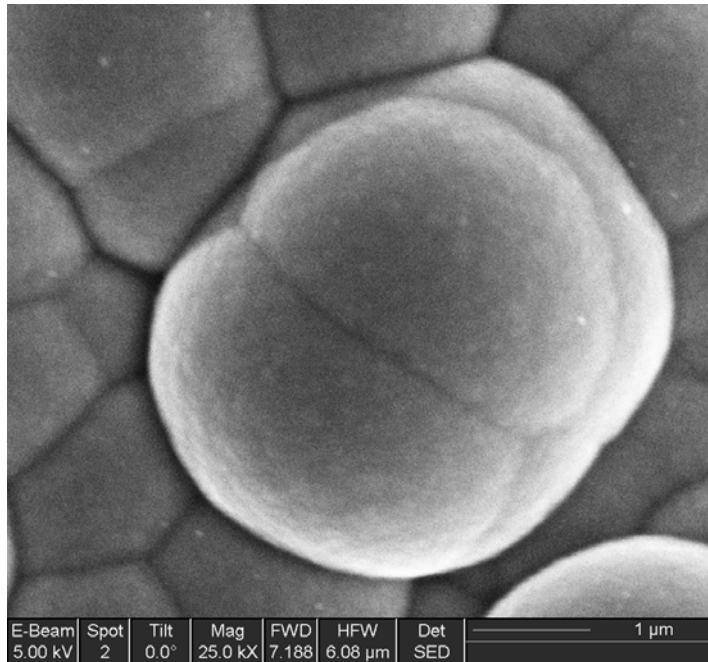


Time

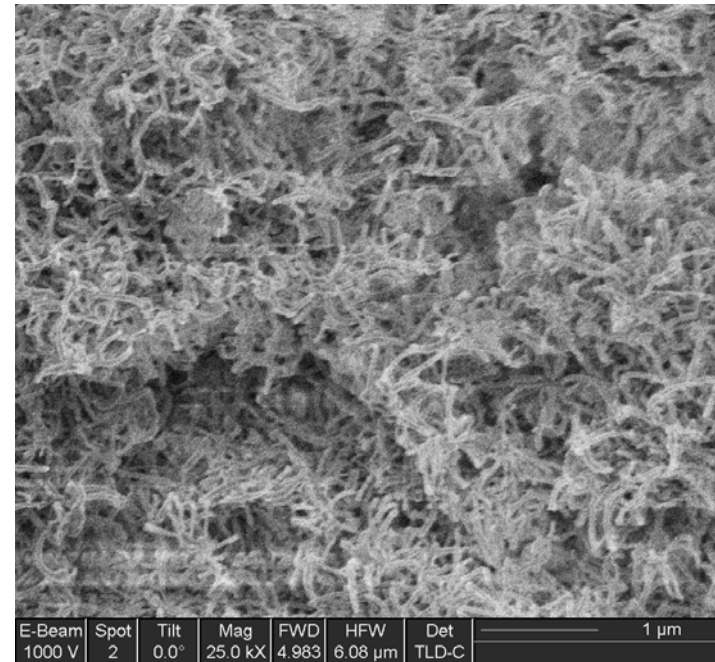


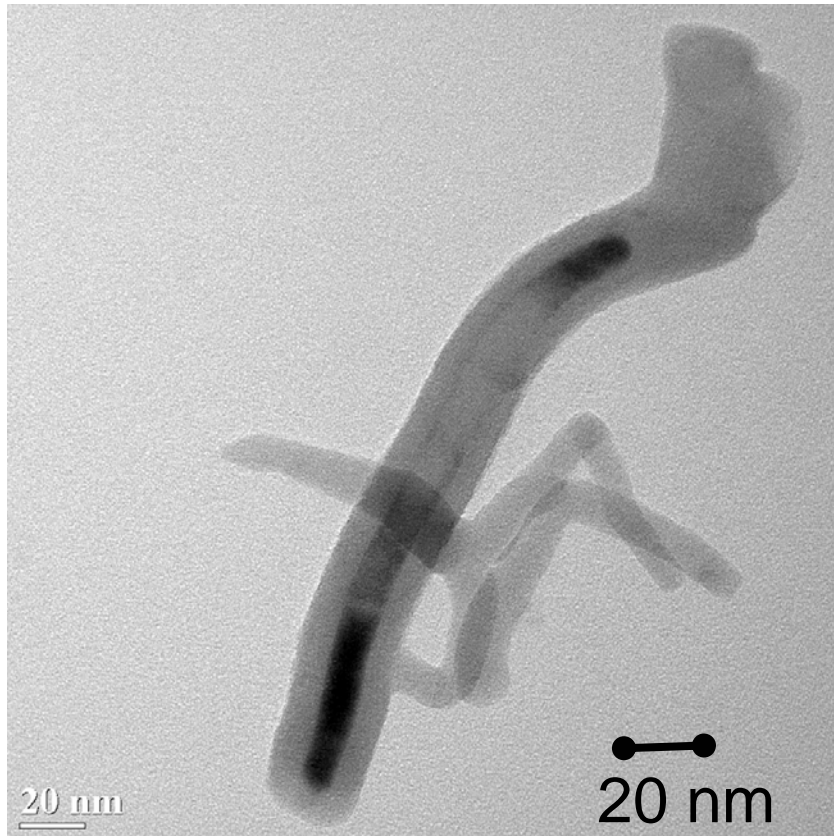
Prepared under different conditions

Ball-like structures

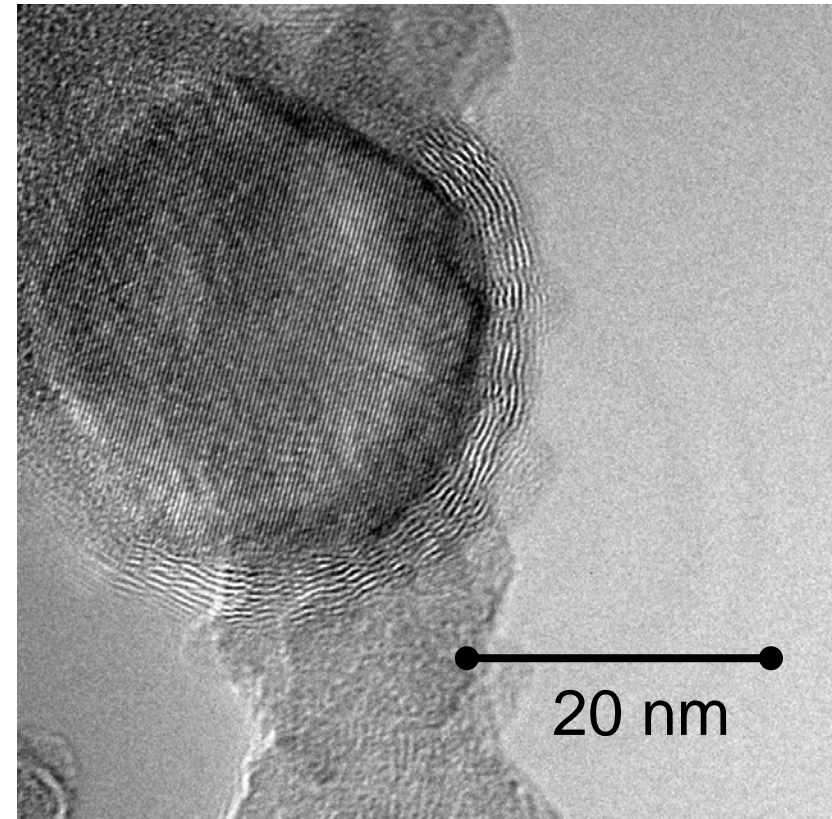


Spagetti-like structures





