

Antimicrobial Coatings for Touch Surfaces

**Oihane Hernandez-Rodriguez^{1,2}, Dermot Monaghan¹,
Victor Bellido-Gonzalez¹**

¹Genco Ltd., Liverpool, United Kingdom;

²IK4-TEKNIKER, Eibar, Spain

Antimicrobial resistance (AMR) is one of the major global challenges facing healthcare. Prevention of infections acquired in hospitals is the most effective way to fight AMR. This paper presents a solution against infections derived from touch surfaces by using a coating nanotechnology based adhesive pad to protect the public from cross contamination. The aim of the coated surfaces was to rapidly kill microbes and viral strains that could be in contact with and hence be continually self-cleaning (self-sanitizing). The coating development has been focused on flexible and transparent substrates and coatings which could be easily upscaled using Roll-to-Roll production techniques. Different biochemical and biological tests would be performed in order to qualify and quantify the antimicrobial efficiency. New analytical techniques would also be applied in order to identify dead & alive and colony forming units (cfu) on the coated surfaces.



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09:20am BT1



Antimicrobial Coatings for Touch Surfaces

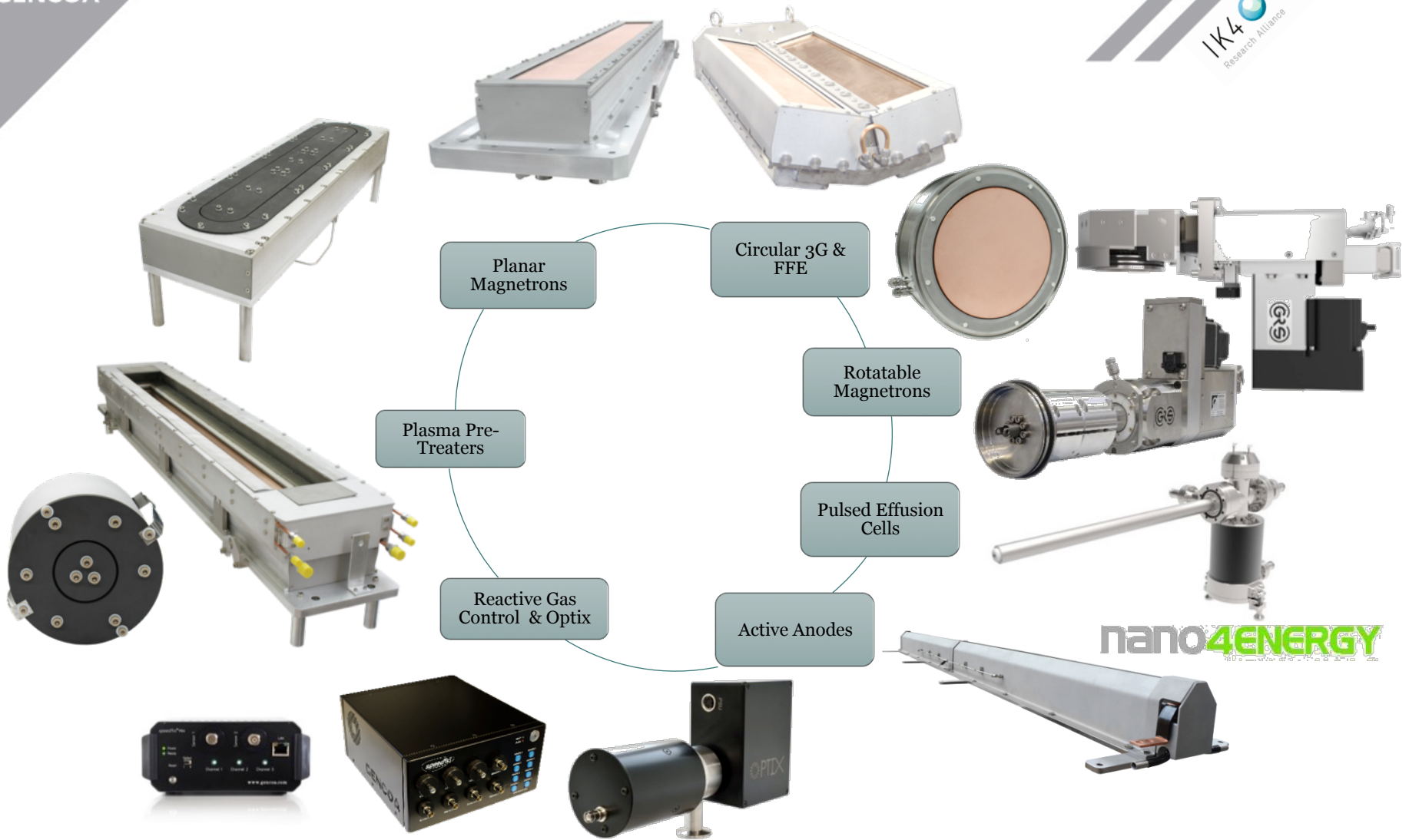


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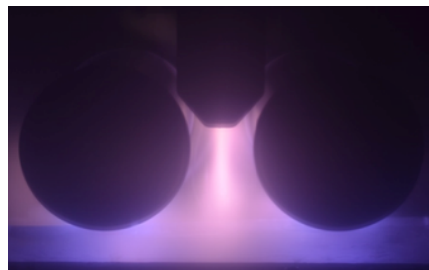
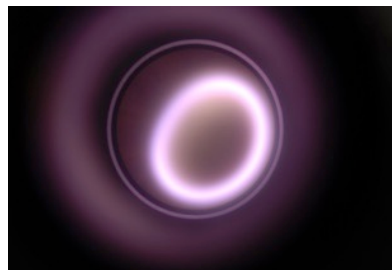
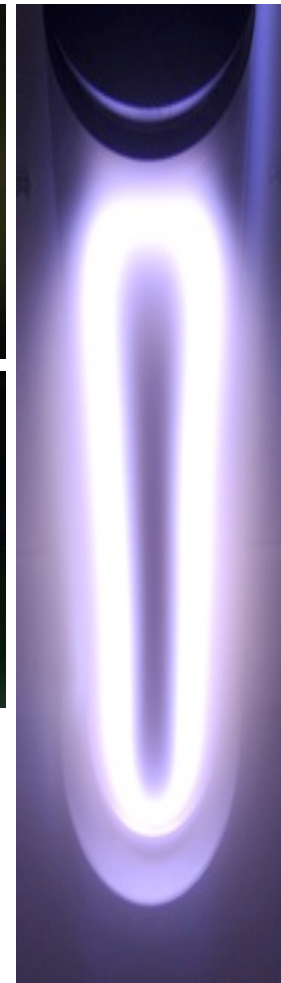
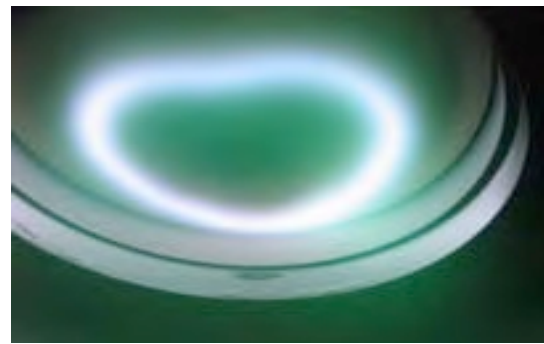
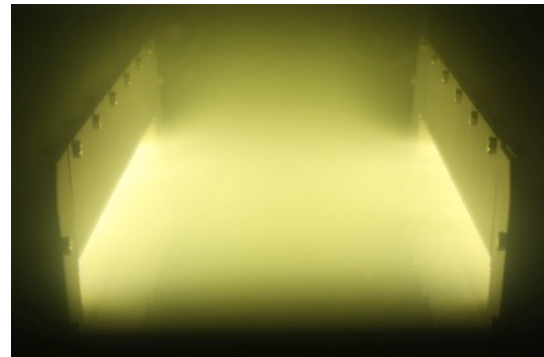
¹Gencoa Ltd., Liverpool, United Kingdom

²IK4-TEKNIKER, Eibar, Spain

23 years of component development and manufacturing from Gencoa



Gencoa plasma design



38 years of research and manufacturing



WHO WE ARE

R&D Centre
(not-for-profit Private Foundation)

Applied research spanning 38 years.

