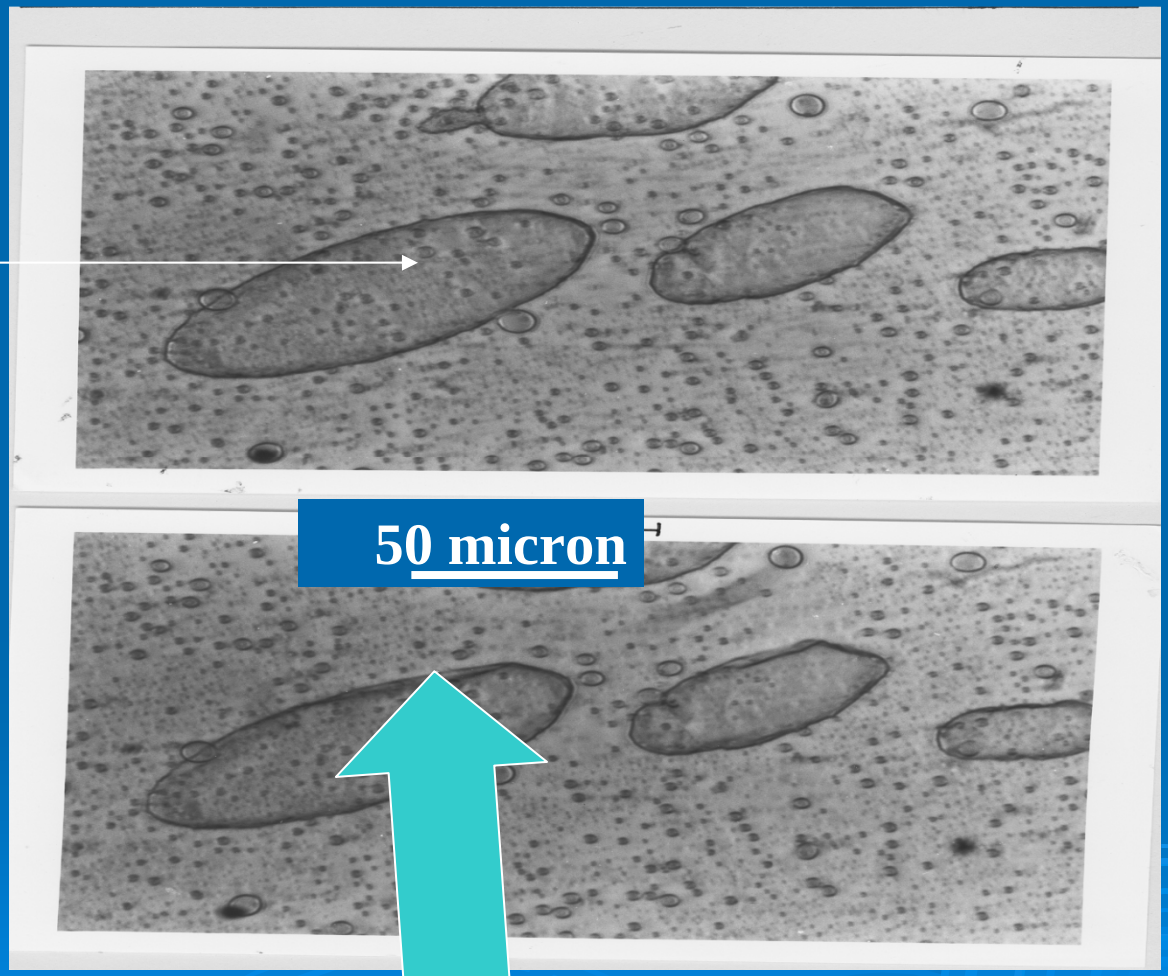
Interfacial rigidity of silica coating, observed at an oil/water interface

Non-spherical oil droplets formed in cationic coated silica dispersion



MRC Discipline Hopper Award

Deposition of Nanoparticles for Control of Cellular Response to Surfaces

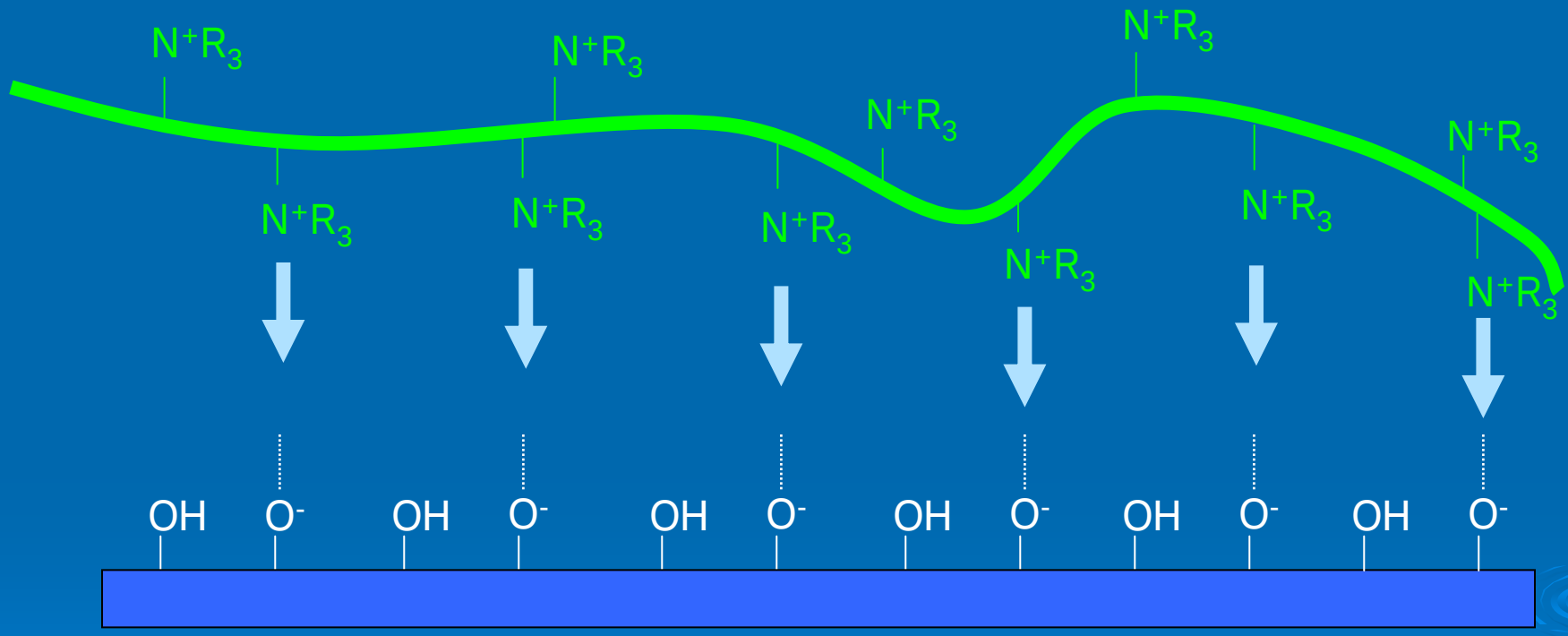
- Cells respond to nanoscale structures and adapt to topography
- Deposition of nanoparticles offers a simple route to topographical modification.

Potential applications in wound dressing, hygienic surfaces and implants.

Study Aim

- The aim of the study was the manipulation of the surface topography to influence cellular response
- Approach uses the deposition of commercially available, nanoscale, silica particles to modify the topography
- Cationic surfactant coated silica limited to hydrophobic surfaces and necessitated an alternative deposition process.