TEM picture of a „wire“



TEM picture of a „ball“

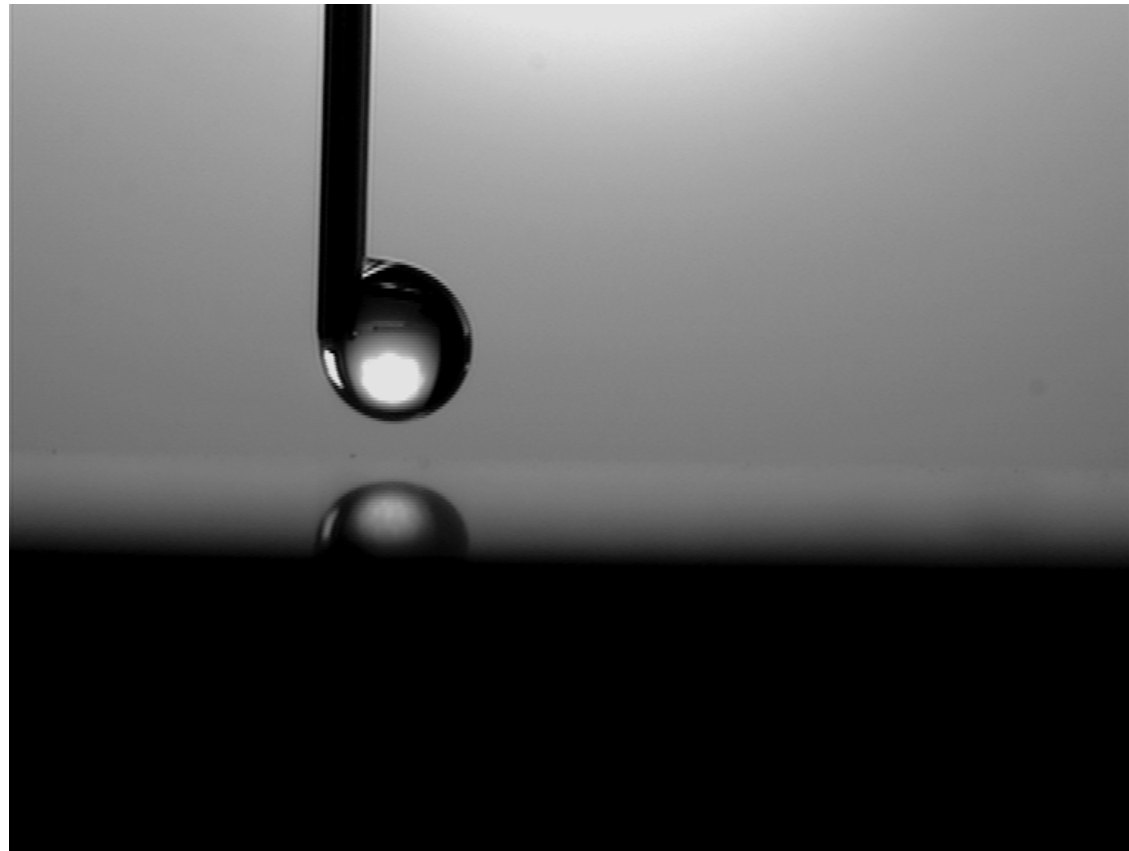
Hydrophobic and Ultra-Hydrophobic Properties: Dependance on the particle sizes and geometries

(Wetting-experiments with K. Jacobs,
Saarbrücken)