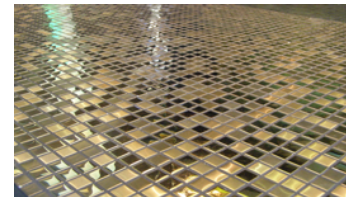
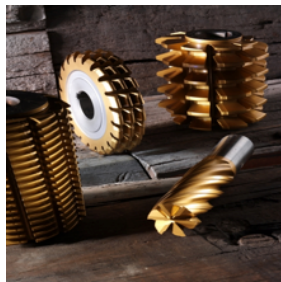
Mission: To enhance the positioning and competitiveness of our clients through technology transfer.

Specialised in **Manufacturing.**

Founder members of the **IK4 Research Alliance.**



- Coatings by PVD... since 1990:
 - ✓ Tribology: tools, mechanical components...
 - ✓ Decorative: ceramic tiles, plastic components, metals
 - ✓ Optics: TCOs, low-E, ophthalmic, solar absorbers, fotovoltaics...



- Technology:
 - ✓ Cathodic arc
 - ✓ Sputtering (HiPIMS, Nanoparticles)
 - ✓ E-beam





OBJECTIVE



High photocatalytic antimicrobial coatings with controlled manufacturing process for touch surfaces.



Outline

- **Introduction**
 - Healthcare Associated Infections data
 - Effect of antimicrobial coatings on bacteria

- **Experimental setup**
 - Samples Memory effect
 - Antimicrobial-Photocatalytic coating
 - Antimicrobial/Biological Testing

- **Results**
 - Topography Effect
 - Chemical Effect

- **Conclusions**

HAls Infections: in US

1 in **20** acquire infection
Your length of stay in the hospital increases by **17.6 days**



5% chance of contracting



1.7million

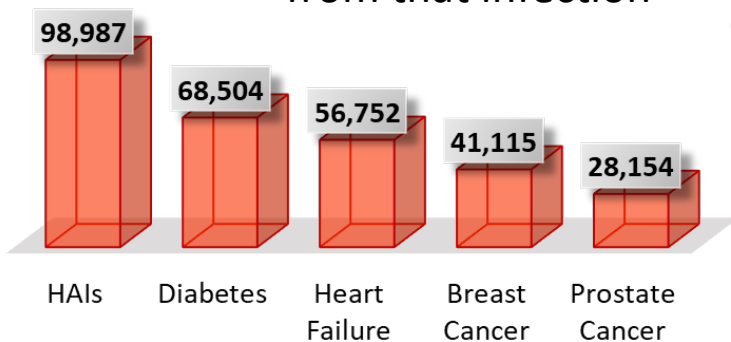
people per year get an infection during the hospital stay

1 in **20** infected die from that infection



~100,000

people in the U.S. die annually by HAls.



HAls kill more people each year than Breast Cancer and Heart Failure combined



leading causes of death in the U.S.

HAls Infections cost in US



9.5% of total inpatient cost are HAI-related > 2/3 of HAIs affect people with Medicare or Medicaid

- Society:

\$20-40 billion/yr.....



- Patient:

\$1,100 per admission.....



Healthcare associated infection sources

Did you know that 80% of infectious diseases are transferred by touch?



Infection Sources

Touch Surfaces

HAIS



Microorganism transfer



Applications for contaminated public touch surfaces

DESK

The desk is one of the least hygienic places in the office and transfers a lot of germs.

RISK FACTOR



KEYBOARD AND MOUSE

Sharing desk equipment greatly increases your risk of becoming infected by other people's germs.

RISK FACTOR



Desk areas have **400 times more bacteria** than toilet seat.



MICROBIOLOGICAL ACTIVITY is 18% higher in **HOT-DESKING** areas.



The average desk harbours 400 times more bacteria than the average toilet seat.



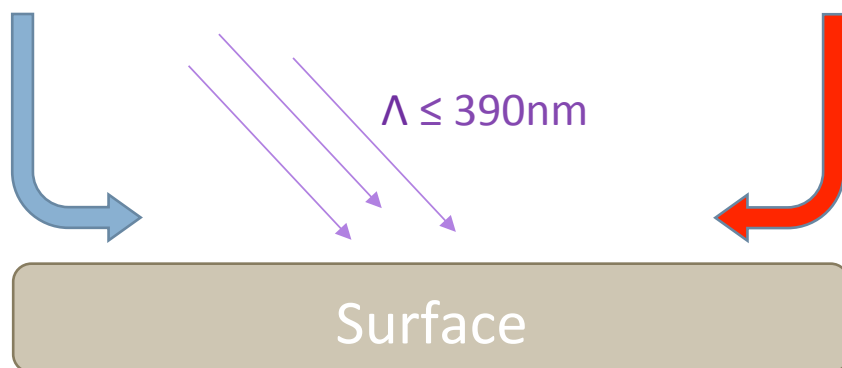
Microbiological activity is 18% higher in hot-desking areas.

Photocatalytic Coating

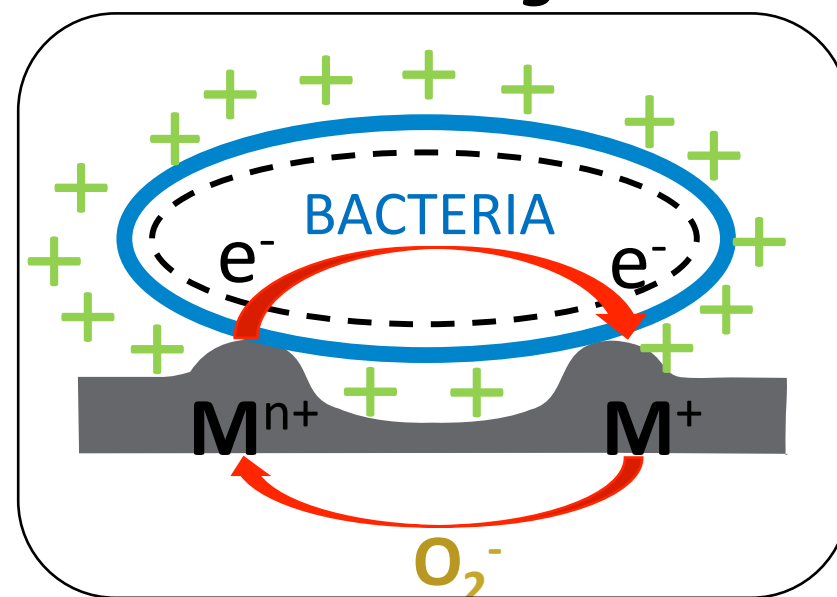
REDUCTION



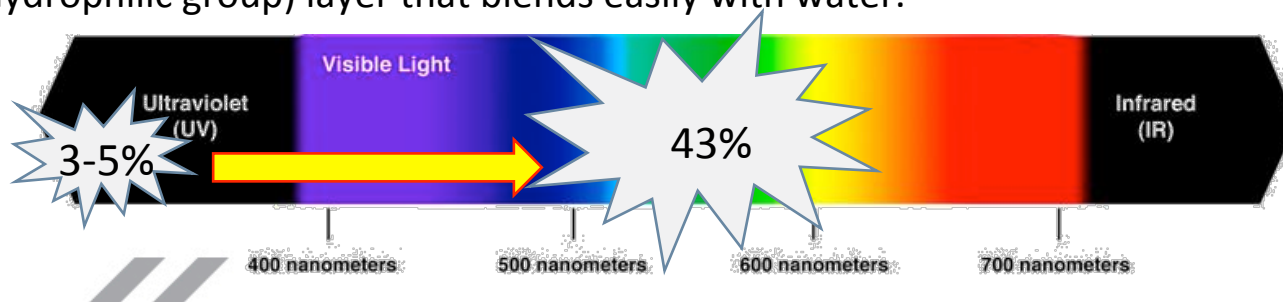
OXIDATION



Cell-damage



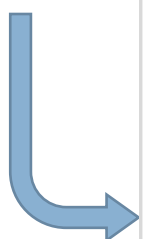
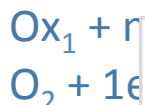
When coating is exposed to **light**, produces reactive **oxygen** species which cause cell-damaging and **hydroxyl** (hydrophilic group) layer that blends easily with water.



