SURFACES, INTERFACES AND COATINGS TECHNOLOGIES INTERNATIONAL CONFERENCE
SICT 2023
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Superhydrophobic bio-inspired micro-architectured stainless steel surfaces

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Université de Lille

UMET Unité Matériaux Et Transformations

INRAE

Summary

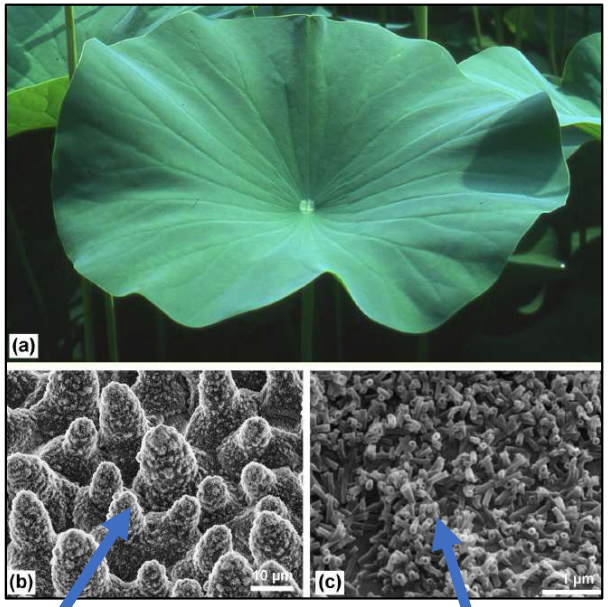
1. Context
2. Microtexturing: 3D printing & casting process
3. Nanotexturing: atmospheric pressure plasma
4. Wettability
5. Conclusion

JF3

Context

Industrial issue :

Bio-inspired architecture :



Microarchitecture

Nanoarchitecture

Purpose of this work :

→ Creating a superhydrophobic bio-inspired textured stainless steel surface

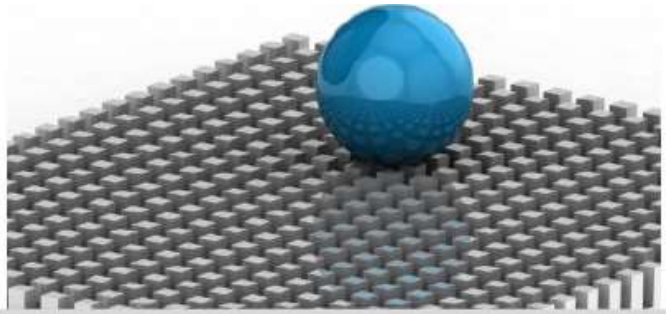
Sharma et Machietto, Fouling and cleaning of plate heat exchangers: Dairy application (2020)
Ensikat et al, Superhydrophobicity in perfection: the outstanding properties of the lotus leaf (2011)

Diapositive 3

JF3 On pourrait y ajouter qqchose en image

Jerome FREMIOT; 01/07/2022

Context and Concept



Superhydrophobic metals

Roughness creation on the metallic substrate
TOP-DOWN

Dry methods

Wet methods

Electrochemical methods

Superhydrophobic layer deposition
BOTTOM-UP

Spay coating

LBL

Plasma deposition

Sol-gel

Electrospinning

Mould the microtexture at the same time as the substrate

+

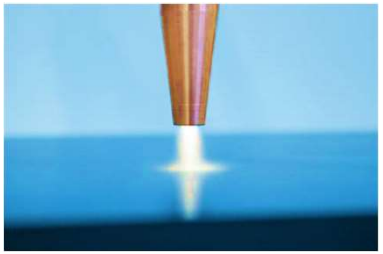
Addition of a nanotexture

Ellinas et al, A Review of Fabrication Methods, Properties and Applications of Superhydrophobic Metals (2021)