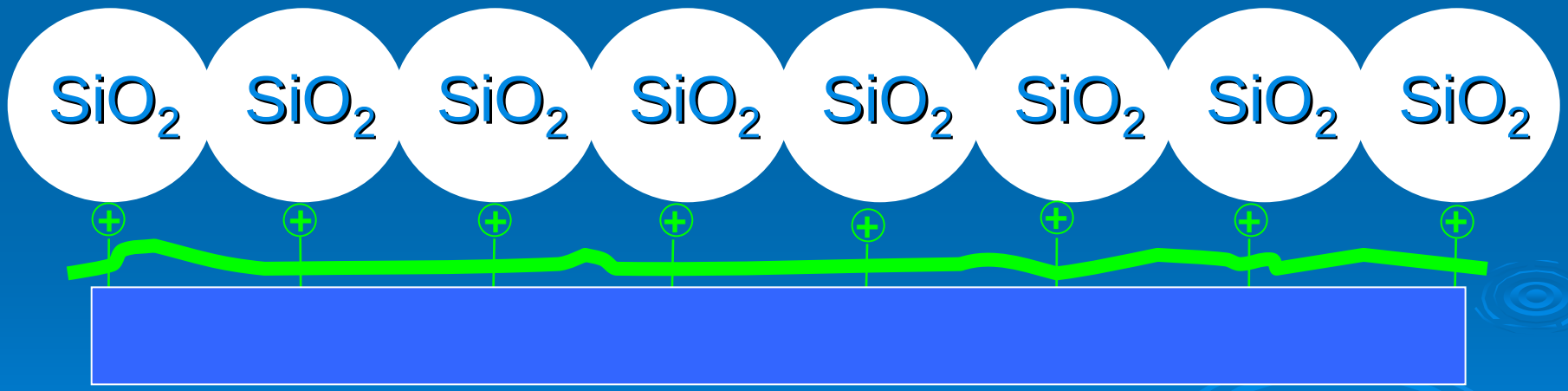
Zetag™
Primary Adhesive Layer



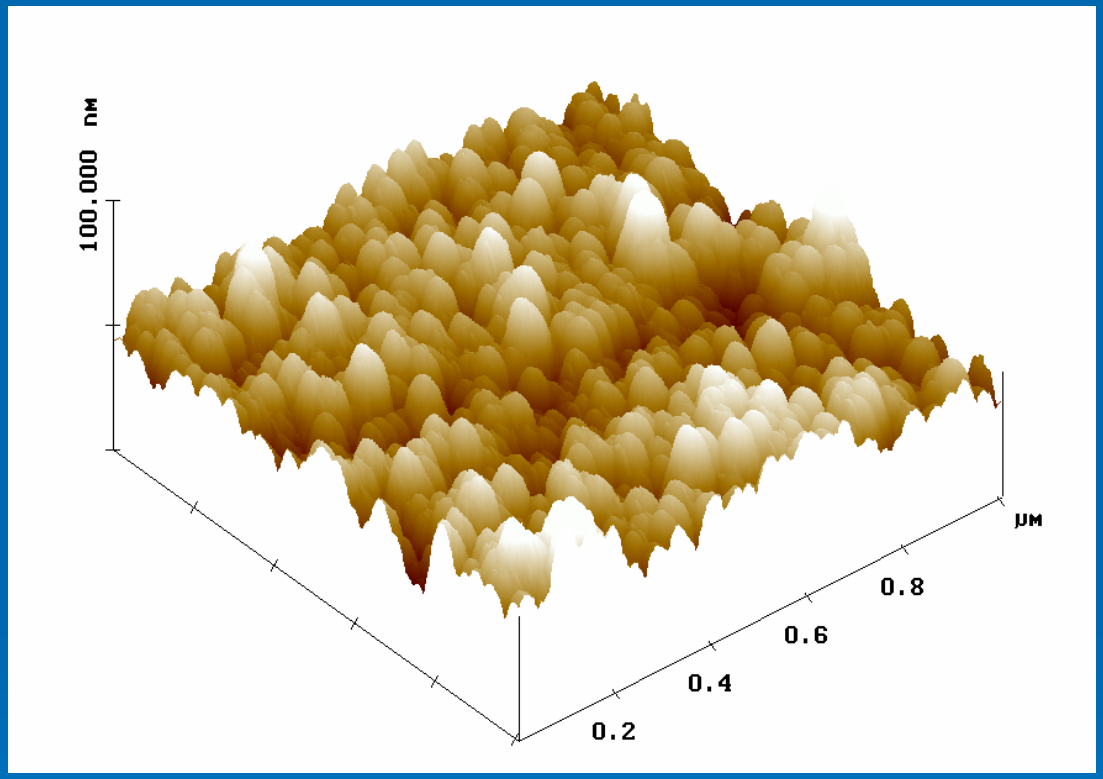
- Ionic adsorption of Zetag on to a glass surface is achieved via (O^- N^+R_3) ion-pairs

Deposition of Silica

- Negative silica particles adsorb on to the cationic polymer

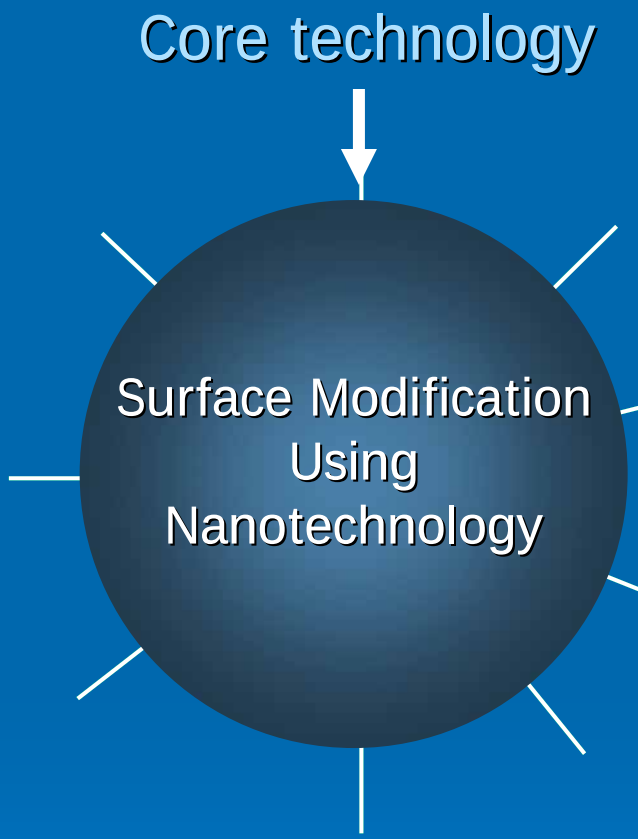


Results



- 21 nm Silica particles attached to glass substrate
- Image is representative of 7, 14, 21 and 80 nm silica particles

