University of Rome "Tor Vergata"
Department of Industrial Engineering
Technology and Manufacturing Systems
Fabrizio Quadrini, PhD

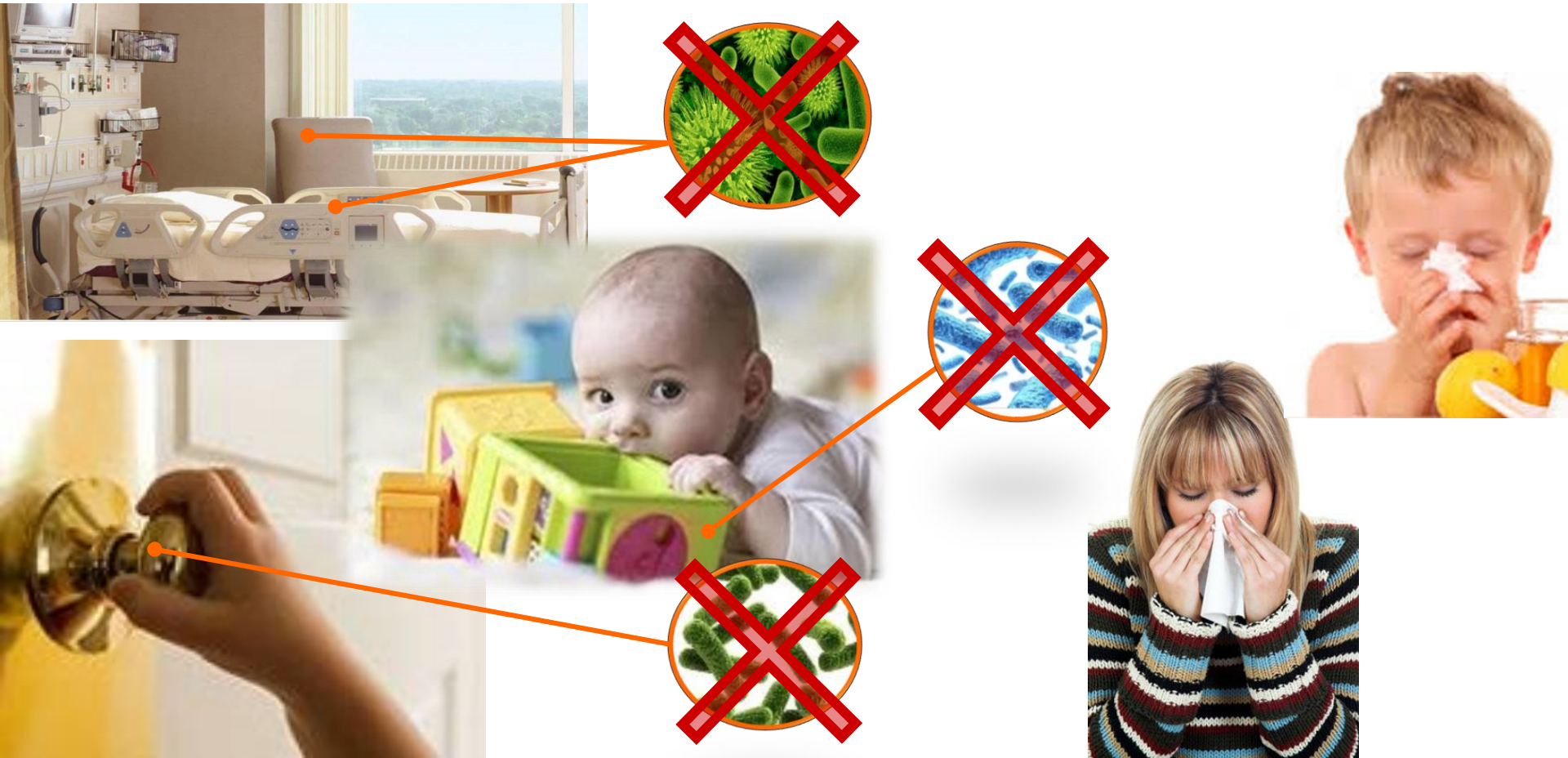
Nano Innovation 2016
Rome, 20-23 September
Conference & Exhibition