Photocatalytic Coating

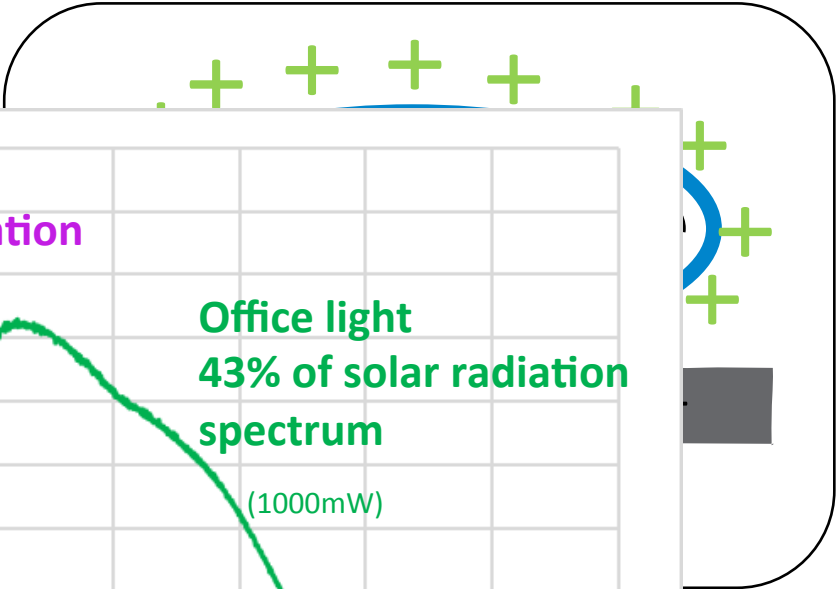
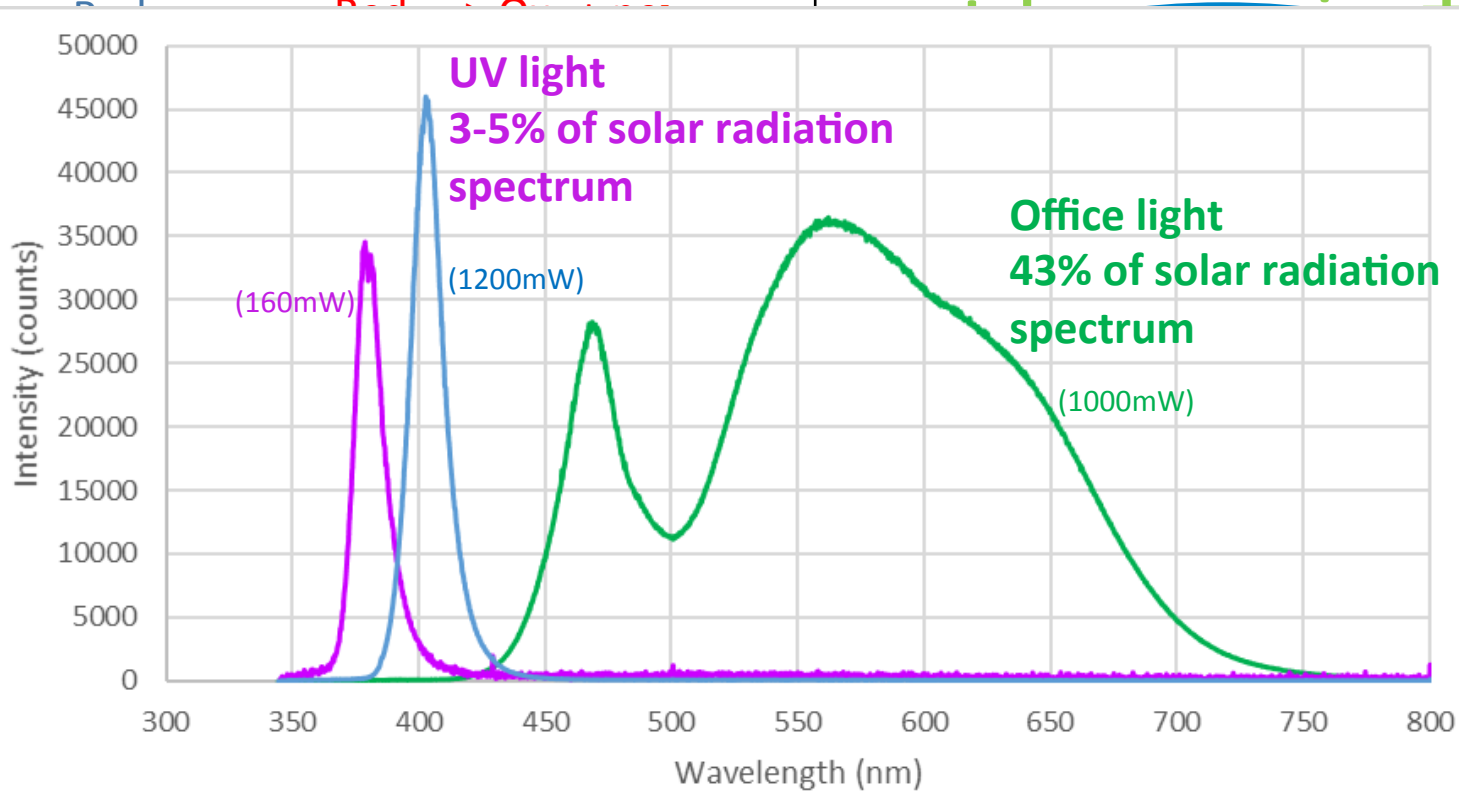
Cell-damage

REDUCTION



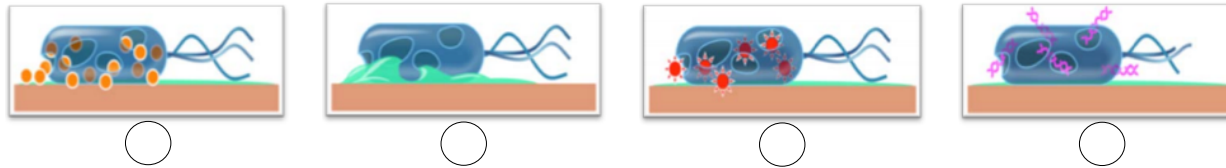
When
hydrated

OXIDATION



g and

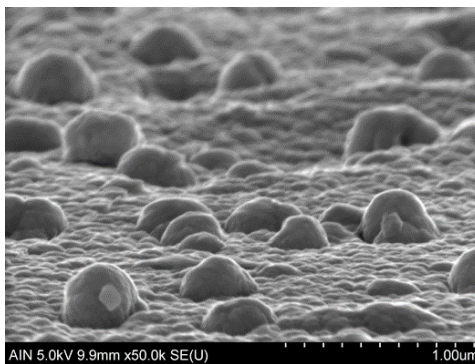
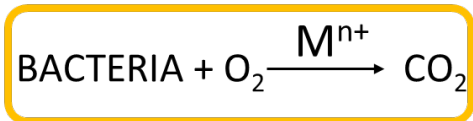
- Chemistry Mode of Action



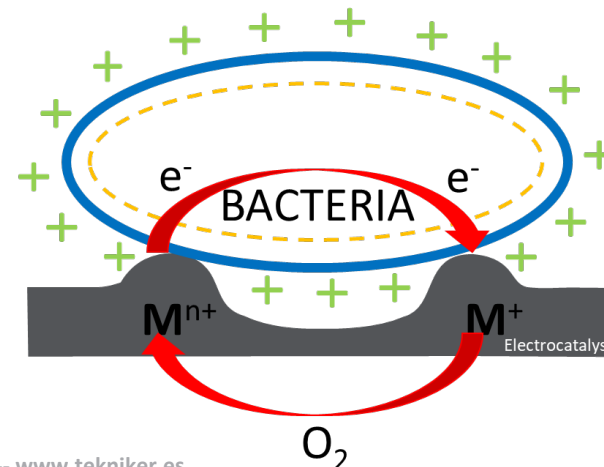
1. Material dissolves and causes cell damage.
2. Cell membrane ruptures.
3. Oxidative stress (further cell damage)
4. Bacterial DNA degradation (no resistance path)