Potential Applications of Core Technology

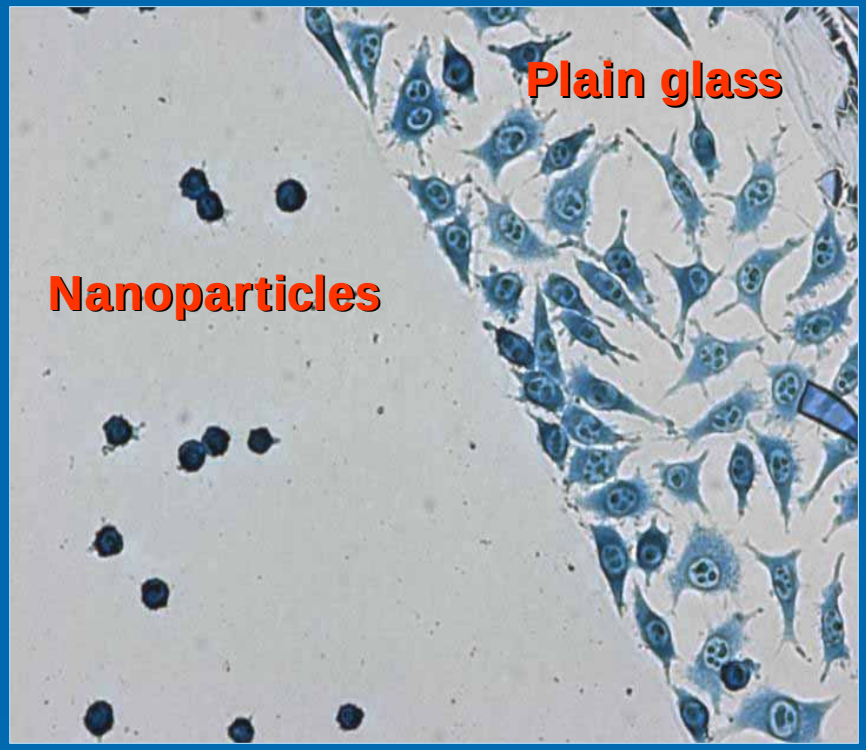


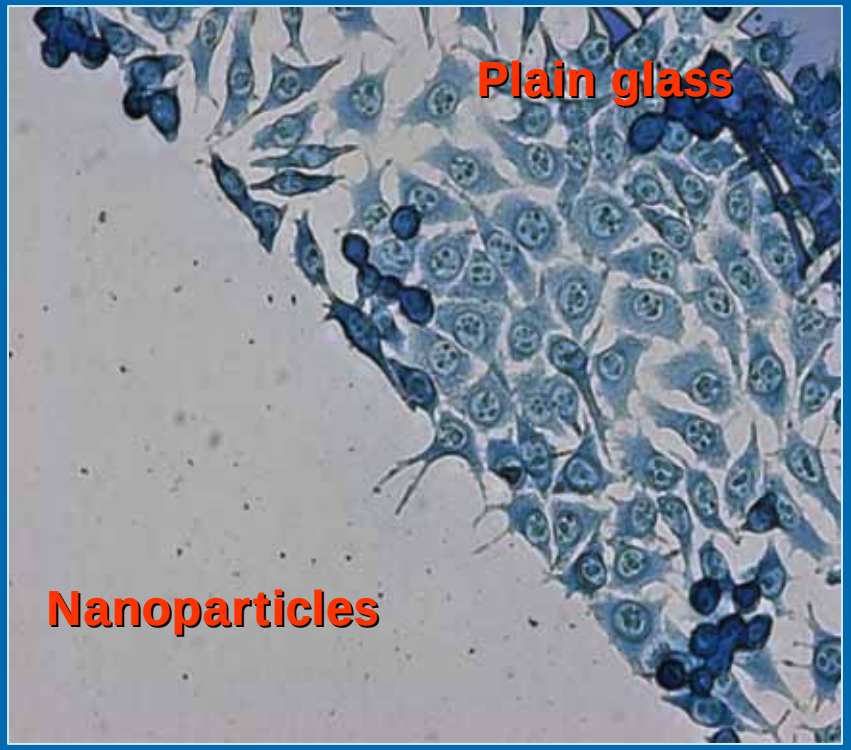
Intraocular lenses

Wound dressings

Bone fracture repair devices

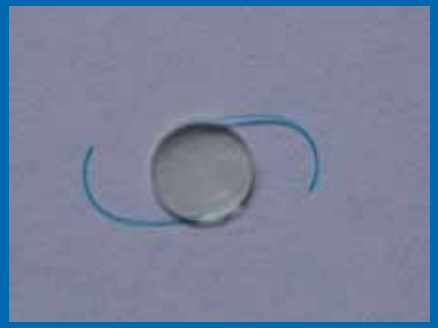
Cell Response to Nanotopography

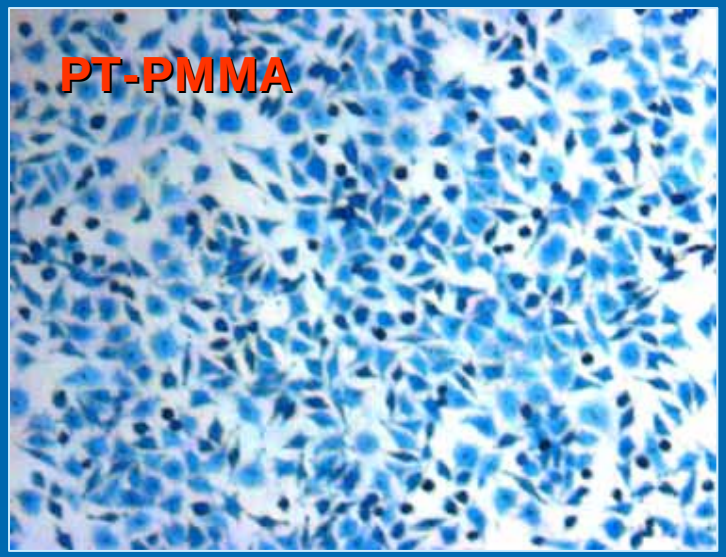


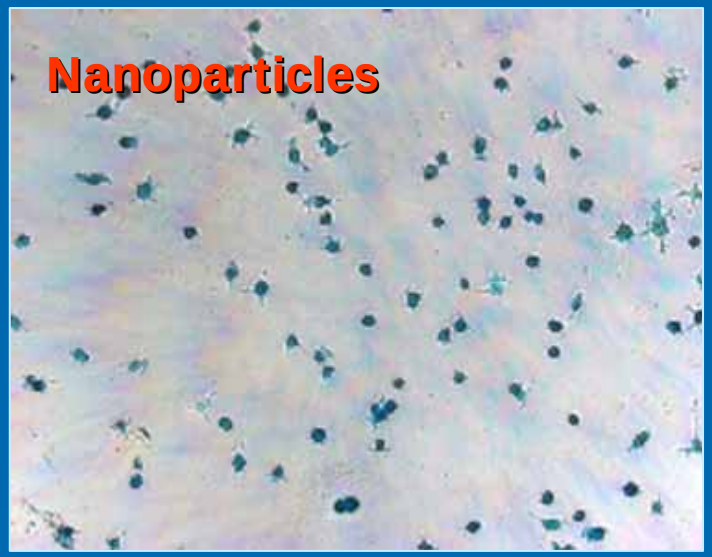


- Fibroblast cells on coated and uncoated glass
- Silica particles inhibit adhesion/spreading of cells
- Silica particles prevent migration of cells
- This effect is not altered by changing protein concentration
- Effect seen with other cell types (primary & established)