Concept

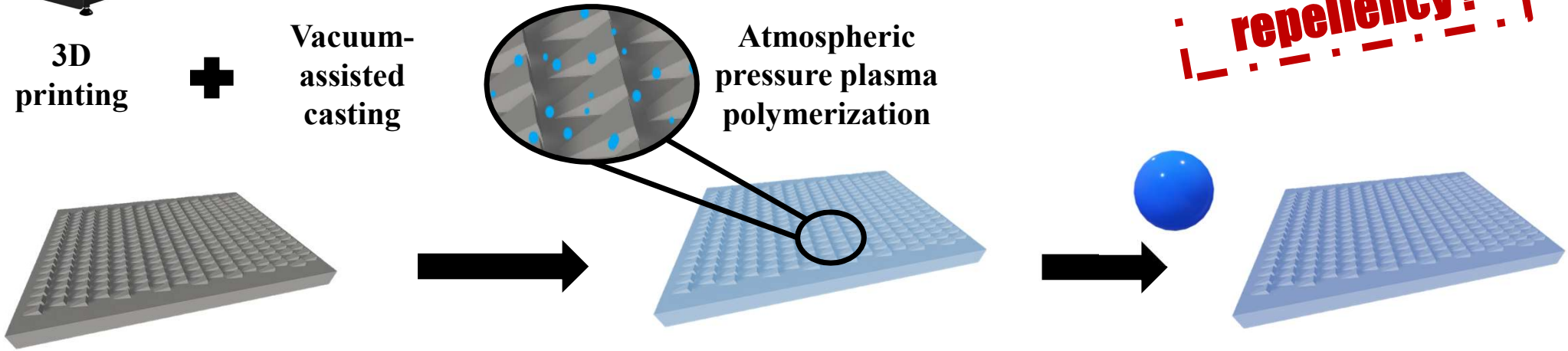
3D printing

Vacuum-assisted casting



Atmospheric pressure plasma polymerization

Water repellency!



Microtexturation

Nanotexturation

Hydrophobicity

Microtexturation process : Vacuum assisted casting

Computer Aided Design

3D printing

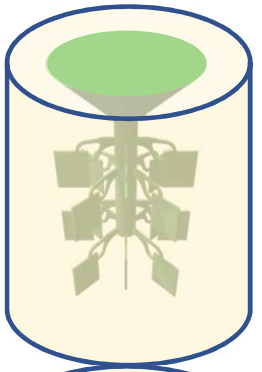
16 x

3D Printed Resin Coupons

Immersion in Refractory Slurry

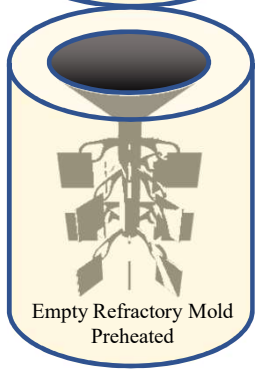
T_{room}
Primary vacuum / Ar

Castable Parts in a Refractory Mold



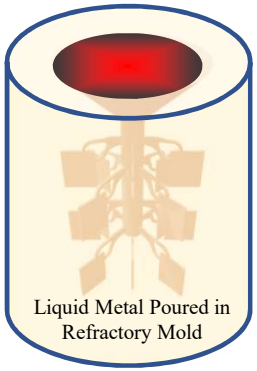
Cooking :
Dewaxing, Dehydration, Sintering