** Dr. Grass, Dr. Keevil, Dr. Rensing & Dr. Solioz*

- Topography Mode of Action

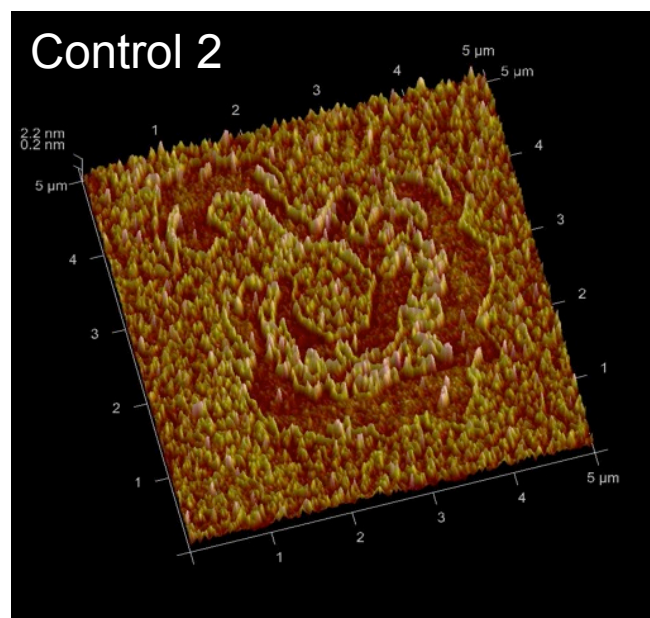
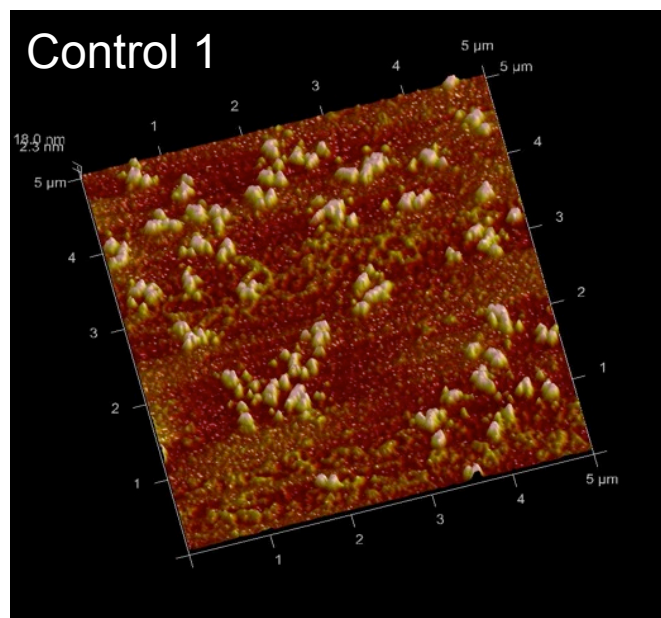
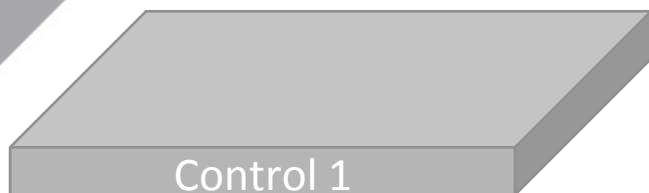


The electrocatalyst helps to “oxidize” the microbe.



Experimental Setup - Memory effect

AFM – 3D Contact Mode Topography



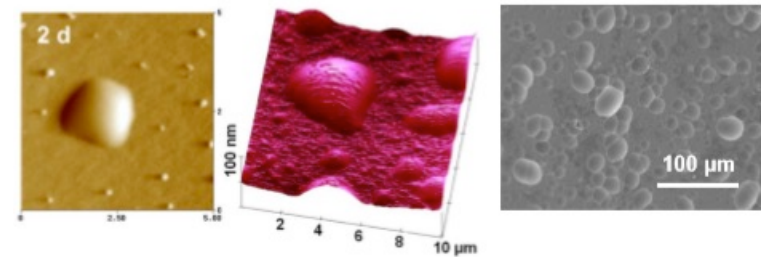
(0.16-0.19mm Thick,
22x22mm)



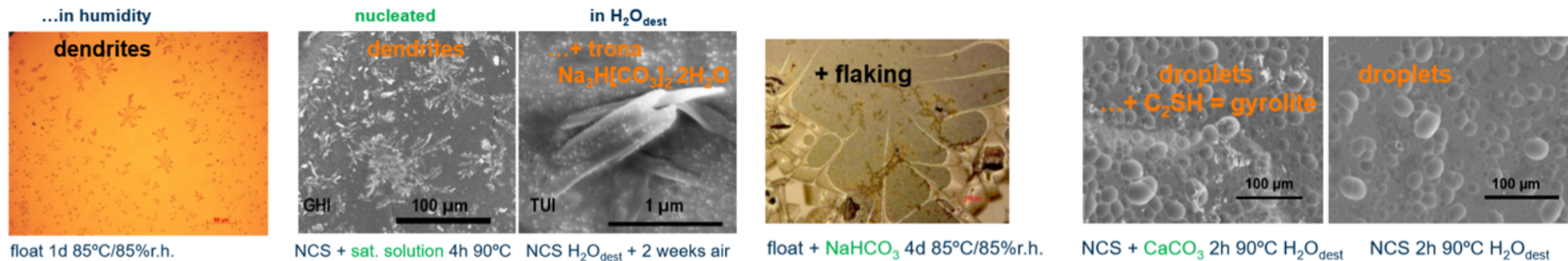
AFM on coated (less than 5nm) glass slide contact mode. The surface profile is very influenced by the **topography** of the **substrate**. Different glass slides have different “memory”. In order to have reproducibility, the “memory” should be removed.

Glass surfaces are ever changing:

- well-known layer formation
- well-known dependency on conditions:
 - ✓ acid–neutral –caustic water–humidity
 - ✓ gases: CO_2 , SO_3 , organics



Examples:

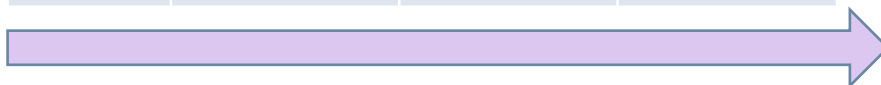


Delamination

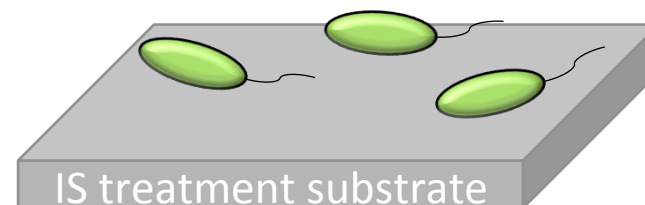
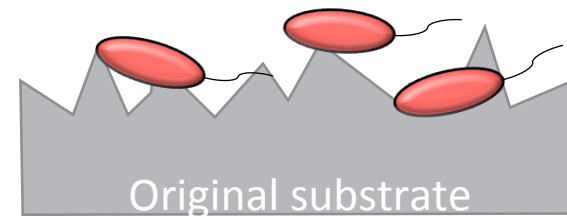
Experimental Setup - Memory effect

Cleaning effect of Ion source treatment on glass surfaces

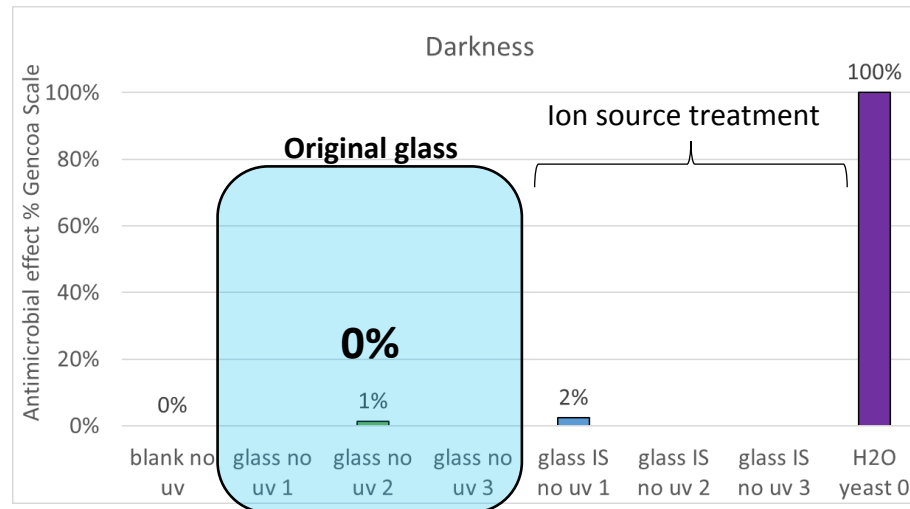
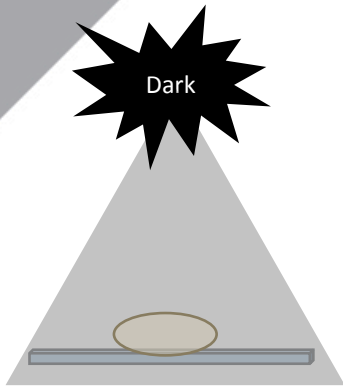
Ion Source Treatment Conditions			
Time	Gas	Current, mA	Voltage, kV
5 min	70 Ar : 30 O ₂	100	2.0
30 min	Ar	50	2.0