Intraocular lens





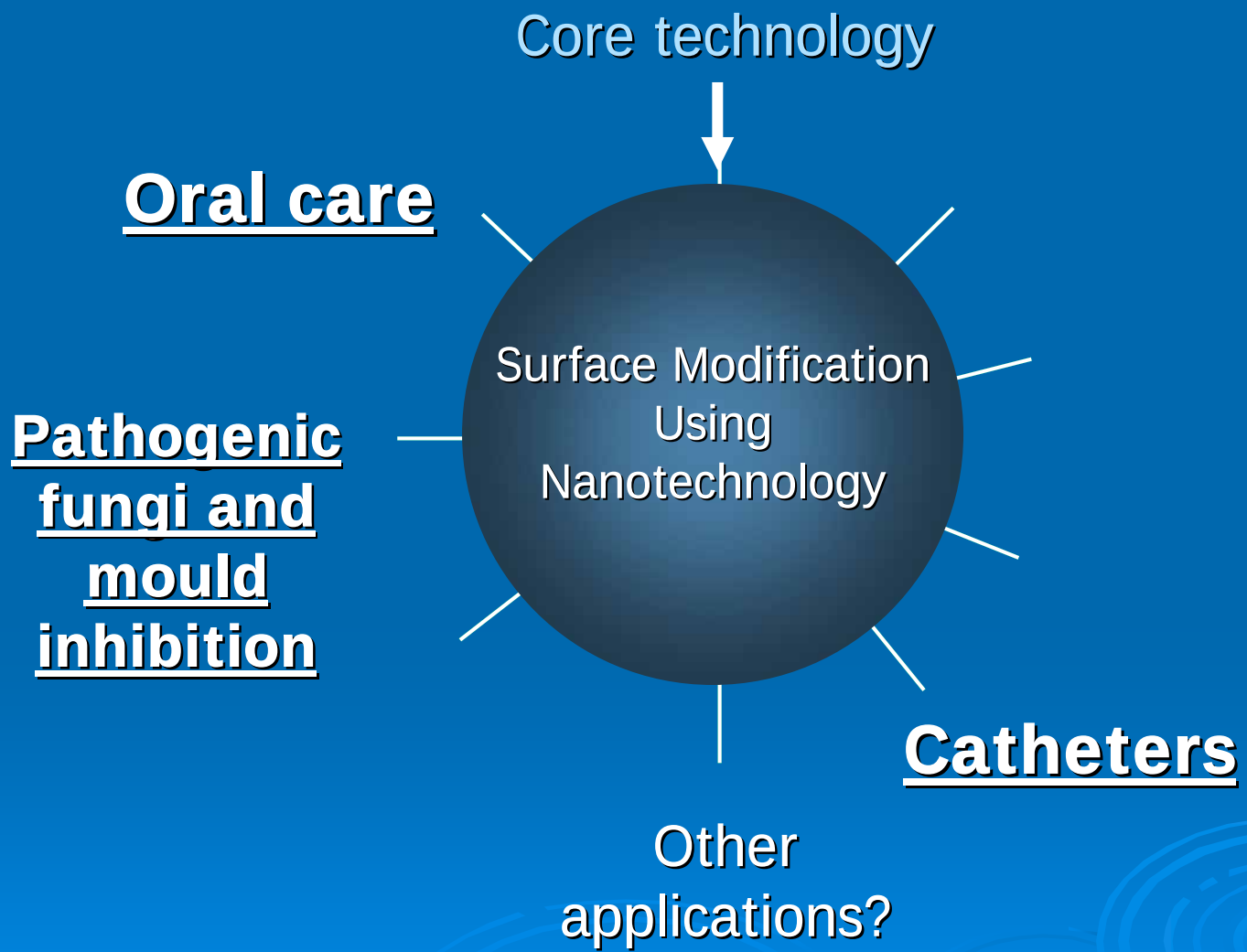


- Fibroblast cells, L929 attach to plasma treated PMMA.
- Cells on 7 nm silica treated surfaces remain rounded and could be removed by gentle rinsing
- Cells remain viable when re-cultured on other substrates
- Similar results for Bovine Lens epithelial cells.

Commercially Pure Titanium (CpTi) Trauma Devices

- Fibroblast cells spread and proliferate on CpTi
- Cells on 7 nm silica treated Ti remain rounded in morphology (x 50 and x 200 magnification)

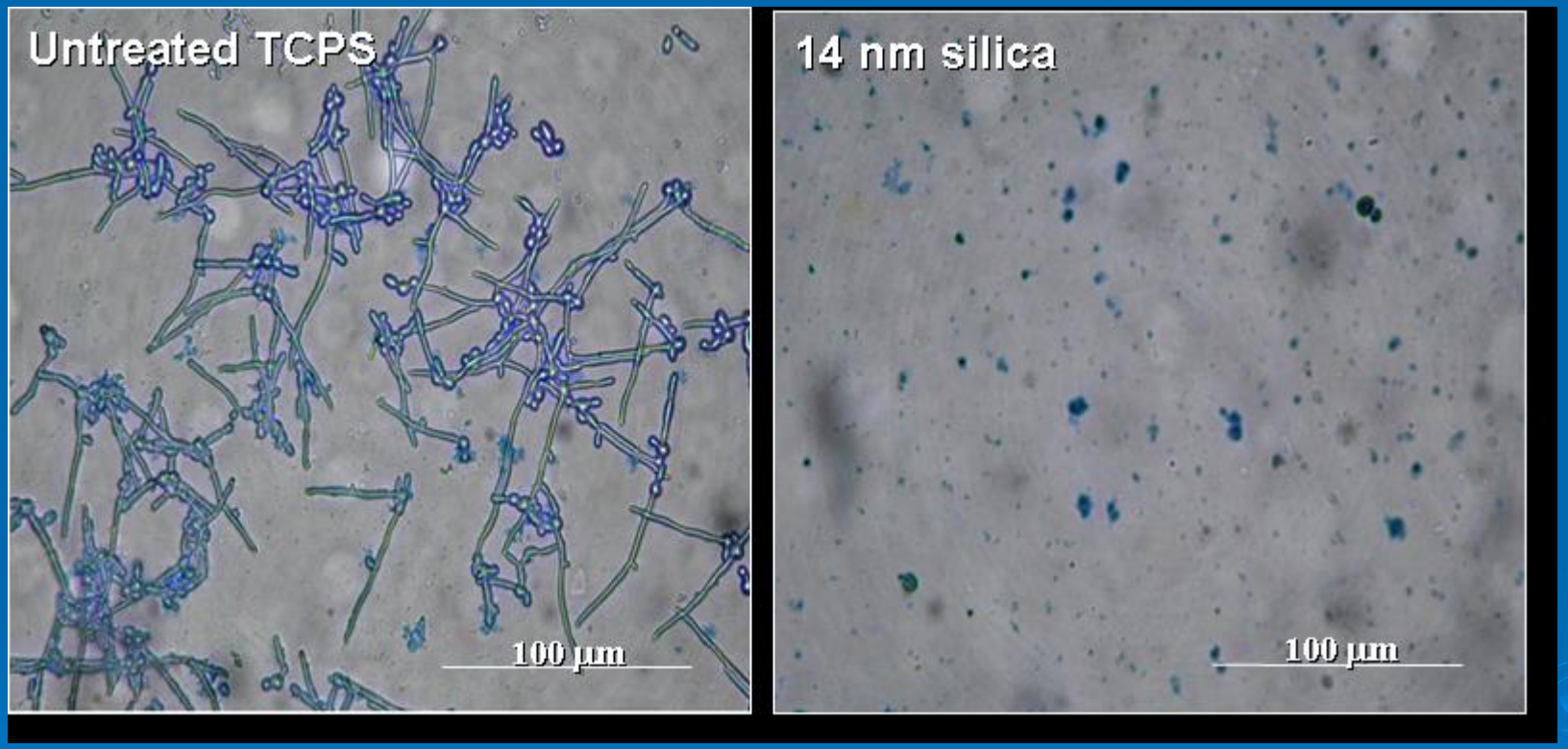
Potential Applications of Core Technology



Biofilm formation by pathogenic fungi *Candida albicans*

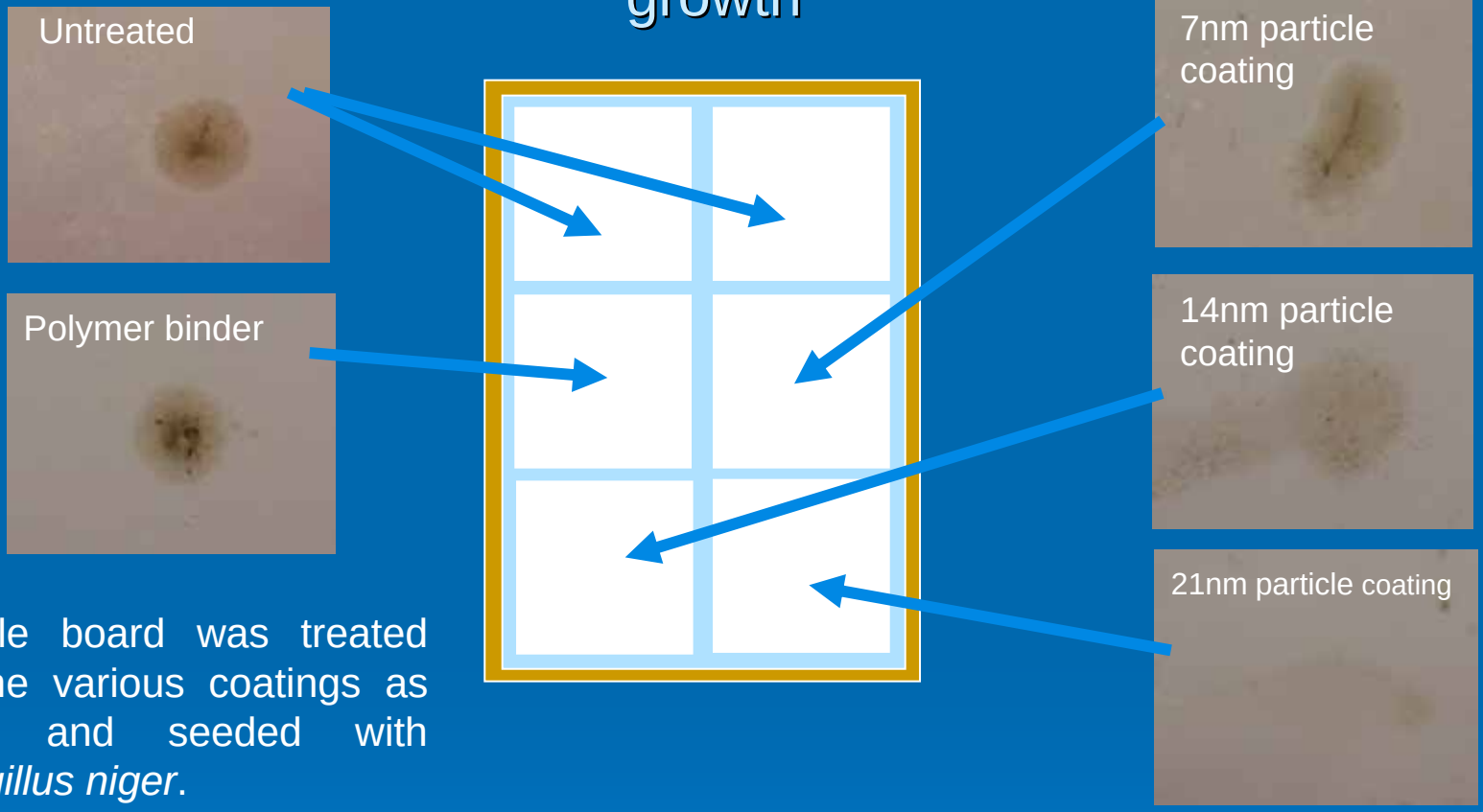
Common pathogen as “thrush”, but also causes severe problems in immunocompromised patients and can be the cause of morbidity