T_{mold} = 850°C
P_{atm}



Empty Refractory Mold Preheated

Liquid Metal Pouring



Liquid Metal Poured in Refractory Mold

T_{metal} = 1600°C
T_{mold} = 850°C
Primary vacuum / Ar

Microtexturation process : Vacuum assisted casting

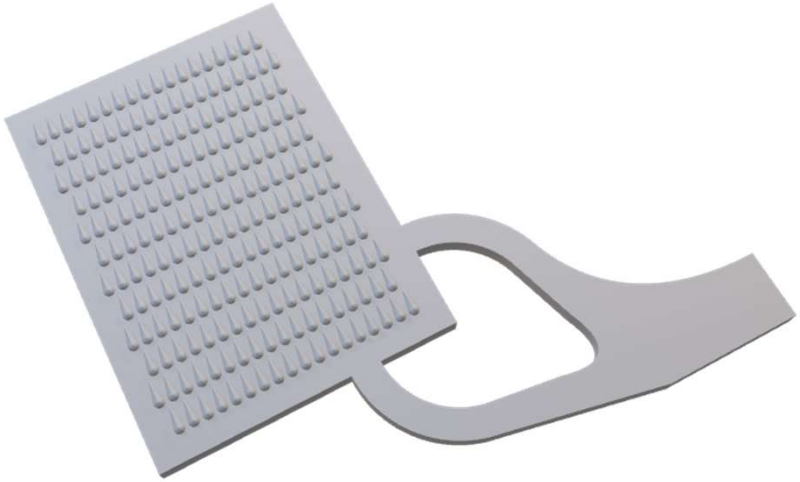
Challenges

→Difficult to implement because very reactive liquid steel

→Stainless steel casting temperature 1600°C
(Cu: 1185°C, Al: 740°C)

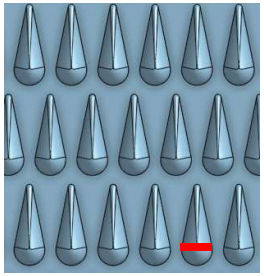
→Very high viscosity and surface tension compared to materials already explored previously or in the literature

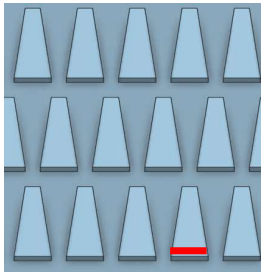
Design a bio-inspired micro-scaled surface

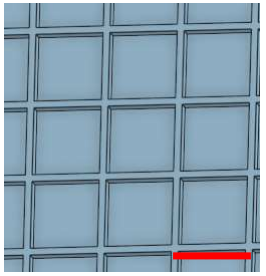


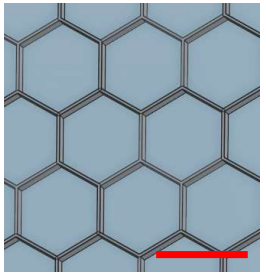
Coupons :

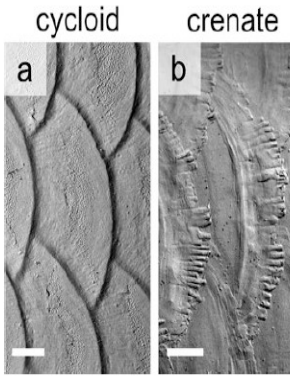
- 20x15x1,5 mm^3
- 2 feeding systems
- Different types of bio-inspired surface architectures