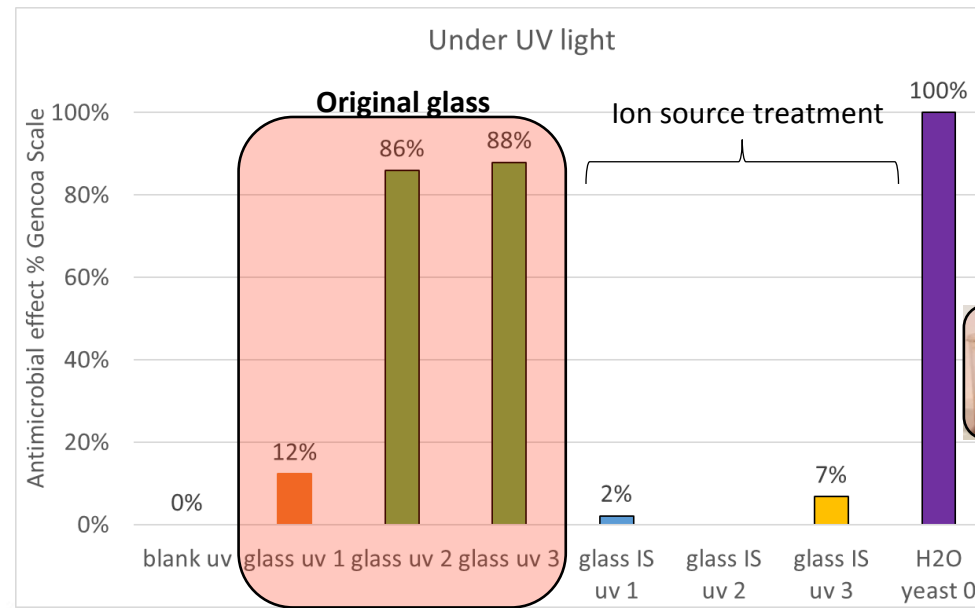
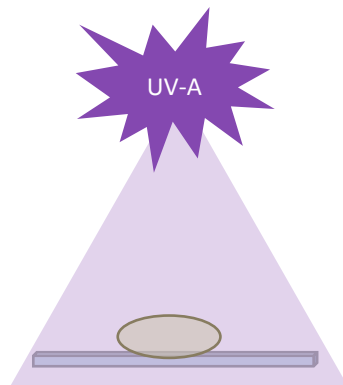
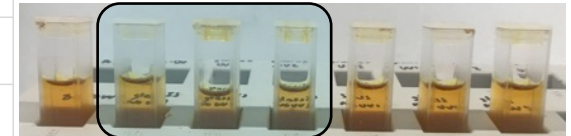
In order to avoid any interference on antimicrobial measurements, erasing any memory effect.



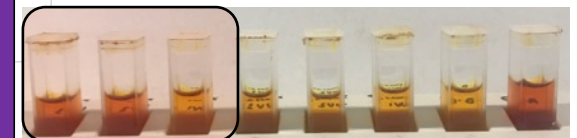
Antimicrobial effect of glass cover Slips before coating deposition



No antimicrobial effect

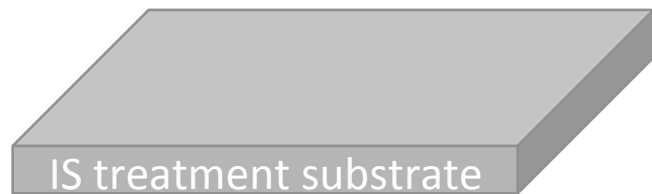


Log 5-6

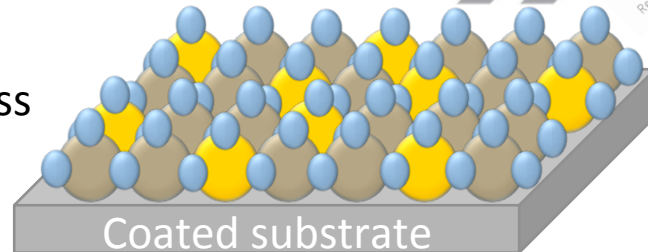


Experimental Setup – Antimicrobial & Photocatalytic Coating

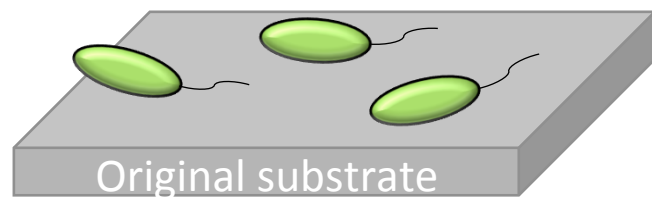
Surface Coating Technology applied as Infection Control



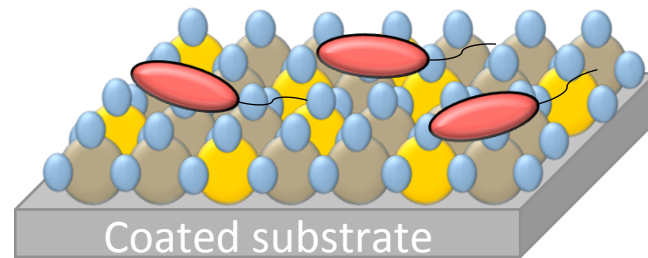
PVD Process



Add microorganisms



Add microorganisms



Microorganism alive
(E.coli, S.aureus...)



Dead microorganism



Doping
metal material



Base material
Ti-based alloy



Reactive gas
O₂





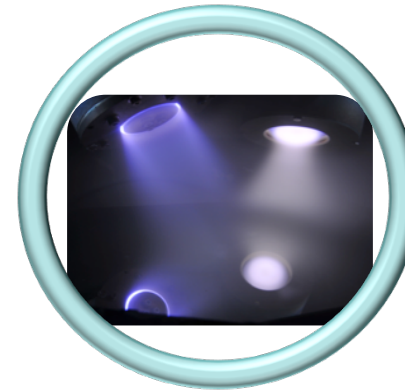
Step 1

High Vacuum
Background $\sim 10^{-6}$
mbar



Step 2

Substrate cleaning
Ion Source **IM300**
Used for coating
adhesion



Step 3

Adhesion Layer
IM300 & Magnetron
To maintain clean
substrate surface



Step 4*

Active Coating
Magnetron
Speedflo
Fibre Optic

Step 4*



Where do you want to work?