C. albicans response to silica nanoparticles: monitoring biofilm development over time (4 h)



- *C. albicans* on untreated (left) and 14 nm silica treated
- tissue culture polystyrene TCPS (right) after 4 h at 37 ^{o}C

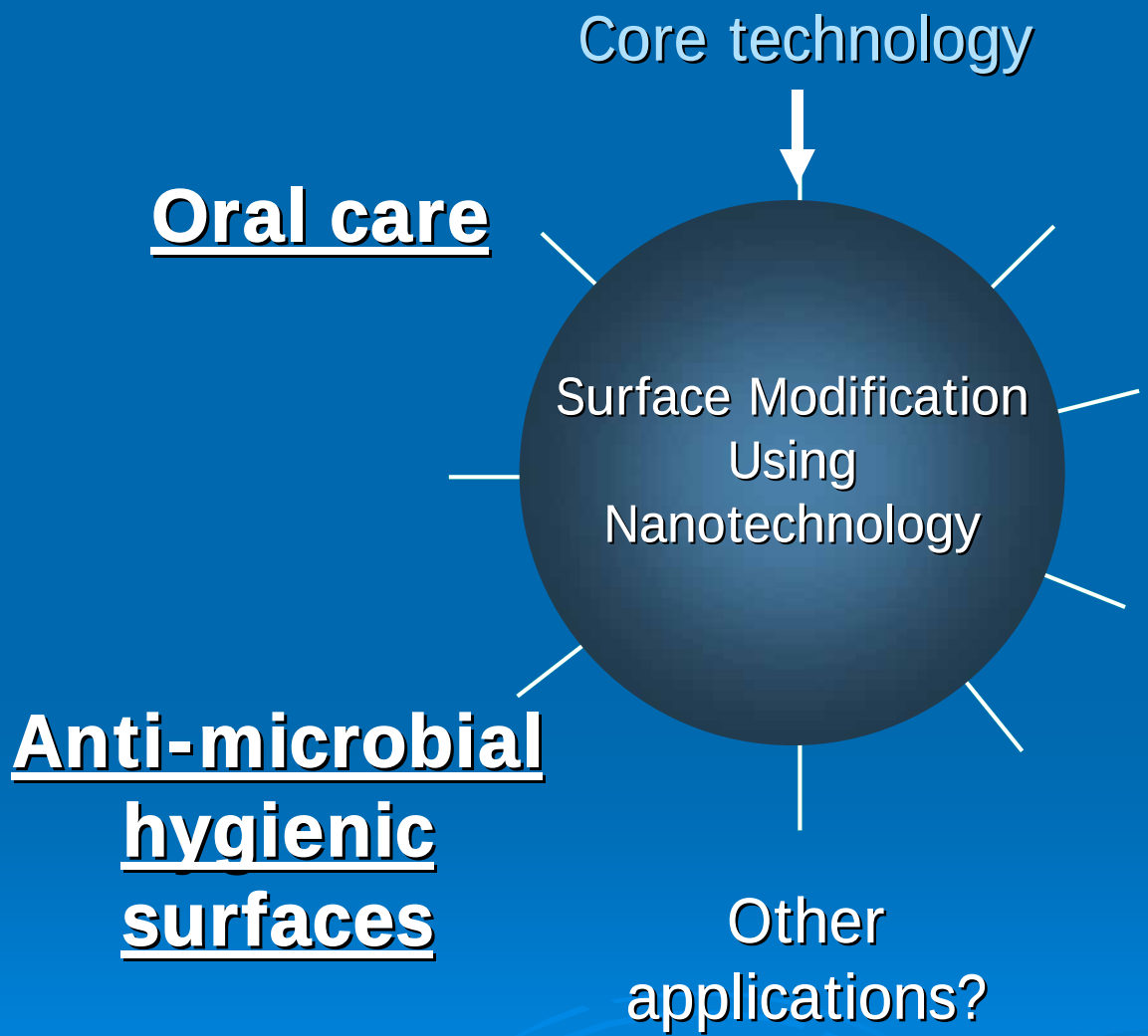
Surface modification using nano particles to control fungal growth



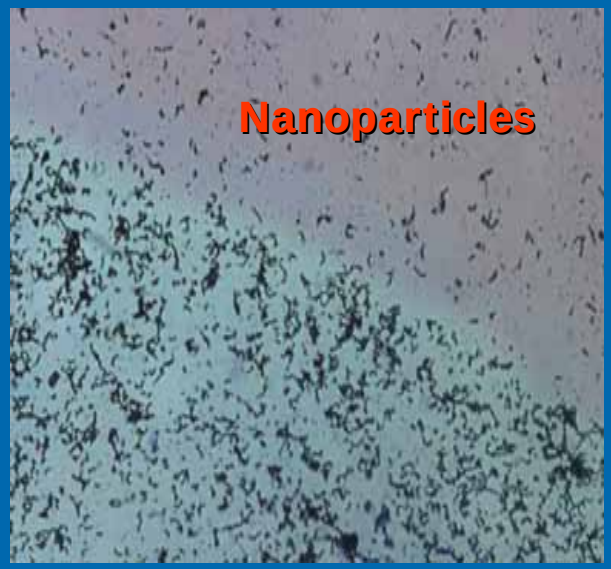
The tile board was treated with the various coatings as shown and seeded with *Aspergillus niger*.

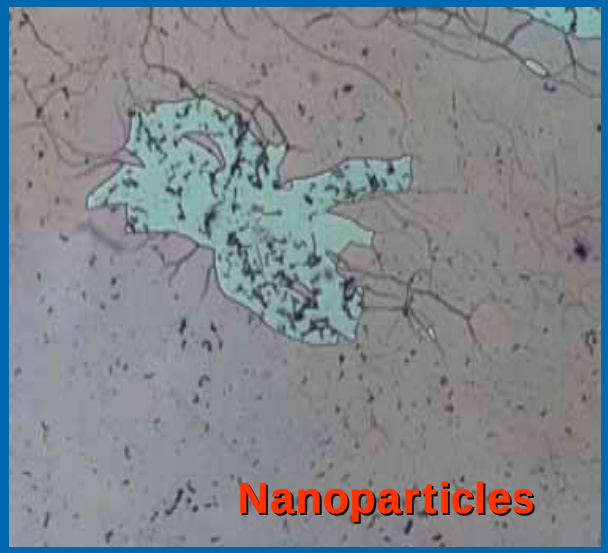
Microscopic examination of the fungal growth demonstrated production of aerial hyphae and spores on the untreated surface and only evidence of quiescent spores with limited or no hyphal growth on the 14nm coated surface.