Nano-coating fragmentation for organic nano-composite production

TS.VIII.F.2

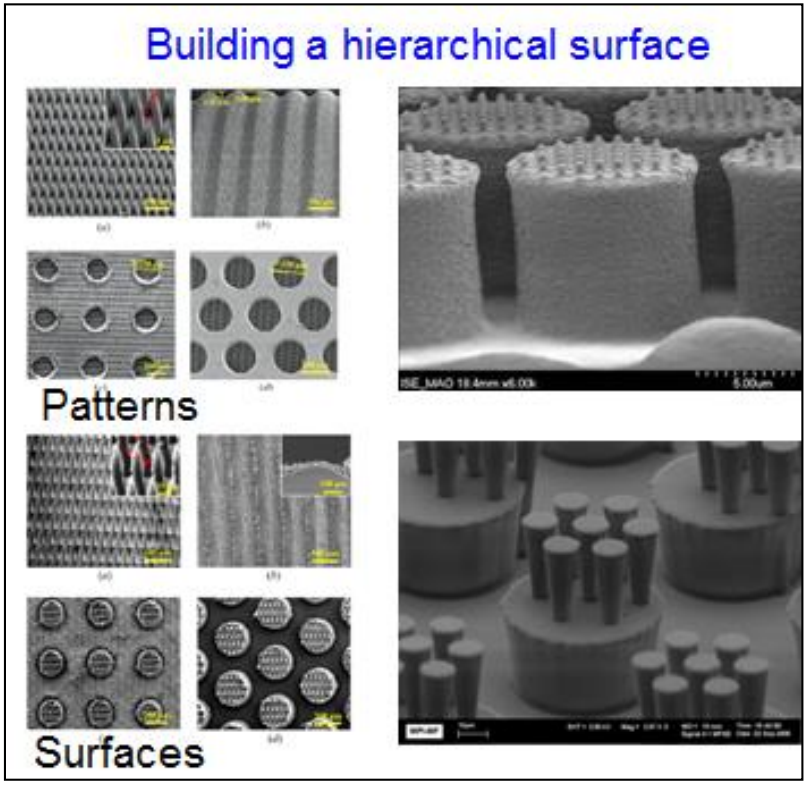
The aim

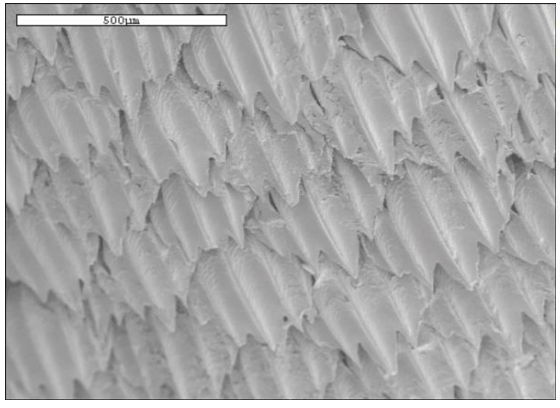
- Bacterial contamination of surfaces is a risk for health and society
- New technological solutions for anti-bacterial surface
- Making a common plastic object an antimicrobial object
- Inhibition or prevention of bacteria colonization

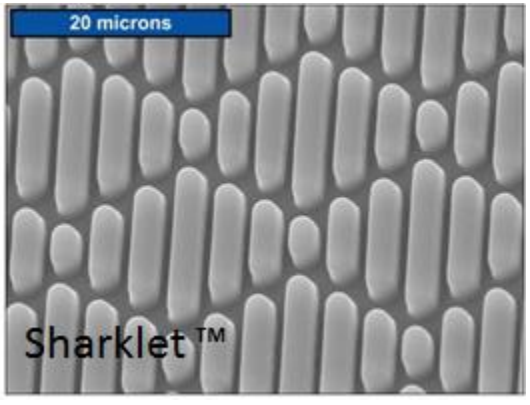


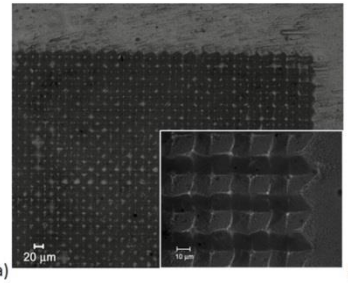
State of the art

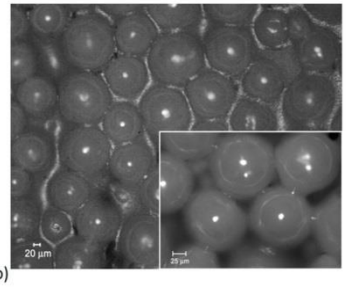
- Many different solutions and many different approach (bio-activity, release system)
- Optimal surface morphology:
  - Hierarchical surfaces
  - Durability
  - Mold manufacturing
- Additives:
  - Silver is the most famous and popular agent