„Normal“ Hydrophobicity on our Al/Al₂O₃
Structures: Water-Droplet and Capillary



Ultra-Hydrophobicity on our Al_2O_3 - Structures: Water-Droplet and Capillary

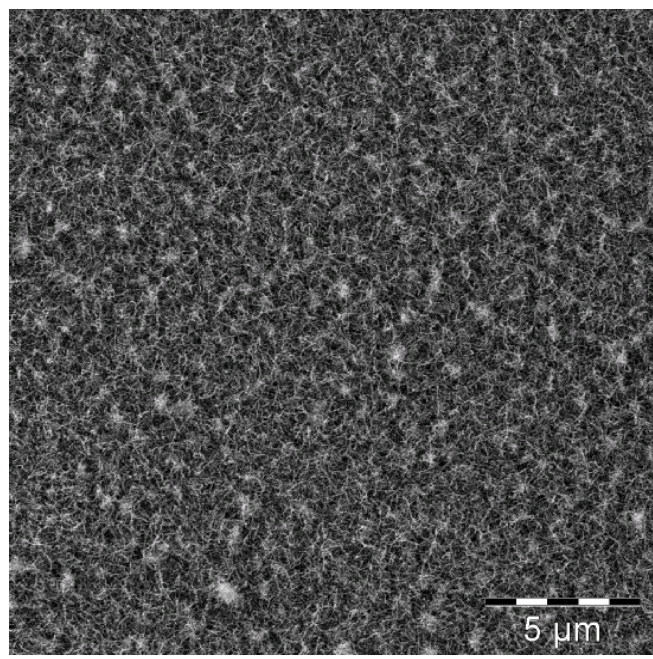




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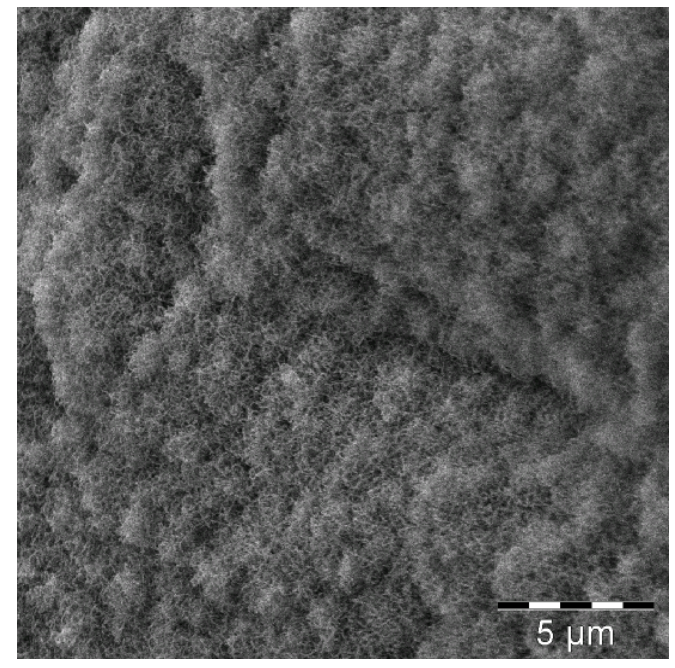
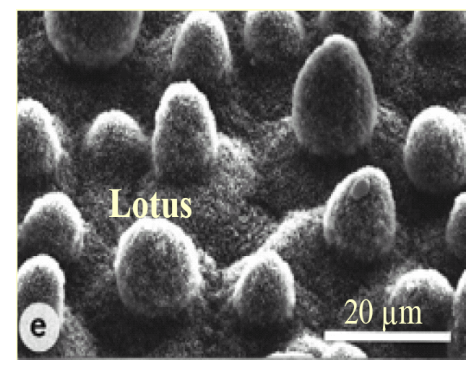
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Nanostructures mimeting nature



artificial n-structures

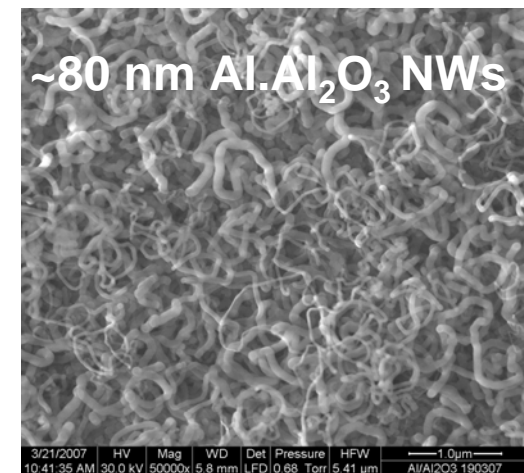
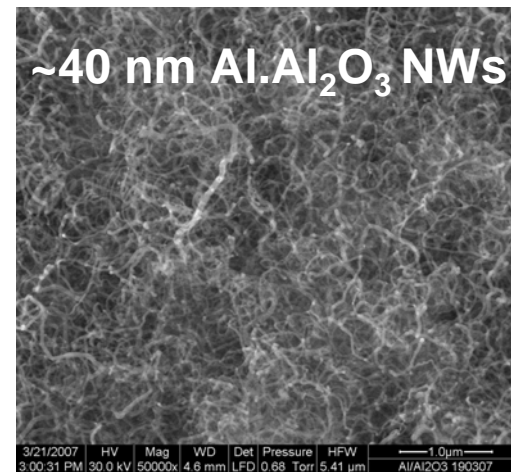
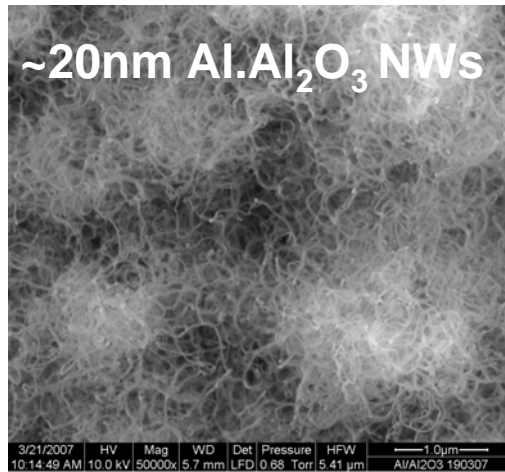
**Lotus leaf: natural
 μ and n structures**