OPTIONS

- Poisoned mode
- Metal mode
- **Oxide mode**

SELECTION

TiOx
(Oxide mode)

CONTROL

Half of the oxide mode
In this case ~30% O₂

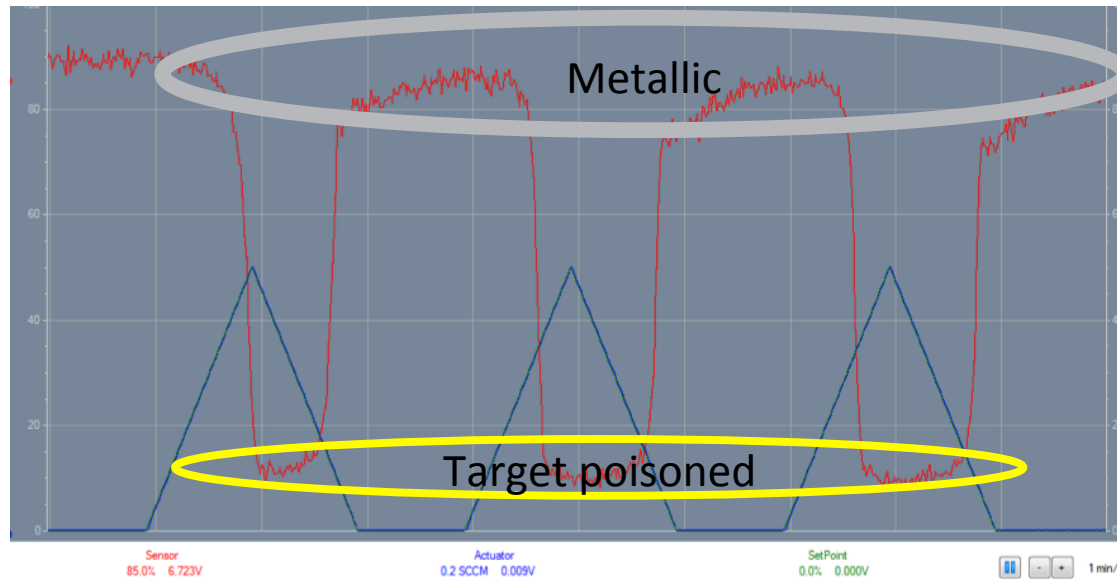
Hysteresis of Ti target with O₂ reactive gas

Metallic area

Oxide area

Working area

Poisoned area



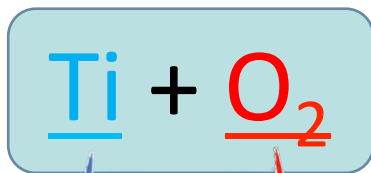
- Titanium 501nm
- O₂ gas setpoint

For the process
30% O₂ in
sensor(inverse*)
mode



Control Options by Gencoa

Control by Plasma



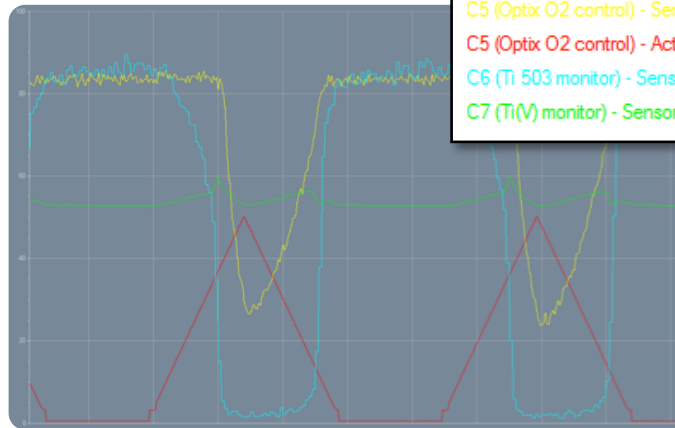
501nm 777nm



Control by pumping exhaust



C5 (Optix O2 control) - Sensor
 C5 (Optix O2 control) - Actuator
 C6 (Ti 503 monitor) - Sensor
 C7 (Ti(V) monitor) - Sensor