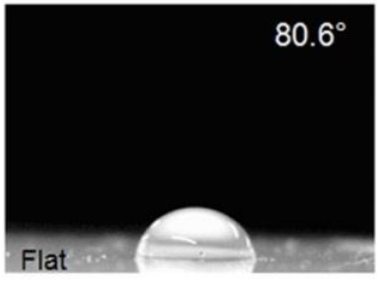


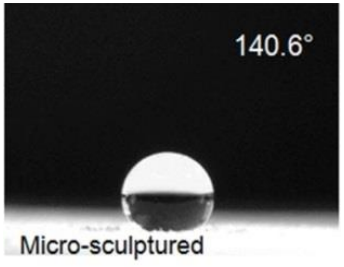


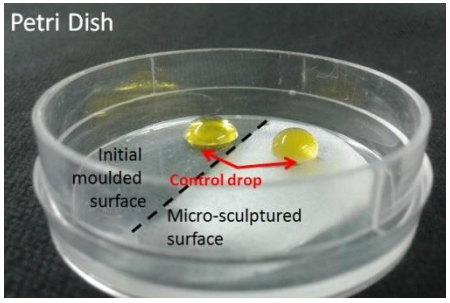










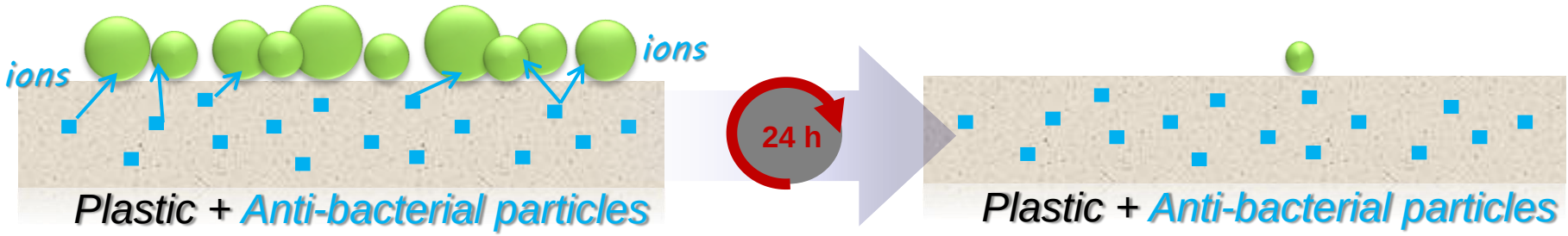


- Ag used from old Greeks (before discovery of bacteria)
- Silver compounds impede the growth of 650 bacterial strains
- Active systems
  - Salts: release into environment
  - Metallic particles
  - Micro and nano-scale
  - Secondary effects (e.g. color)