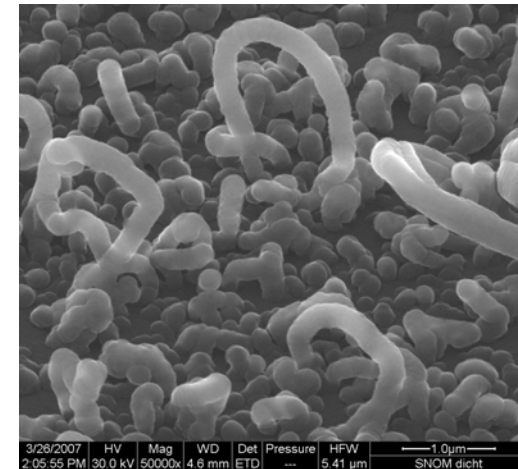
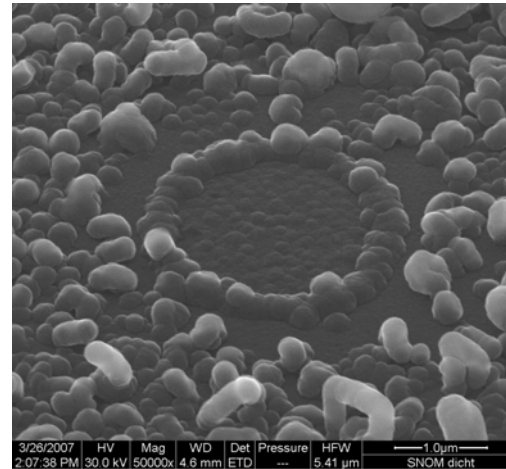
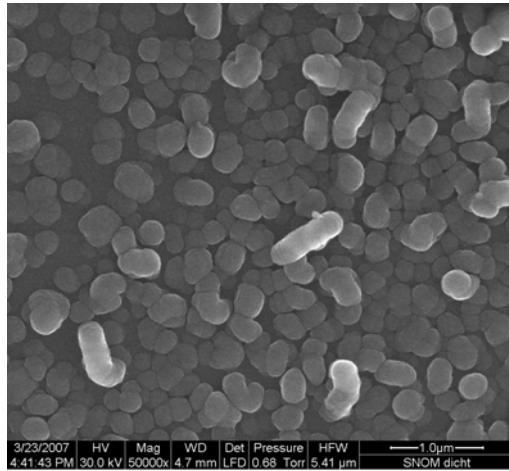
artificial μ and n structures



Nanowires having adjustable dimensions



Further fine structures: Nano Loops...



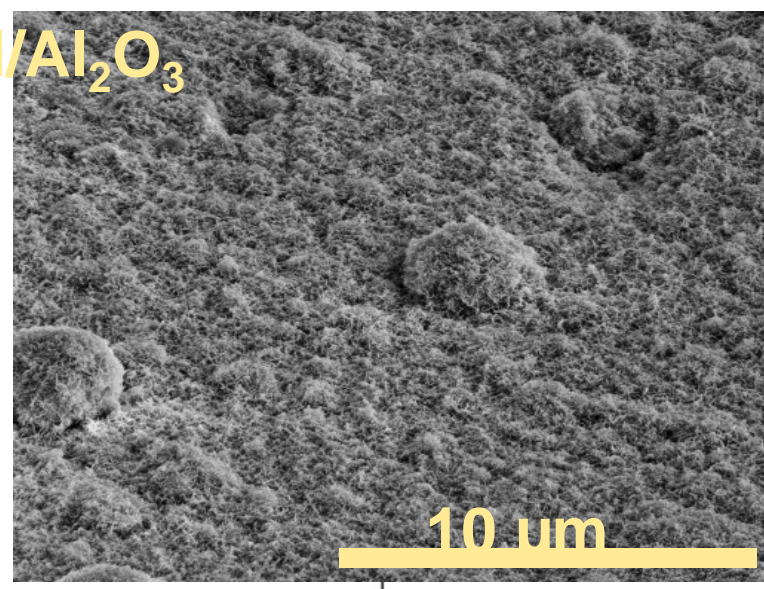
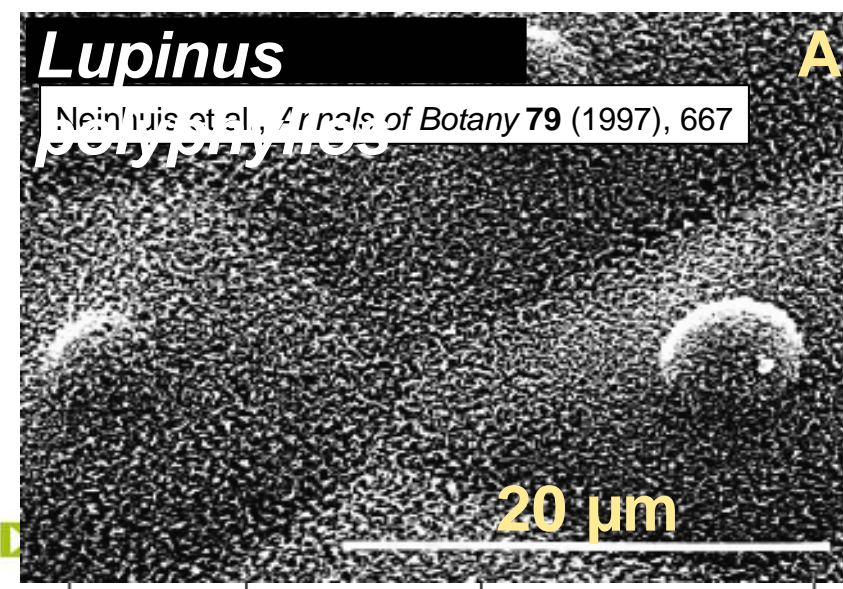
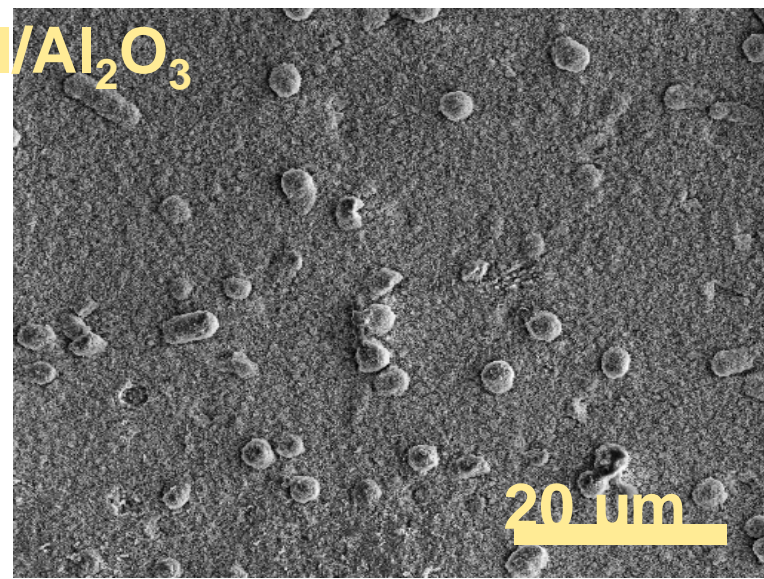
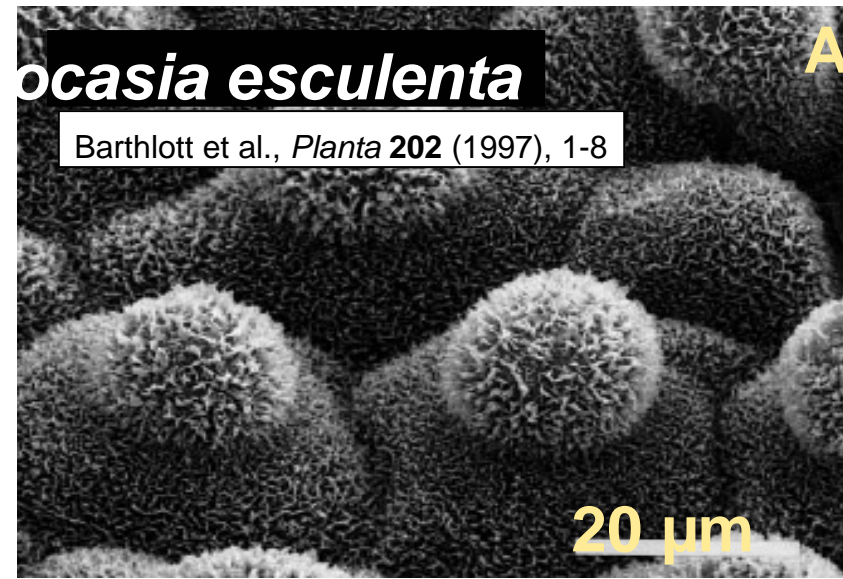
Al:Al₂O₃ nanoparticle self-assembly