Penning-PEM

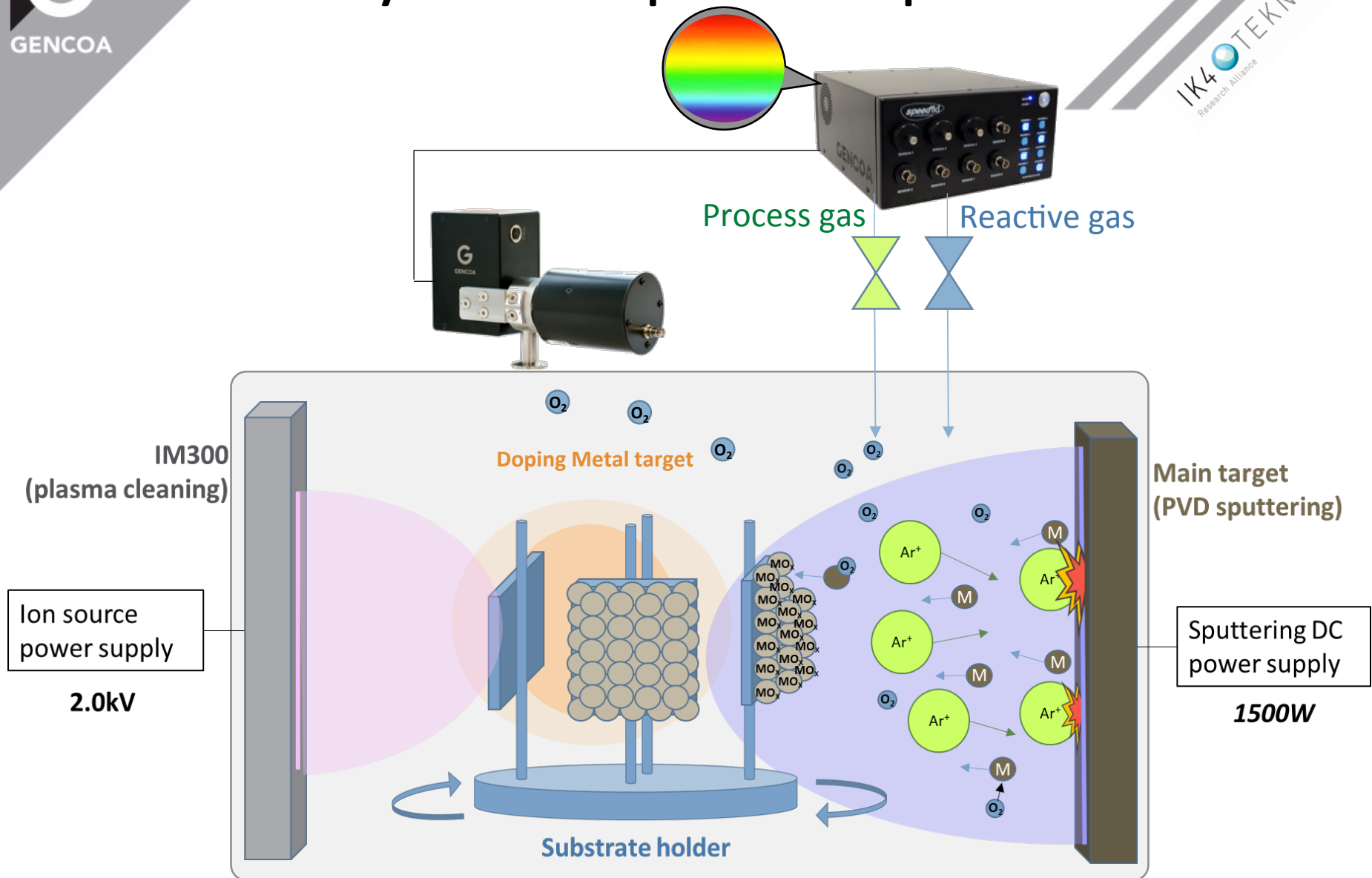


OPTIX

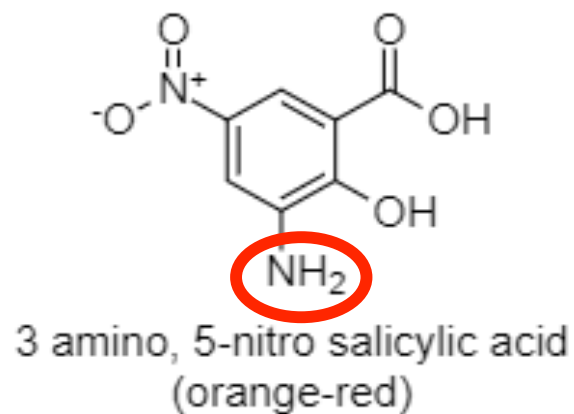
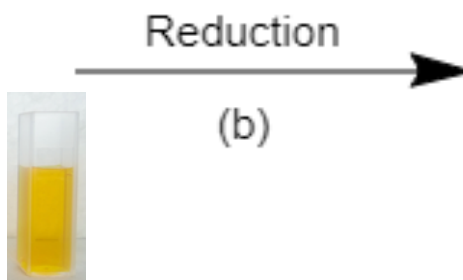
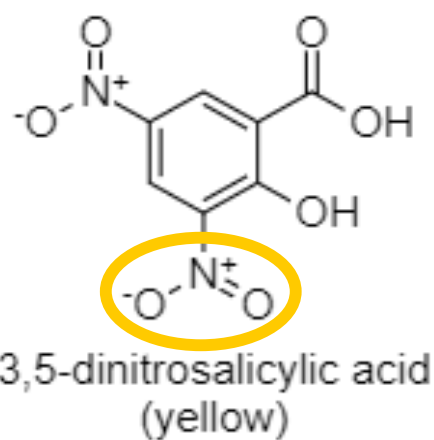
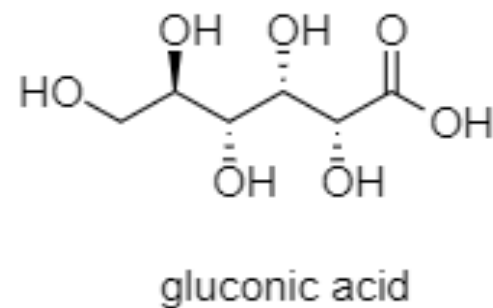
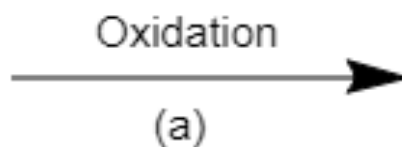
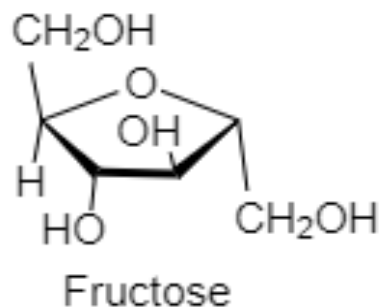
V

Fibre

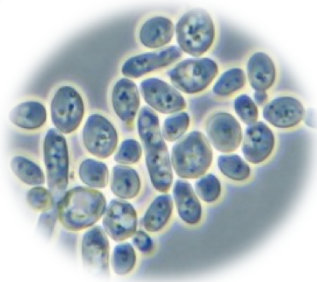
Physical Vapour Deposition



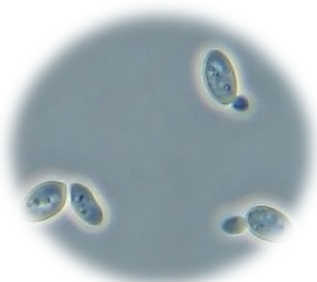
Antimicrobial Miller Test



Antimicrobial level assessment



NO ANTIMICROBIAL
More microorganisms – Less Fructose



ANTIMICROBIAL
Less microorganisms – More Fructose



CCD Spectrophotometry (Absorbance)

The spectroscopic methods would allow a higher precision on the concentration of fructose.

$$A = \log \left(\frac{I_0}{I} \right)$$

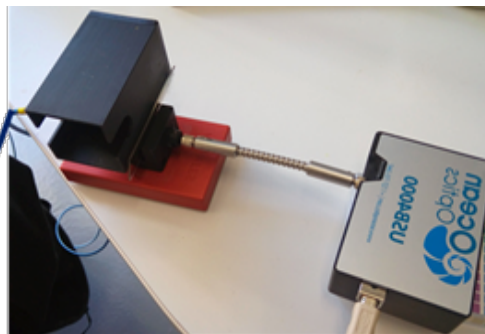


I_0 = intensity of the light entering the sample

I = intensity of the light leaving the sample

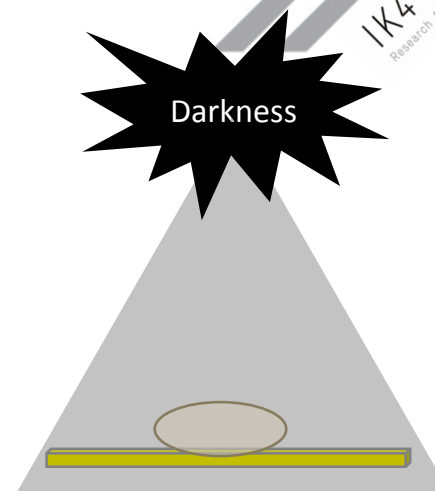
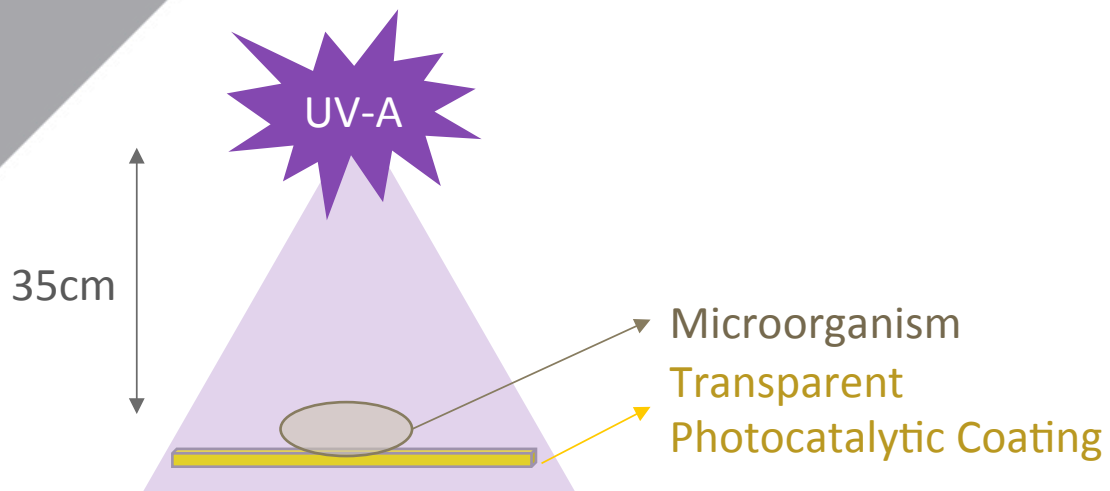


Ocean Optics
(Halogen Lightsource HL-2000)

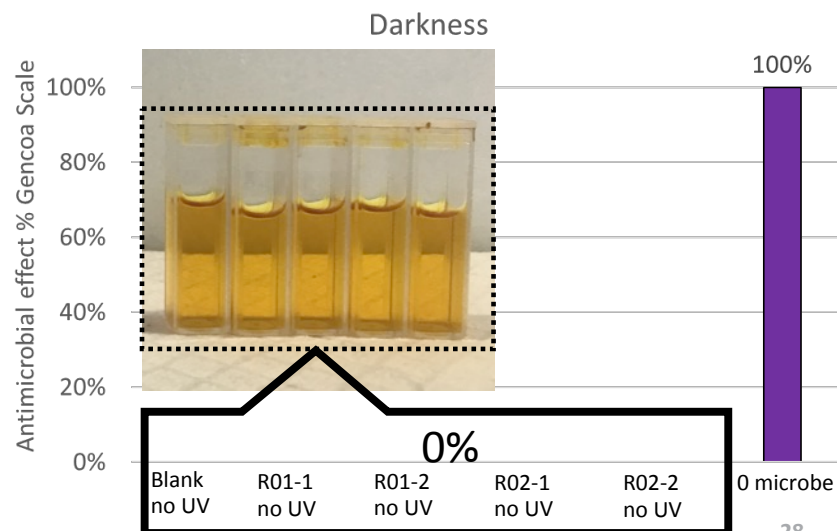
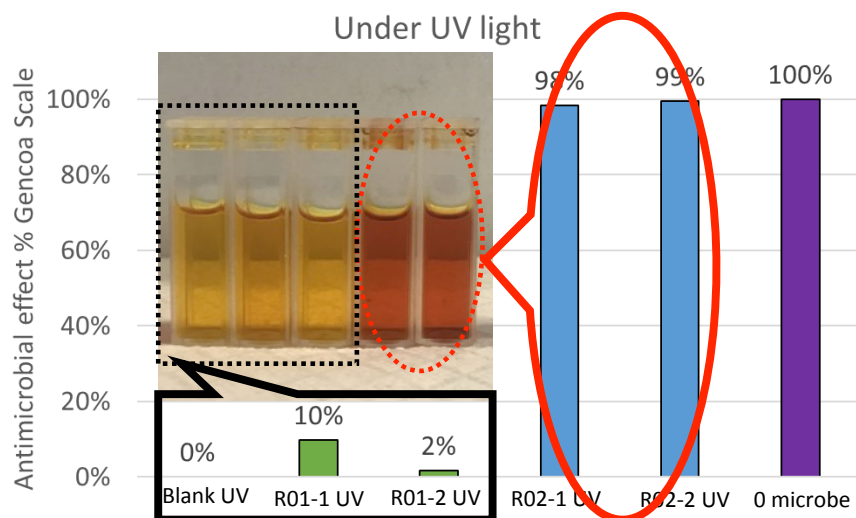