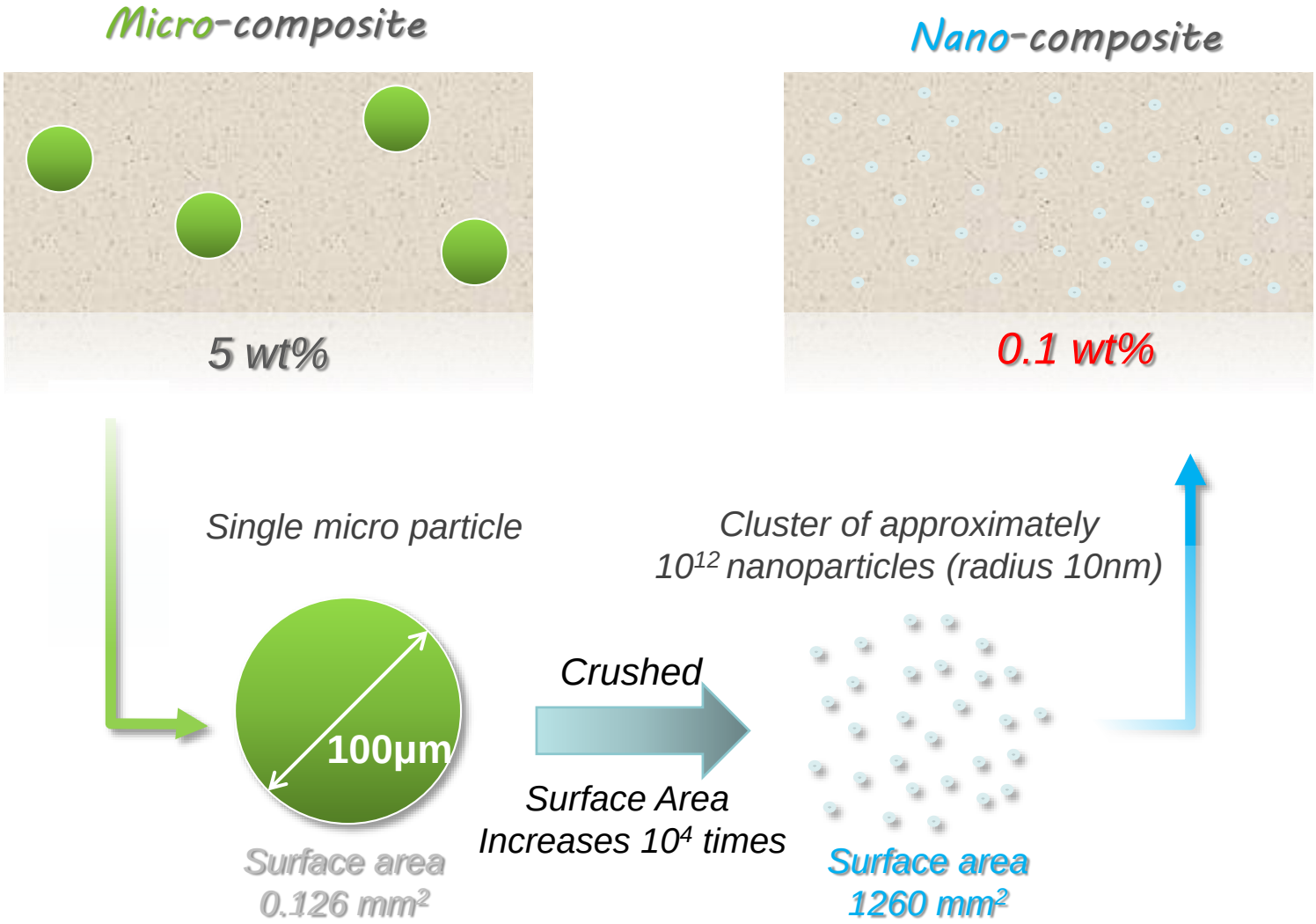
Clariant BASF NANUP 晋大科技 HPC Srl

$Ag_{0.18}Na_{0.57}H_{0.25}Zr_2(PO_4)_3$

Active Surface

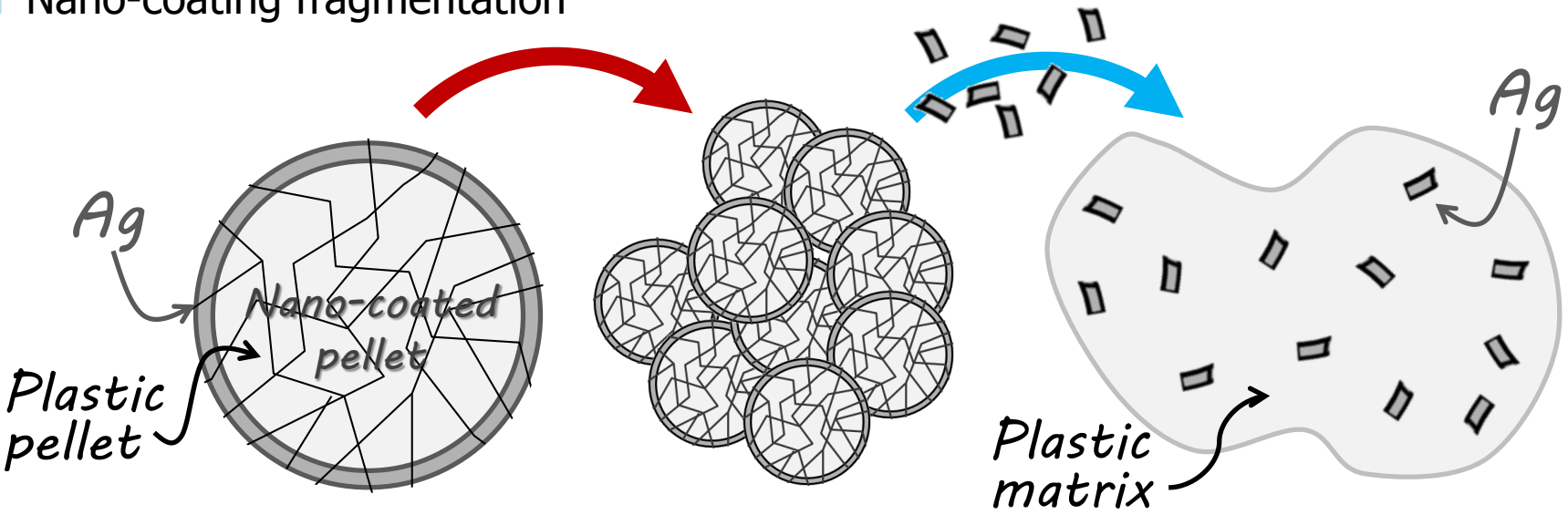


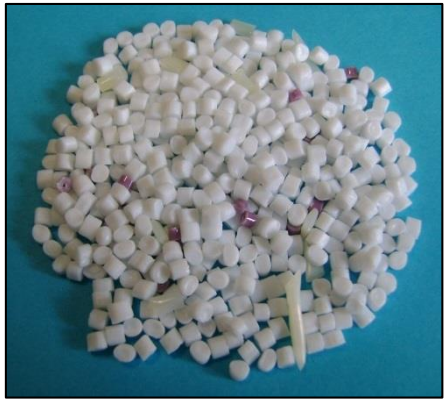
- Costs
- Health issues

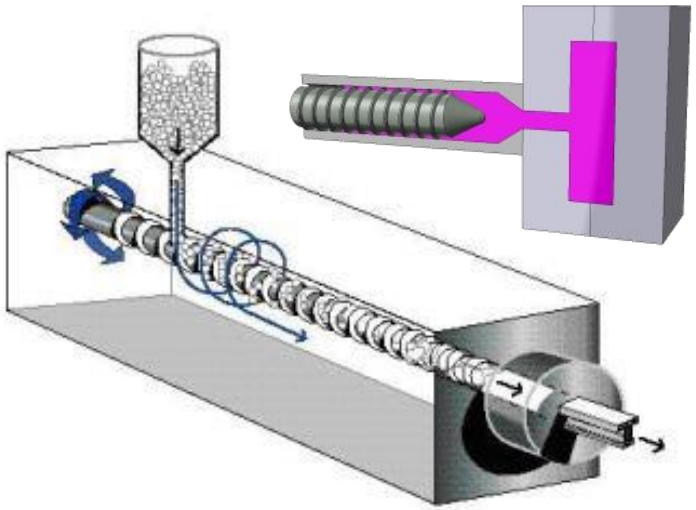


The innovation

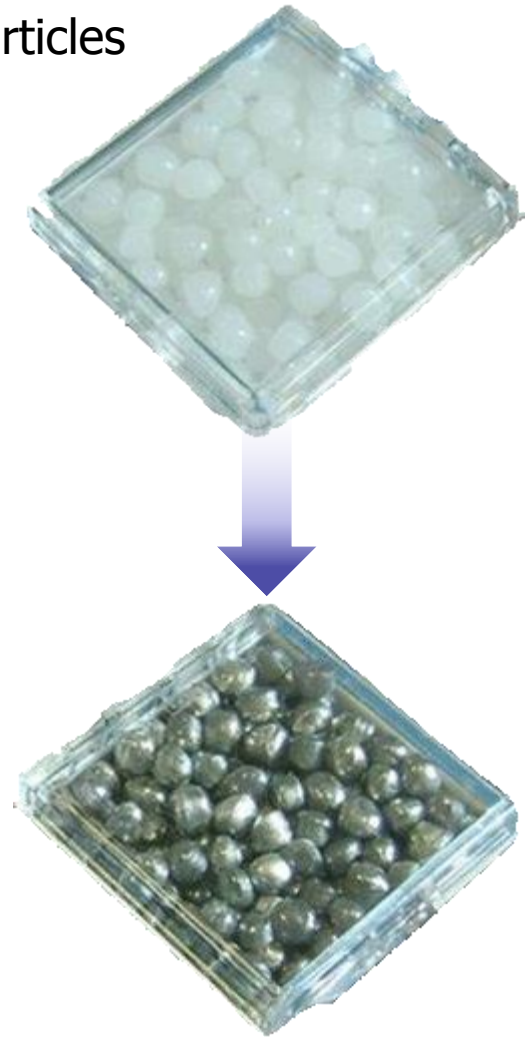
- Nano-coating fragmentation

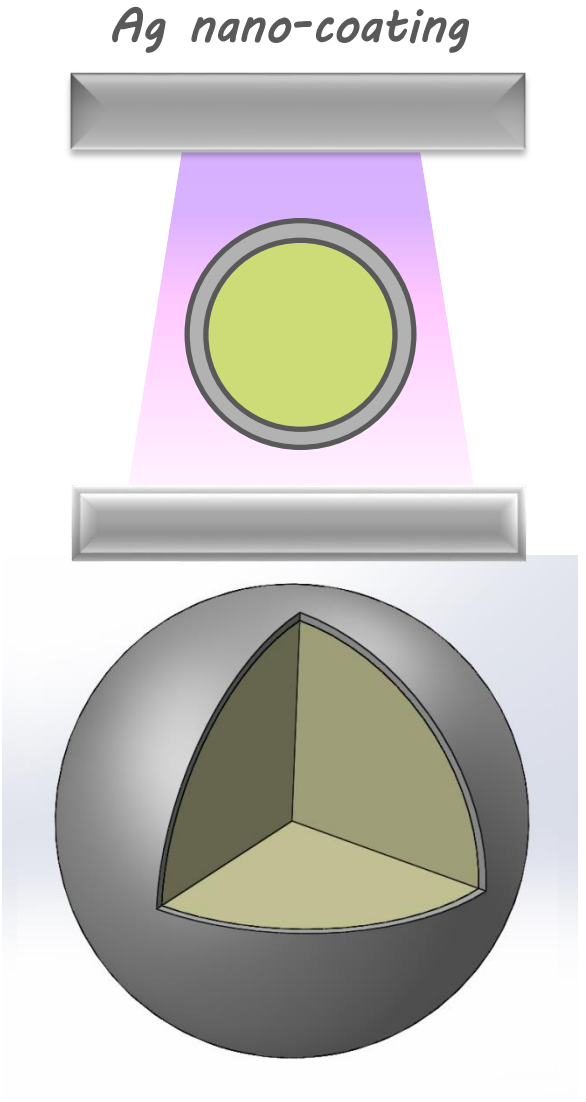