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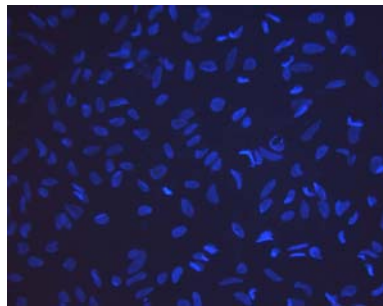
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Mimic natural surfaces

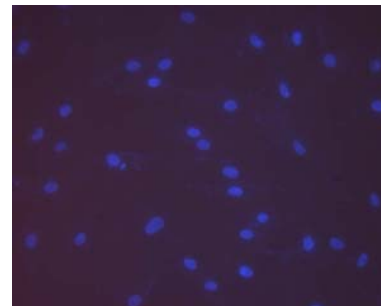


Results – CVD films (I)

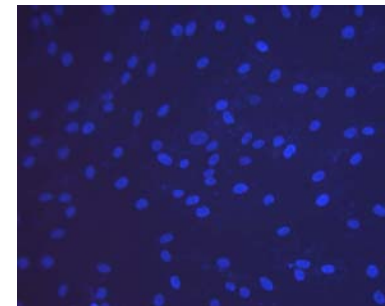
→ human fibroblasts adhere on CVD films



HAIO-C-013-a
(310°C, 120 min)



HAIO-C-013-a
(550°C, 30 min)

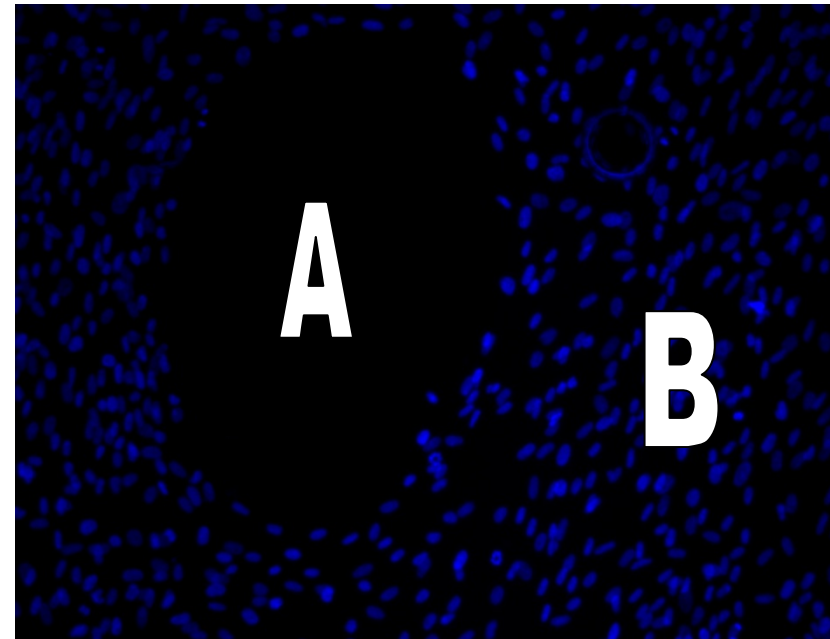
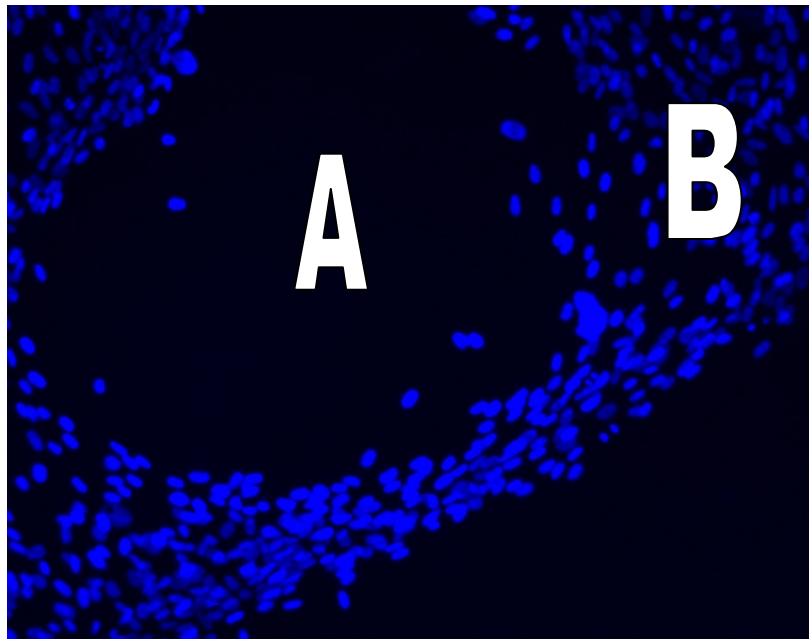