Ocean Optics USB4000 spectrophotometer
+ AVANTES cuvette holder

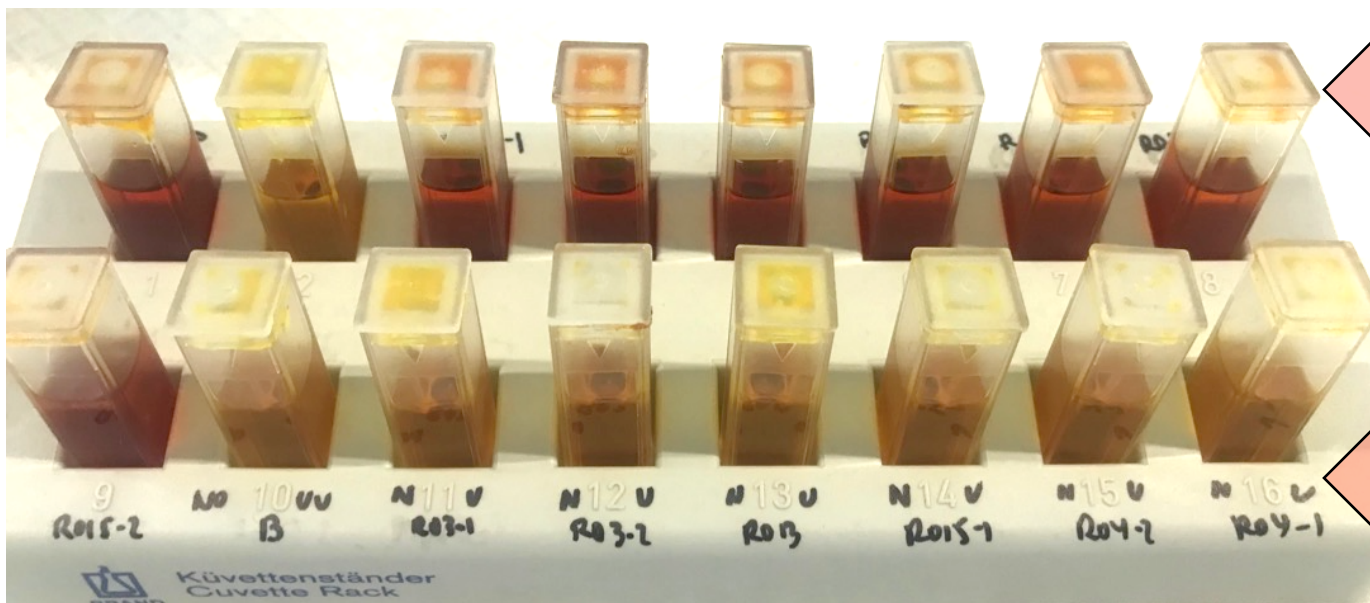
The **absorbance** measured using a UV-Vis spectrophotometer is **directly proportional** to the amount of **reducing sugar**. (Adney and Baker, 1996)



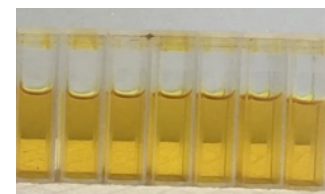
Analyse solution absorption by **CCD Spectrophotometry**



Topography and chemical antimicrobial effects

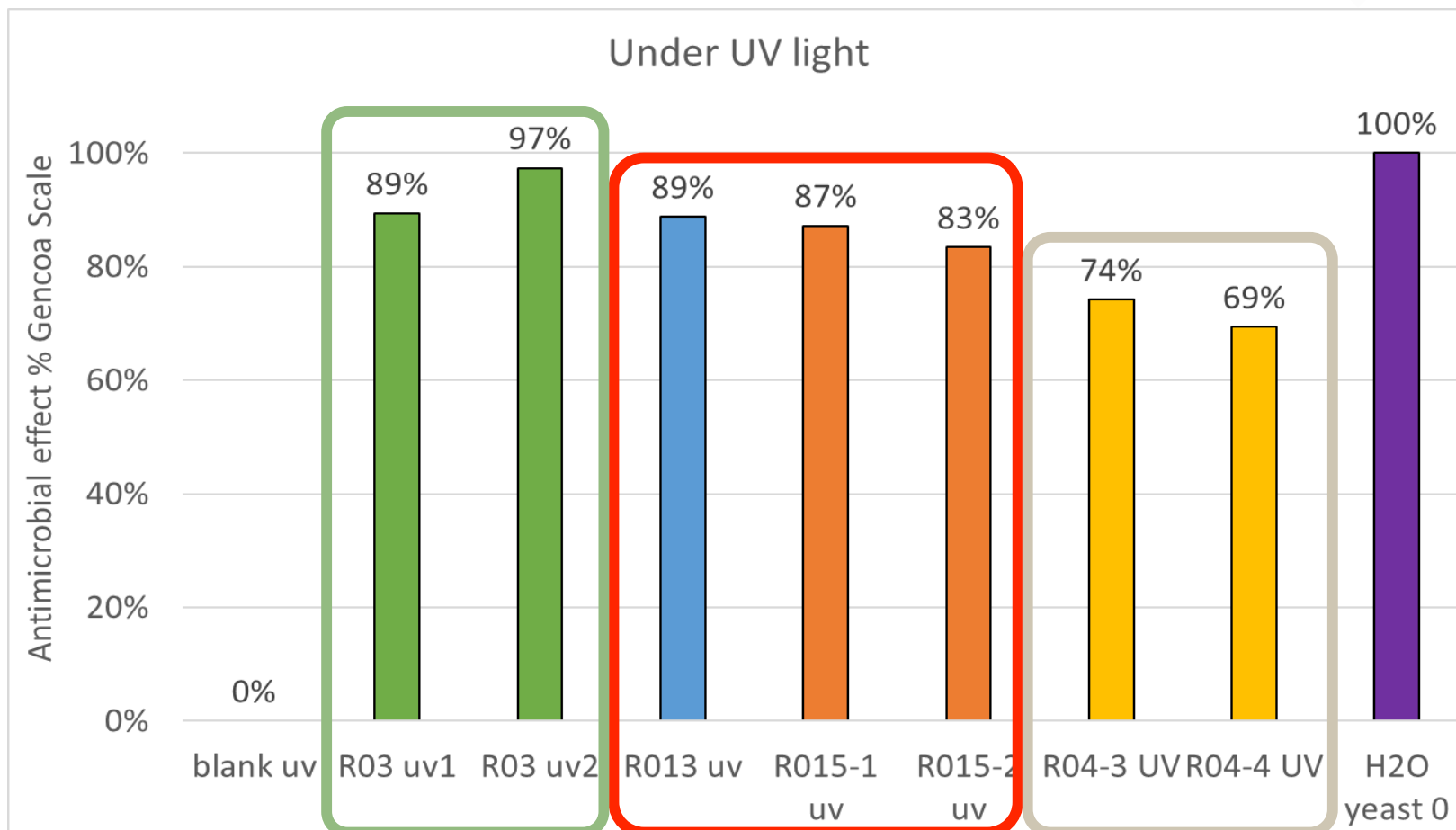


Reaction under UV light



Reaction under darkness

Topography and chemical antimicrobial effects



Thin transparent

Strong topography

Topography & transparent

Conclusions

- A reliable method for quantifying antimicrobial photocatalytic surface activity has been developed.
- Successful photocatalytic antimicrobial activity has been created on surfaces with strong topography and smooth topographies.
- High photocatalytic coatings with controlled manufacturing process.
- Substrate effects could affect photocatalytic response, and it would always be necessary to remove that memory from the material in order to have a consistent surface response.
- Main research has been conducted using UV. Some positive results using VIS light will be presented in the future.