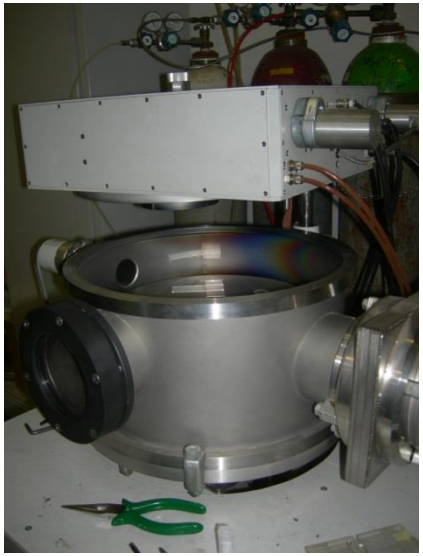
- PVD coating
- No contact with nano-particles
- Low cost
- High compatibility
- Nice aesthetics
- 100 nm on 2mm pellet leads to 0.33 wt%

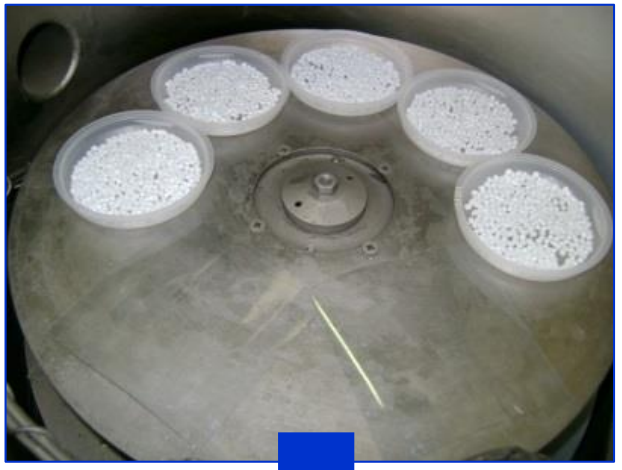




Experimentation: prototyping

- PP (PPRO-A01, Atofina)
- PVD with Ag target (99.99%)
  - Pre-vacuum 1.7 × 10^{-5} mbar
  - 35-40 °C temperature
  - DC 180 W, 8 min, Ar (4 Pa)