Potential Applications of Core Technology



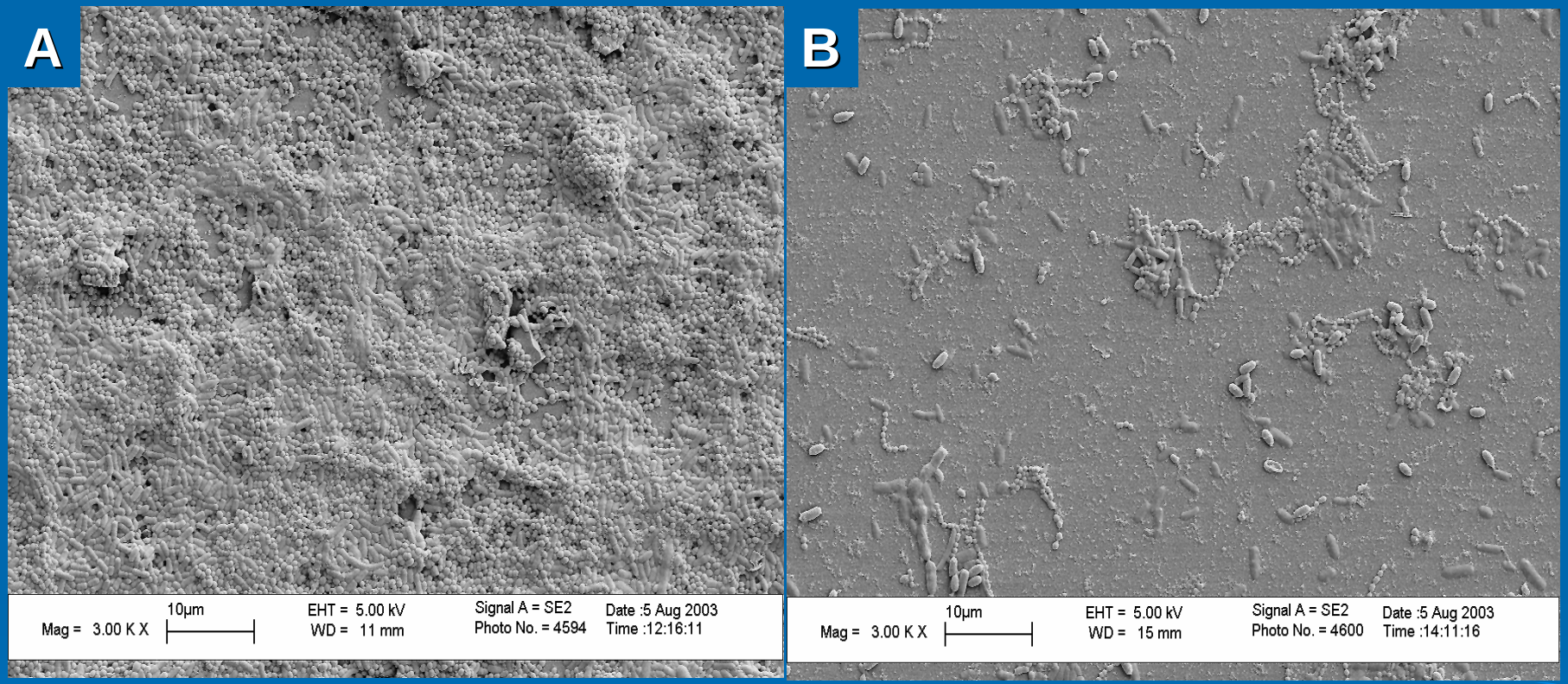
Streptococcus mutans





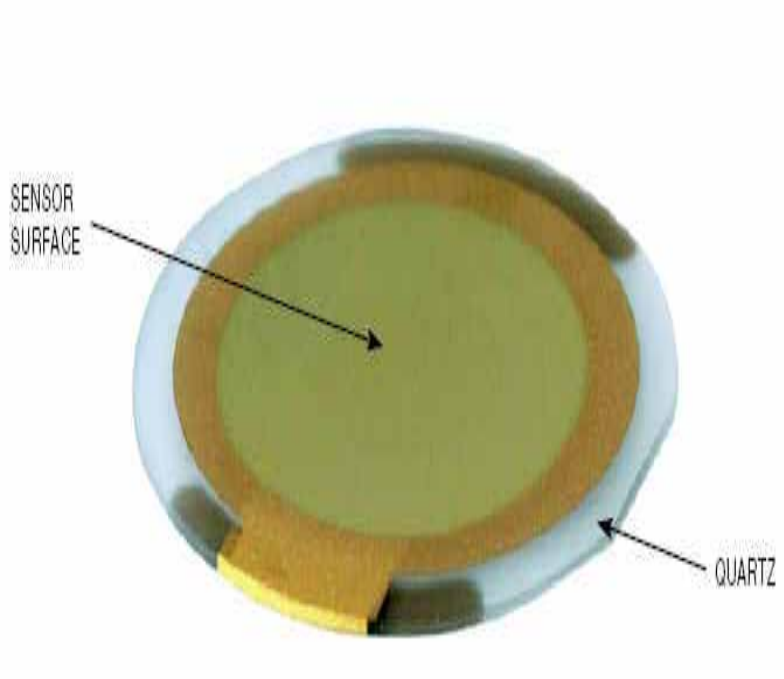
- The adhesion of *S. mutans* is reduced on the silica treated surface

SEM of S. ***mutans***



- Non-sterile nutrient broth inoculated with *S. mutans*
  - (A) Zetag coated substrate (left)
  - (B) 7 nm silica coated substrate (right)

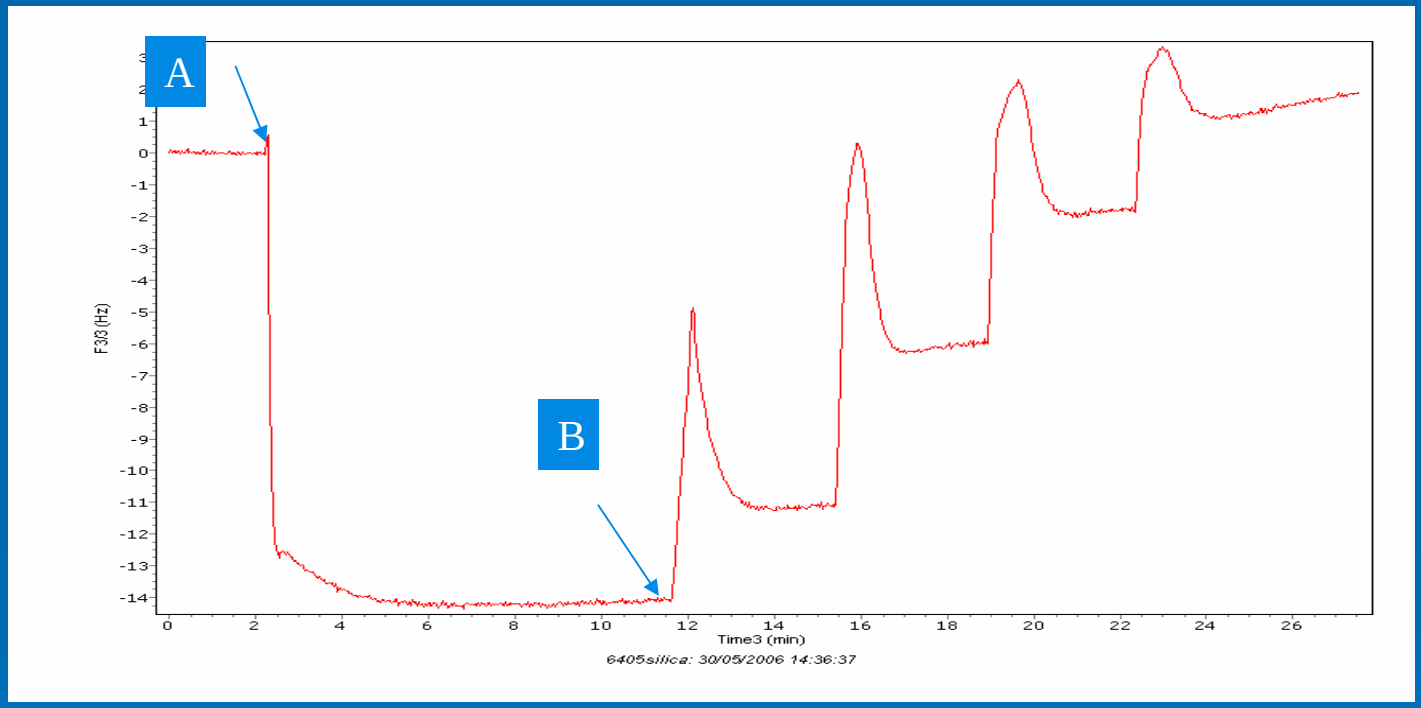
The Quartz Crystal Microbalance (QCM)