Si<100>

DAPI staining

USAAR4/1



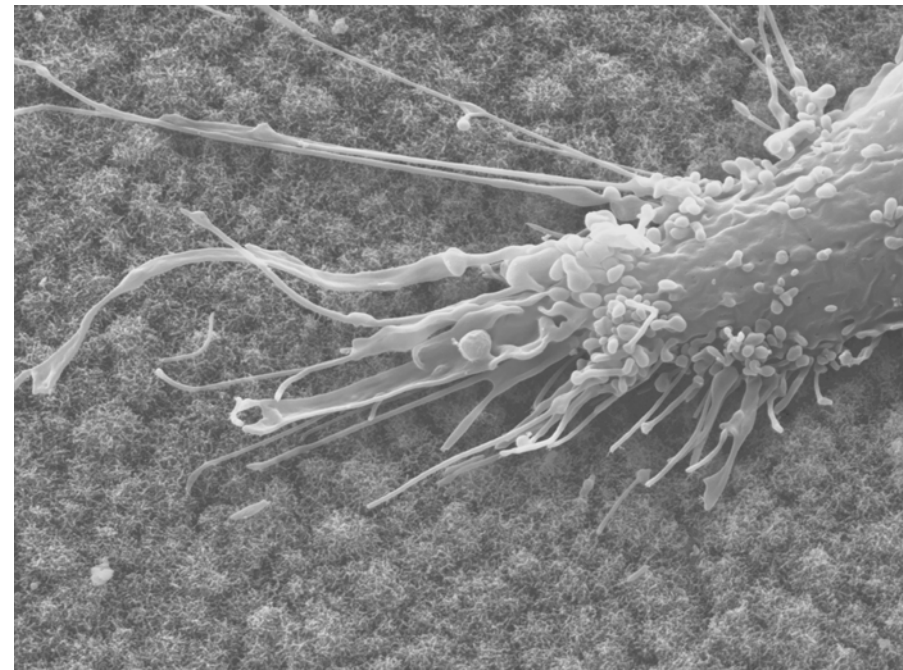


Regions A and B have different scaled structures

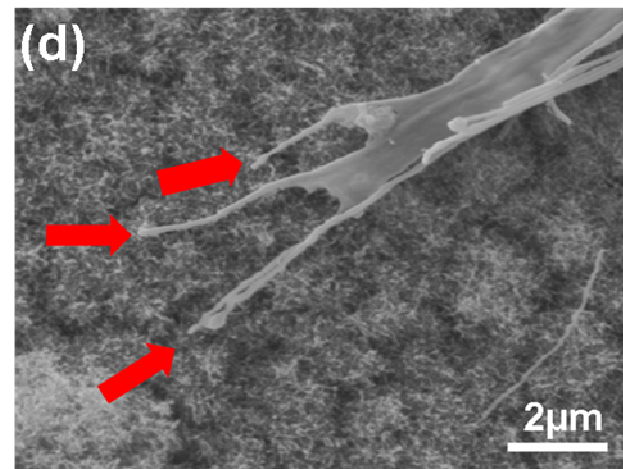
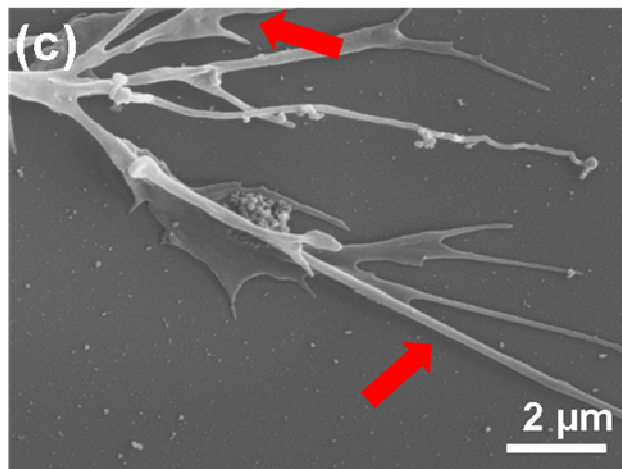
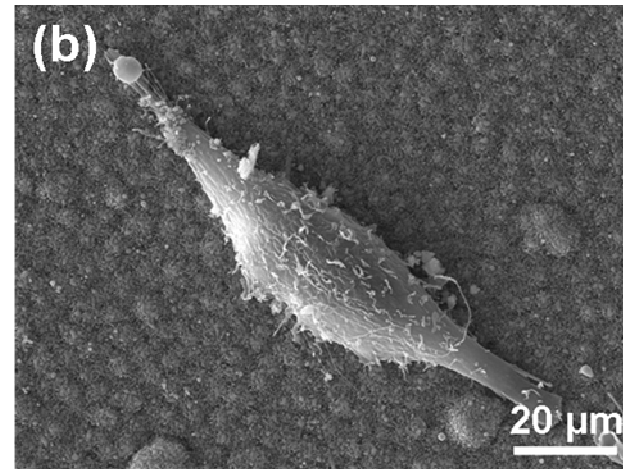
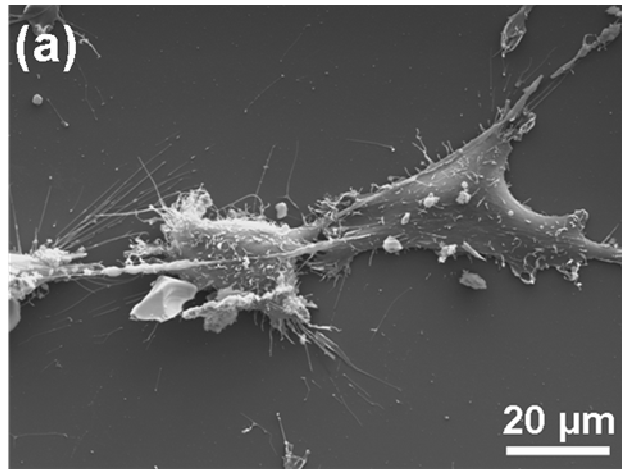
Fibroblast on nano-wire structured surface