  - Single layer (
- Mixing
  - Batch mixer
  - 180°C, 50 rpm, 15 min
- Molding
  - Compression (200°C, 1 bar, 5 min)

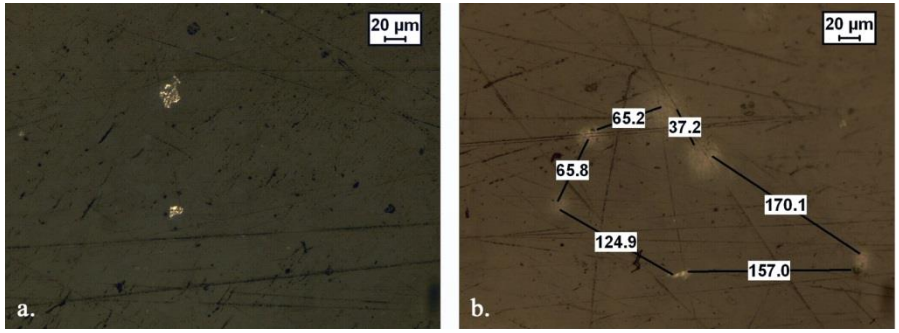




Experimentation: testing

- Content and microscopy
- ISO22196: 2007
  - Plastics measurement of antibacterial activity on plastic surface
  - Staphylococcus aureus, ATCC 6538
  - Escherichia coli, ATCC 8739
  - Colonies forming unites (CFU)