The Quartz Crystal

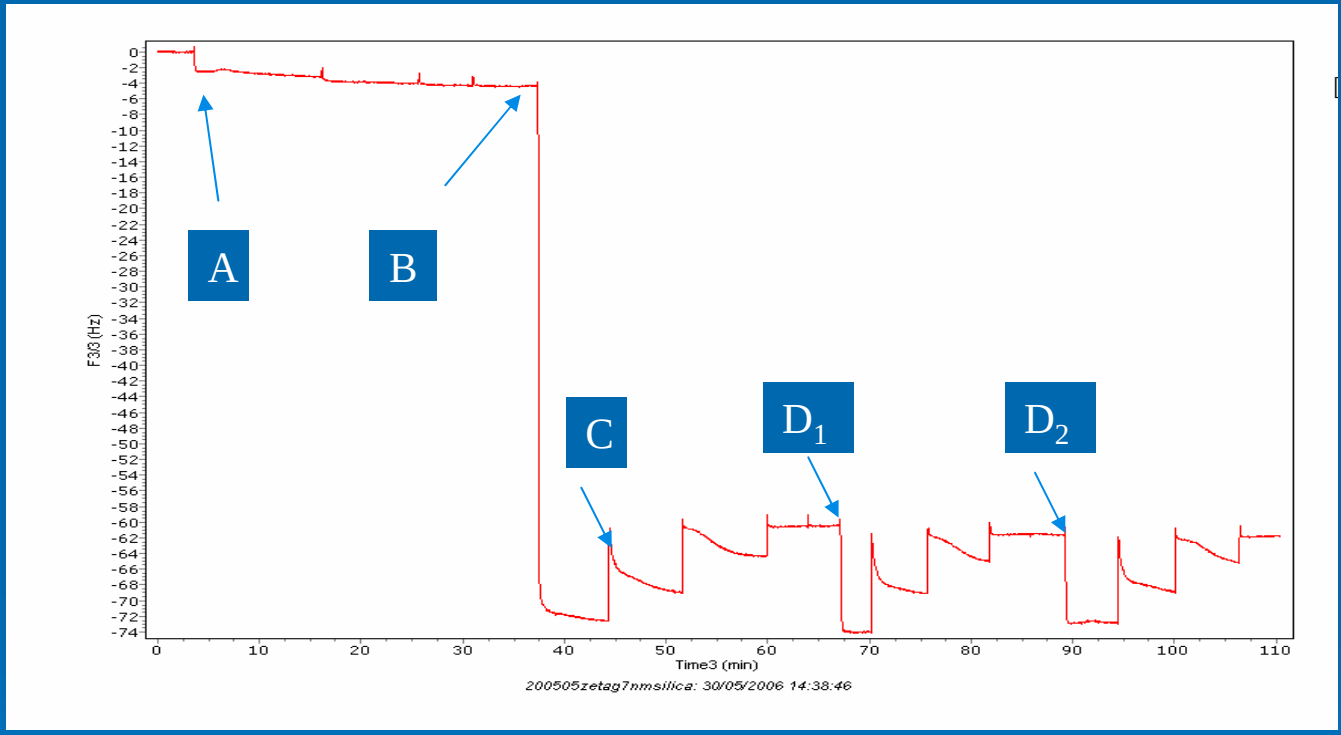
- When a thin film is attached to the surface of the sensor crystal the frequency decreases.
- If the film is thin and rigid the decrease in frequency is proportional to the mass of the film.
- In this way the QCM operates as a very sensitive balance.

QCM-D results 1



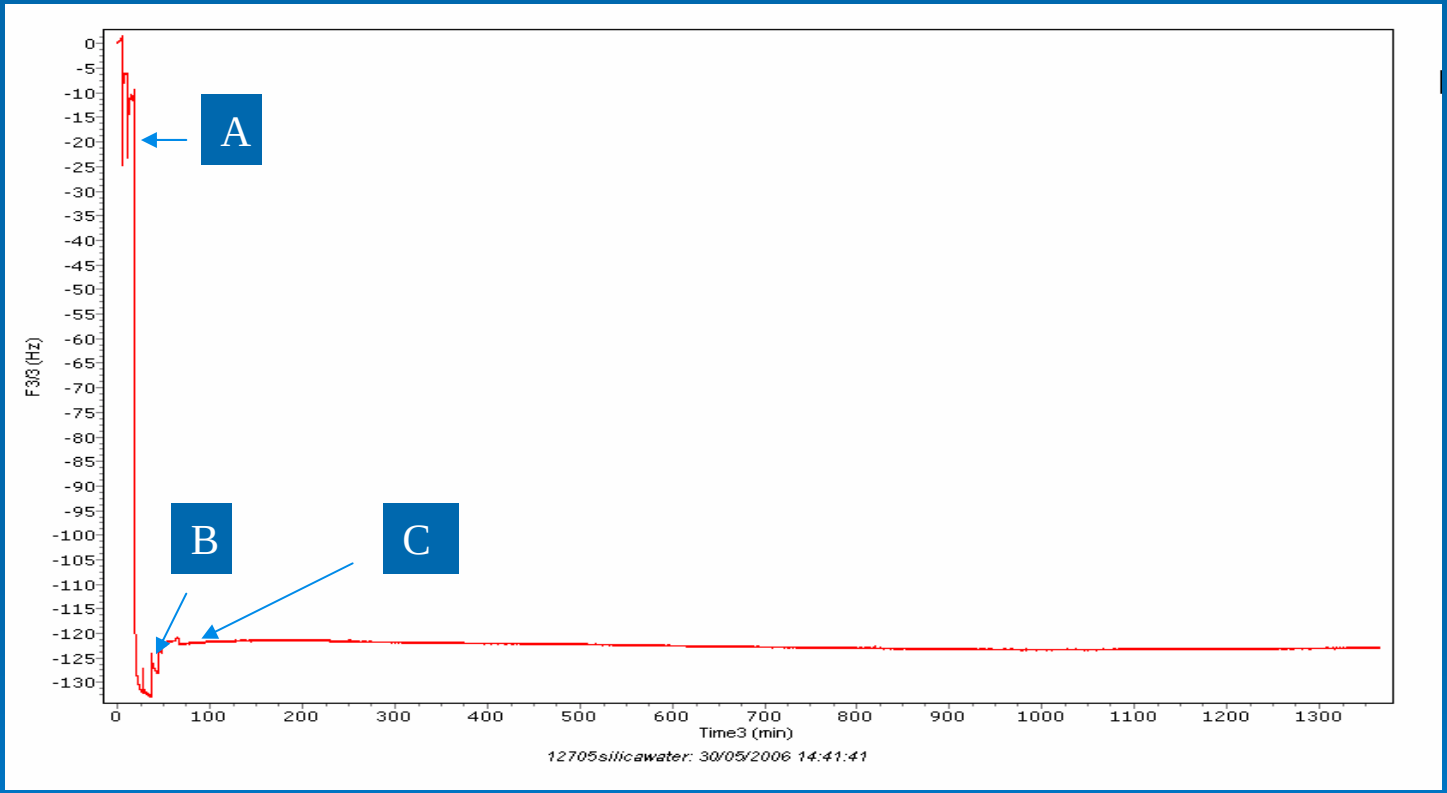
- Red line : frequency
- A: silica added
- B: begin washes with NaOH 10^{-5} M