Detailed view of filipodias:



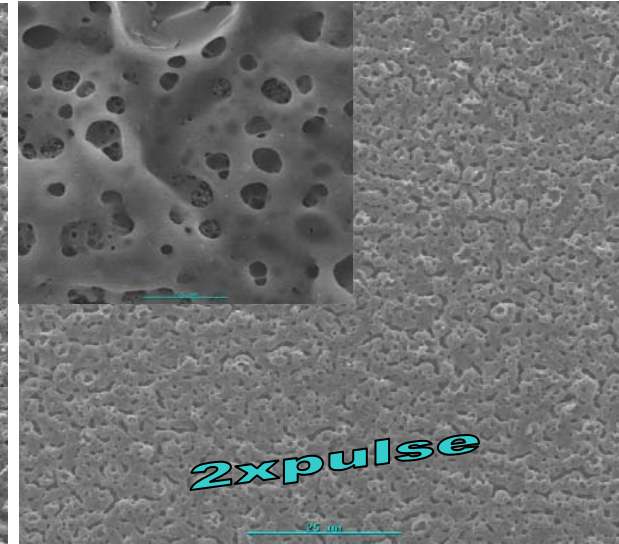
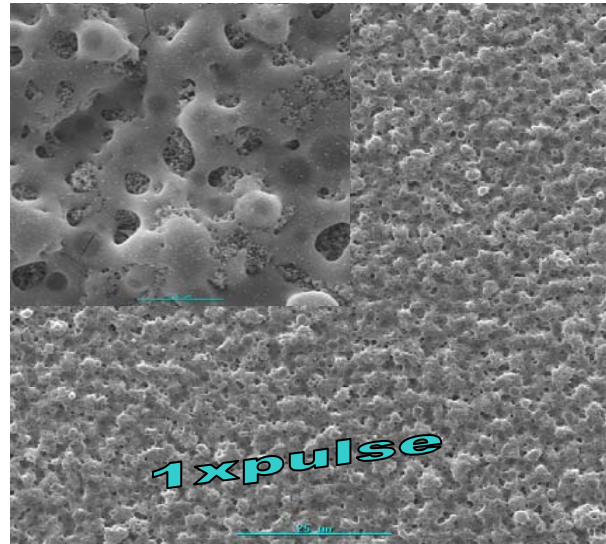
Comparison of glass surface (left) with Al/Al₂O₃ nanowires



Evolution of Al/Al₂O₃ nanowires by laser pulse

1xPulse

- Nanopores
- Nanowires



2xPulse

- Nanopores

3xPulse

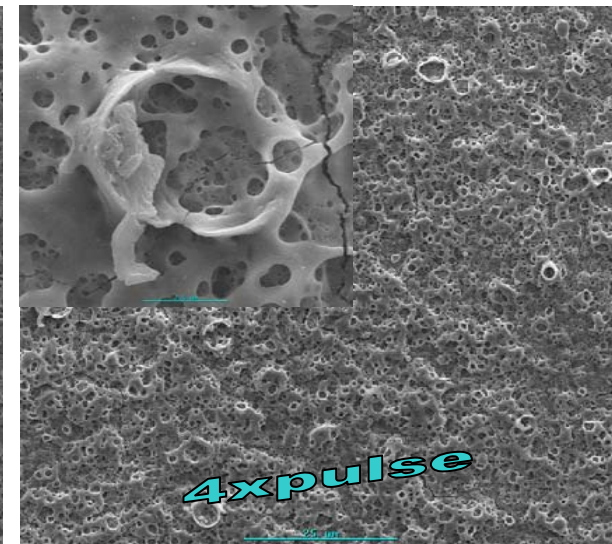
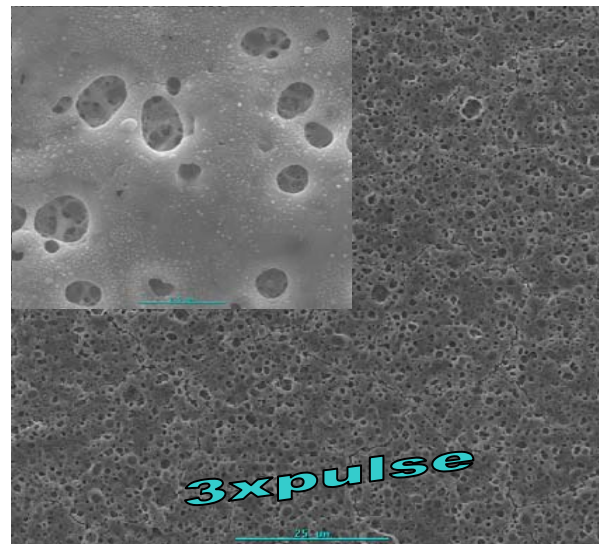
- Micropores