Test	Ag content, wt%
1	0.19
2	0.18
3	0.16
4	0.17
5	0.17
6	0.18
7	0.19



$$R = (U_t - U_0) - (A_t - U_0)$$

U_0 = average of the common logarithm of the number of viable bacteria, in cells/cm2, recovered from the untreated test specimens immediately after inoculation;

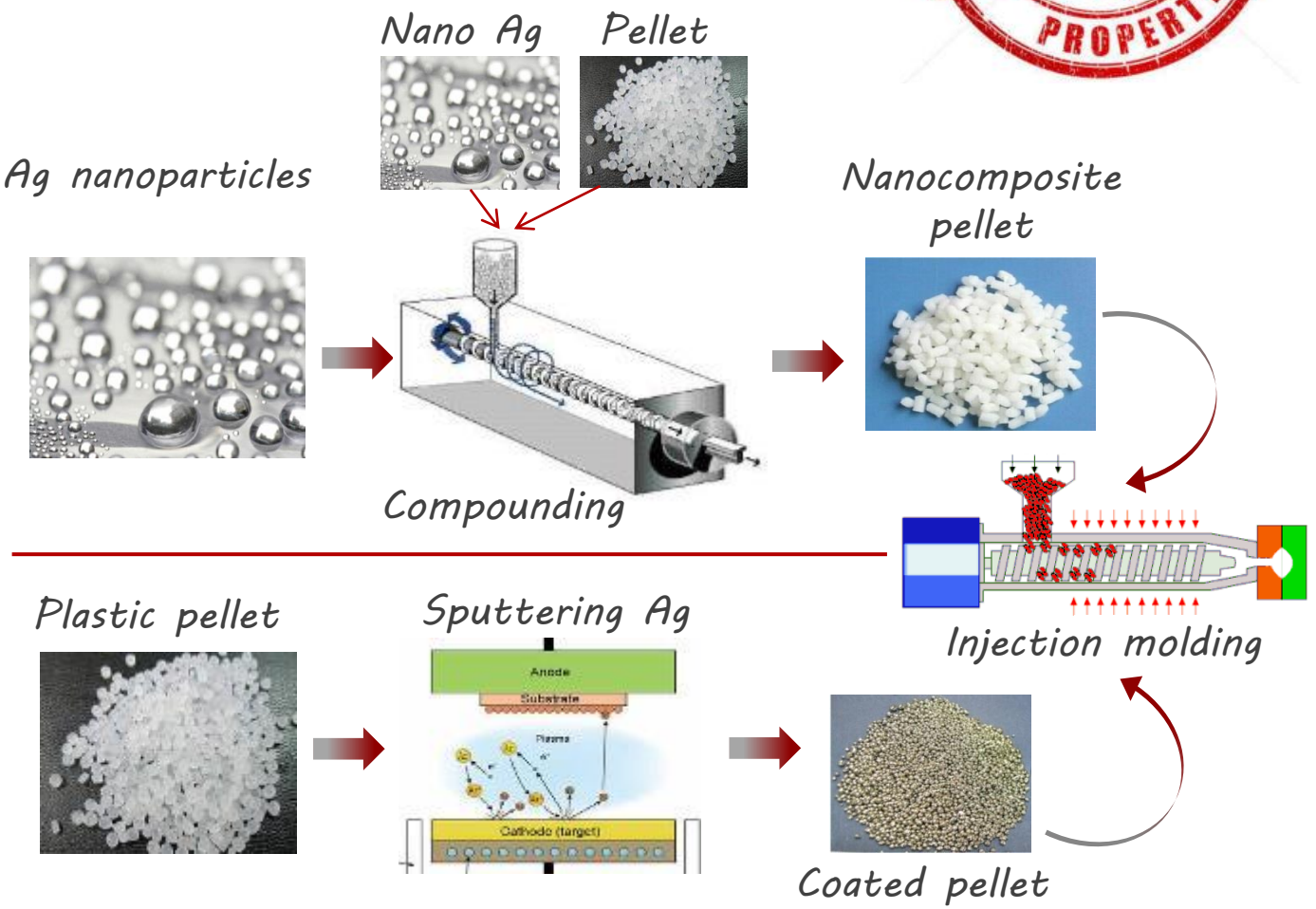
U_t = average of the common logarithm of the number of viable bacteria, in cells/cm2, recovered from the untreated test specimens after 24 h

A_t = average of the common logarithm of the number of viable bacteria, in cells/cm2, recovered from the treated test specimens after 24 h.