QCM-D results 2



- A: Zetag™ 7109 added, followed by washes with NaOH 10 $^{-5}$M.
- B: 7nm silica added.
- C: washes with 10^{-5} M NaOH begin
- $D_{1,2,}$: addition of excess silica and then washes with NaOH 10 $^{-5}$M

QCM-D results 3



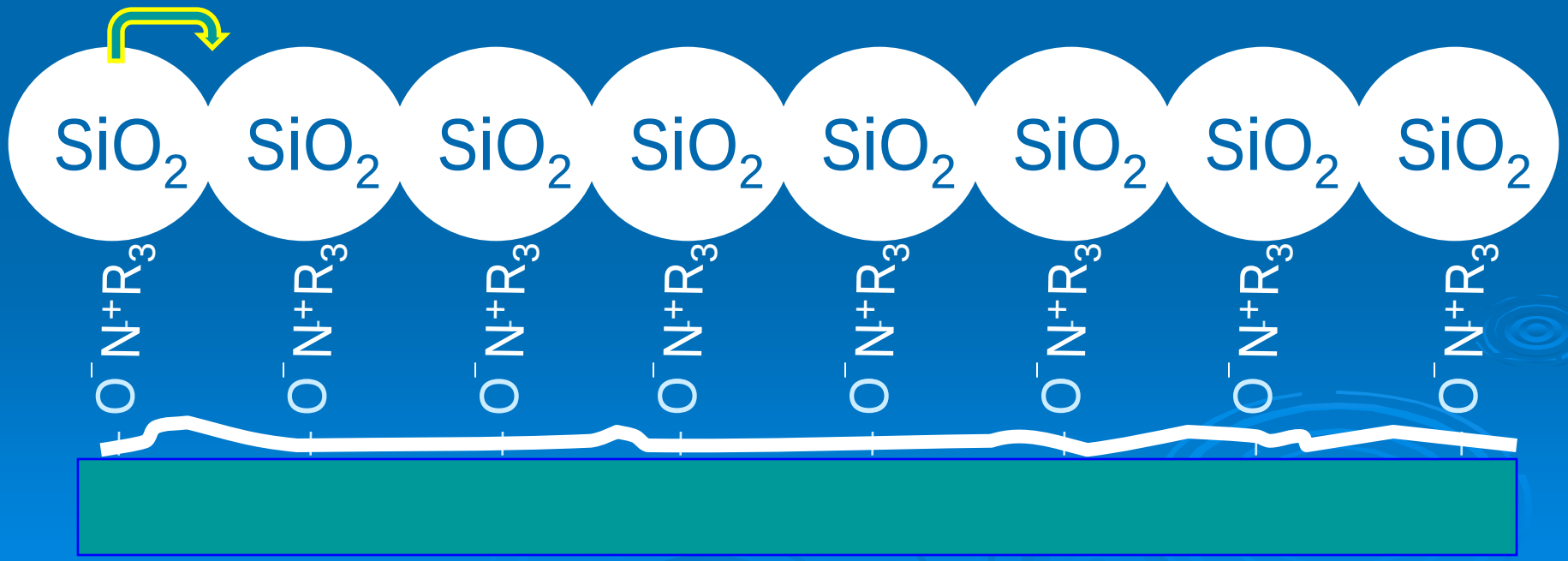
- A :deposition of Zetag™ and 7nm silica coating
- B :Wash with 10^{-5} NaOH.
- C :flow distilled water over surface at a rate of 50µl per minute (18hours)

Summary

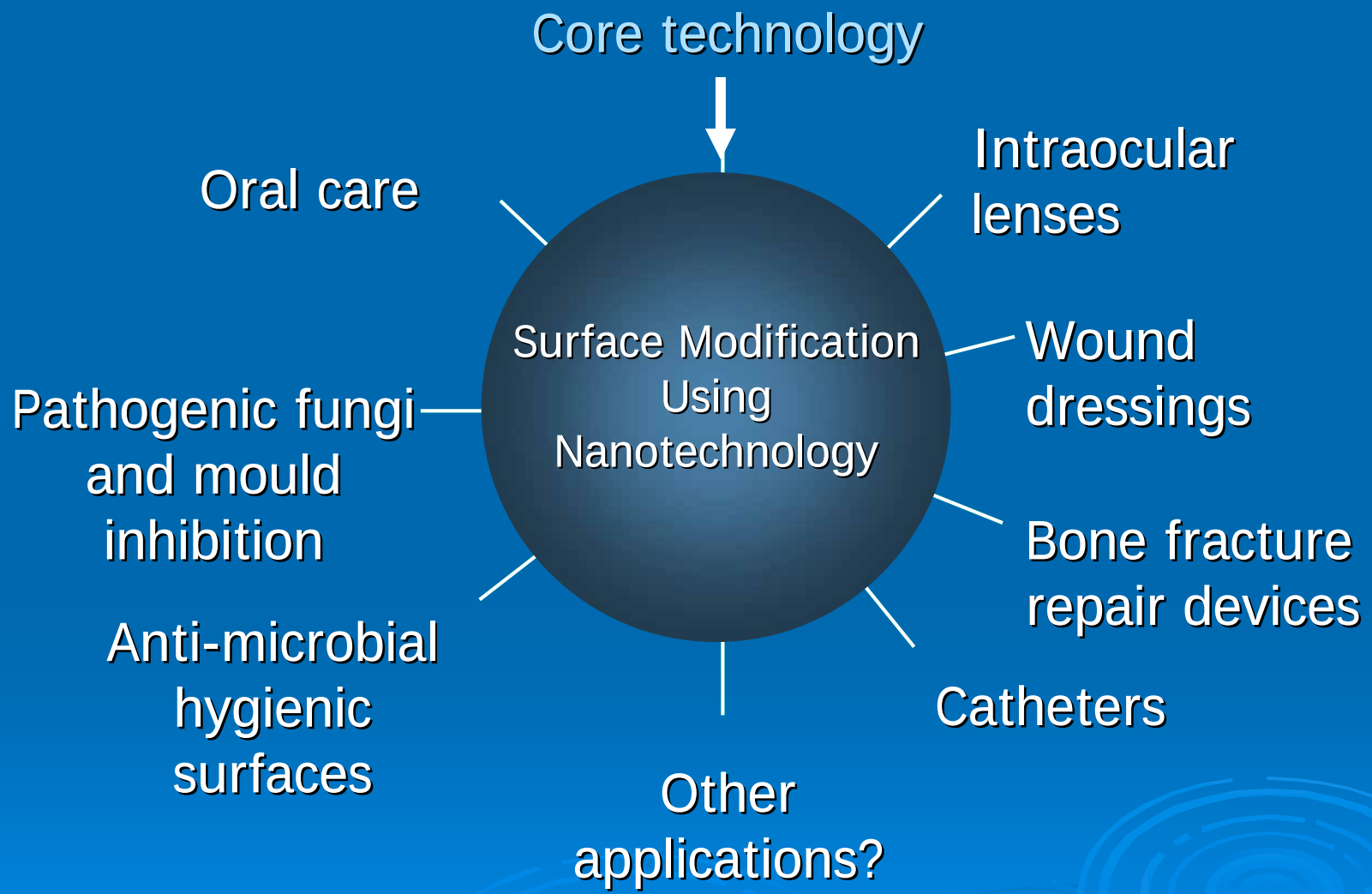
- Demonstrated the cell response with a range of cell types
- Coat a wide range of materials producing stable coatings of silica nanoparticles
- Uses the deposition of commercially available, nanoscale, silica
- International Patent. WO 02101028, June 2002
- Is effect due to chemistry or nanotopography?

Mechanism of inhibition

•Continuous dissolution of the silica from areas of high positive curvature to the areas of negative curvature (between the particles) inhibits cellular adhesion.



Potential Applications of Core Technology



Need to optimise delivery mechanisms and efficacy