- Nanopores

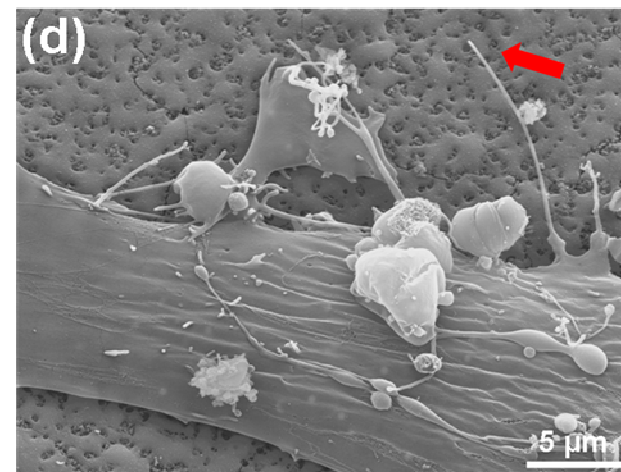
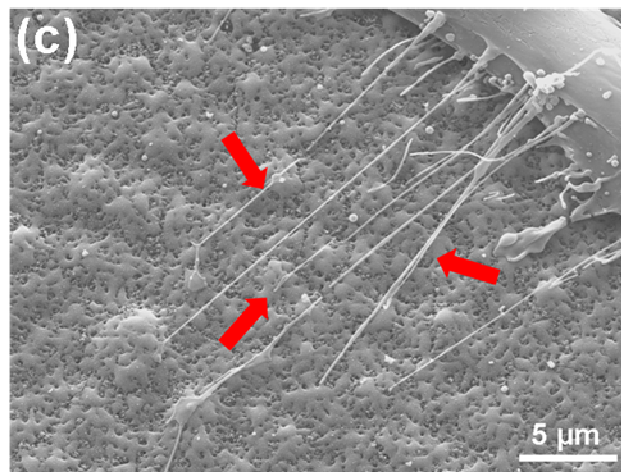
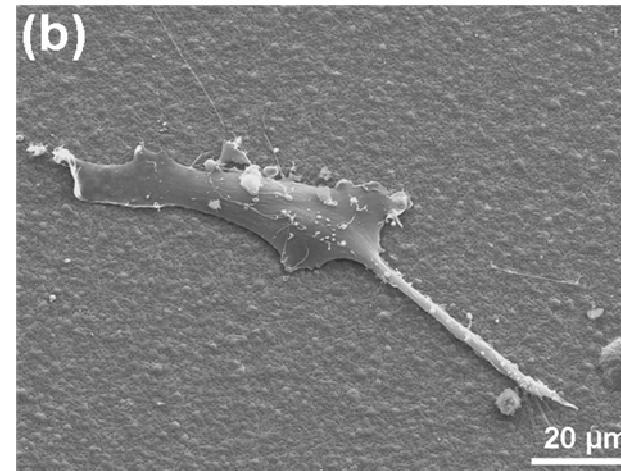
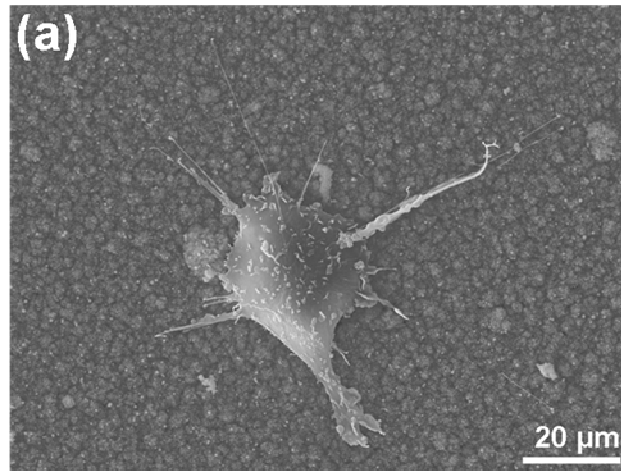
4xPulse

- Micropores

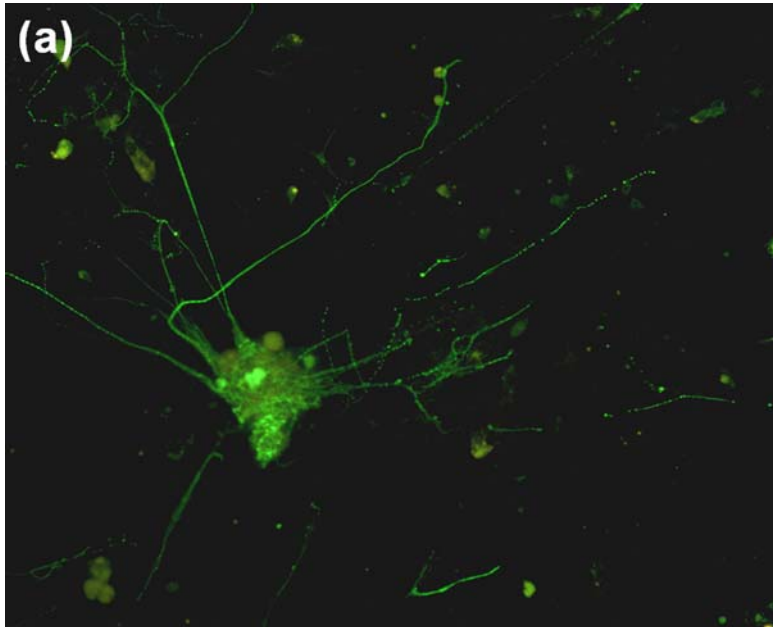
- Grooves



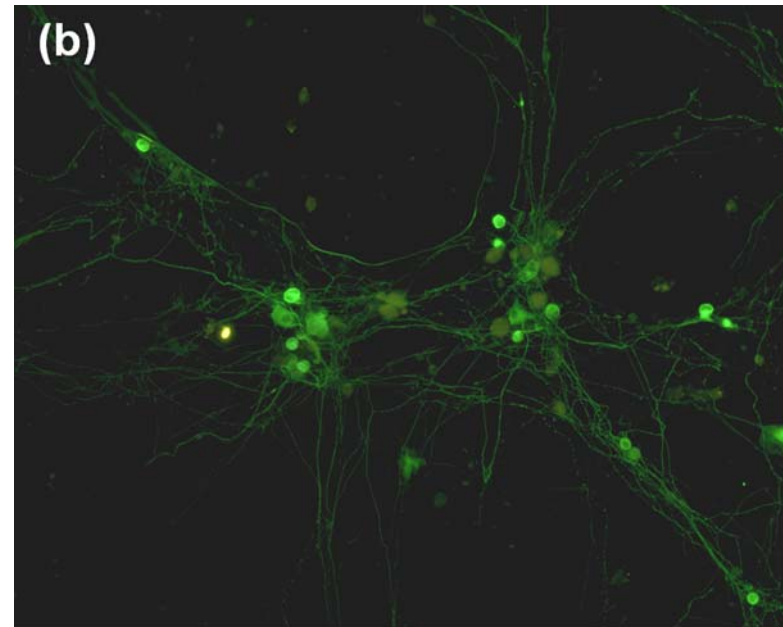
Pulsed laser transformed Al/Al₂O₃ (left 1 pulse, right 2 pulses)



DRG neurons fixed in 4% formaldehyde and immunohistochemically stained by the marker tubulin.



Control experiment: glass



Al/Al₂O₃-surface