Sample	CFU/cm² after 24h				
PP	257				
PP-Ag	4				
Polymer	Time	U_0	U_t	A_t	R
PP	T0	5.4			
PP	T24		2.4		
PP-Ag	T24			0.6	1.8

Conclusion

- Many possible applications of NCF
- Revolution in TP matrix nanocomposite production

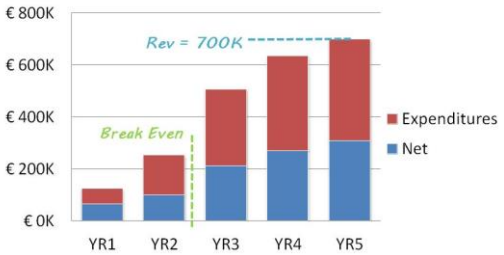


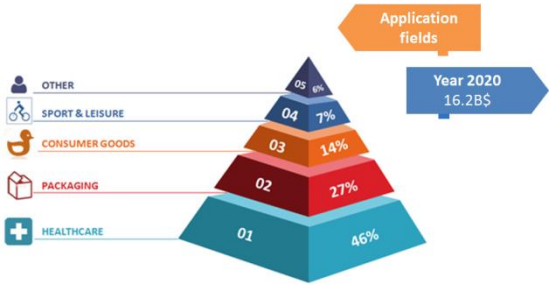
The future

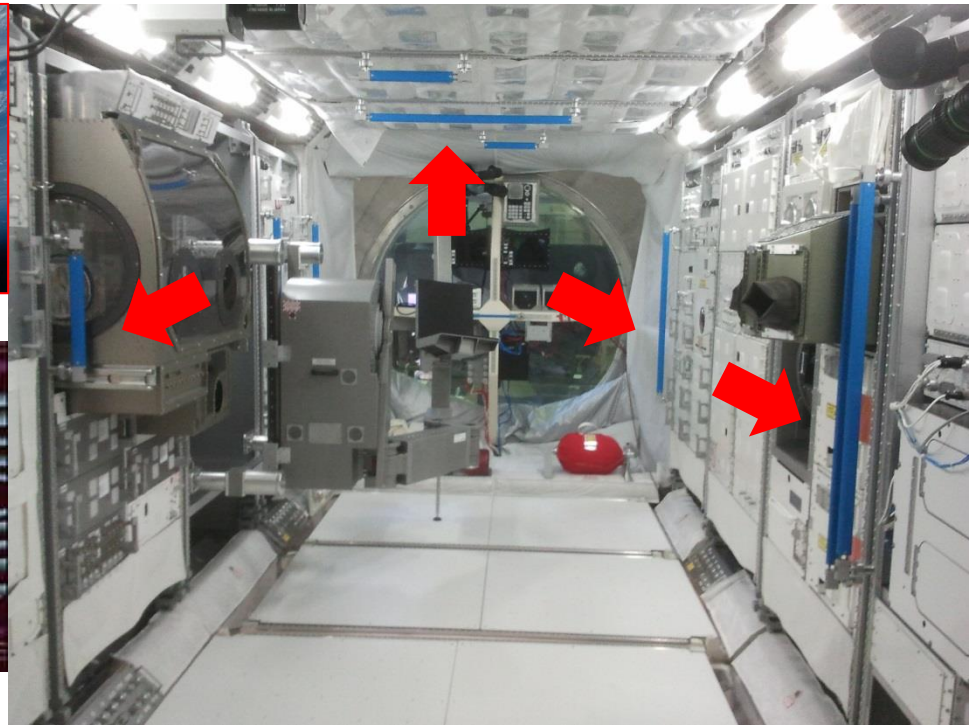
- Laboratory research
- University spin-off
- Materials for Space

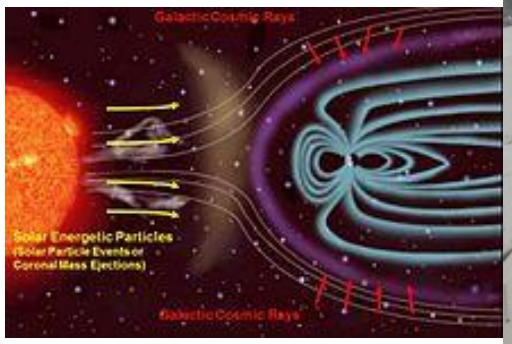
Safe-Surface

LIPI









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THERMEC'2016
International Conference on
PROCESSING & MANUFACTURING OF ADVANCED MATERIALS
Processing, Fabrication, Properties, Applications

May 29 - June 3, 2016
GRAZ, AUSTRIA

Anti-bacterial nanocomposites by silver nano-coating fragmentation

Invited