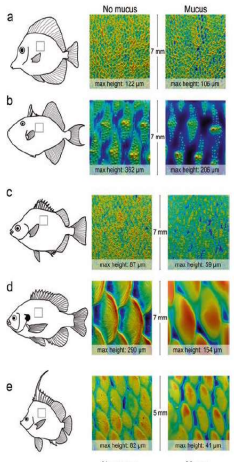








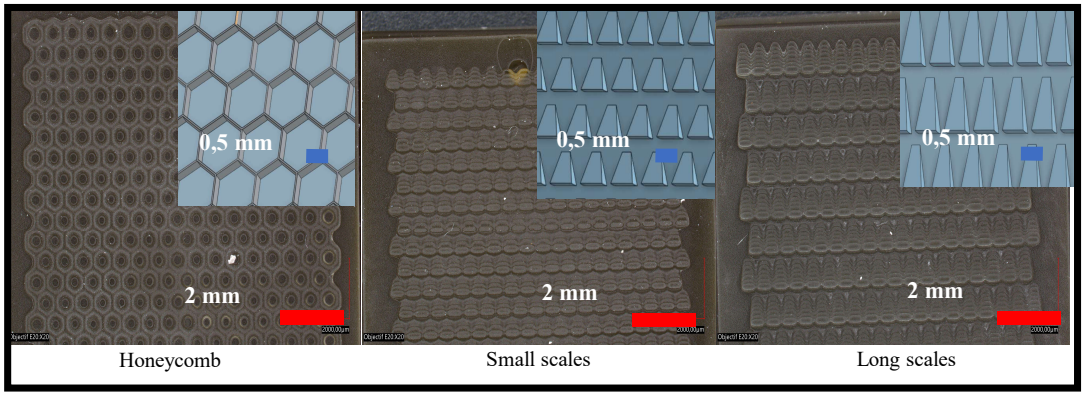




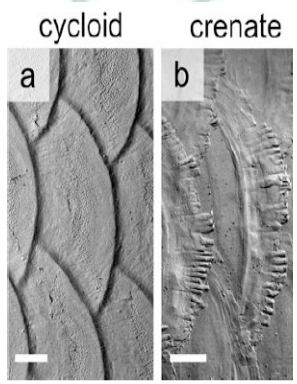
Scale bar = 500 µm

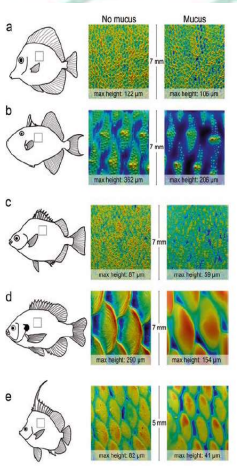
Microtextured bio-inspired surfaces

Bio-inspiration

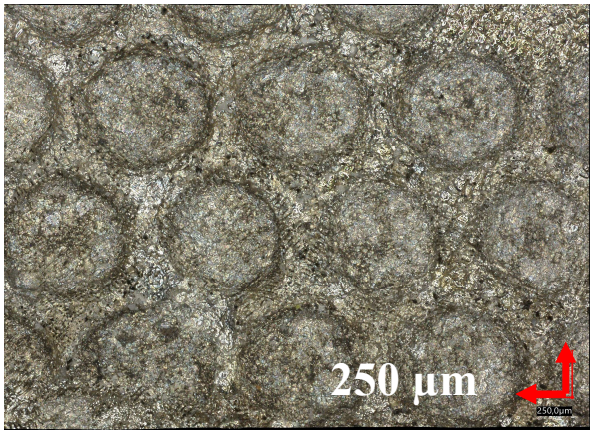


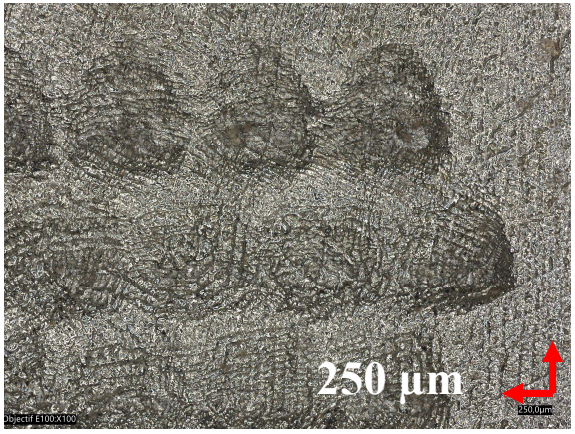
Bio-inspiration

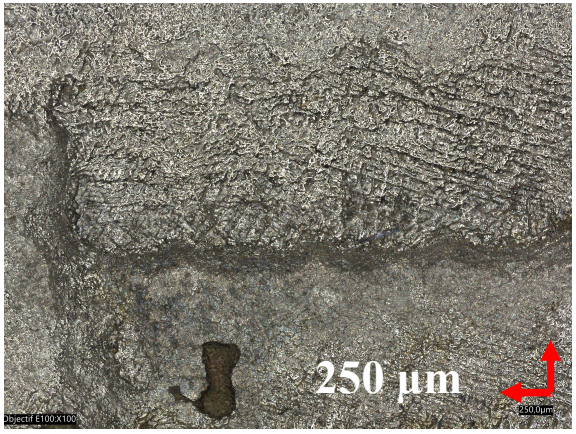




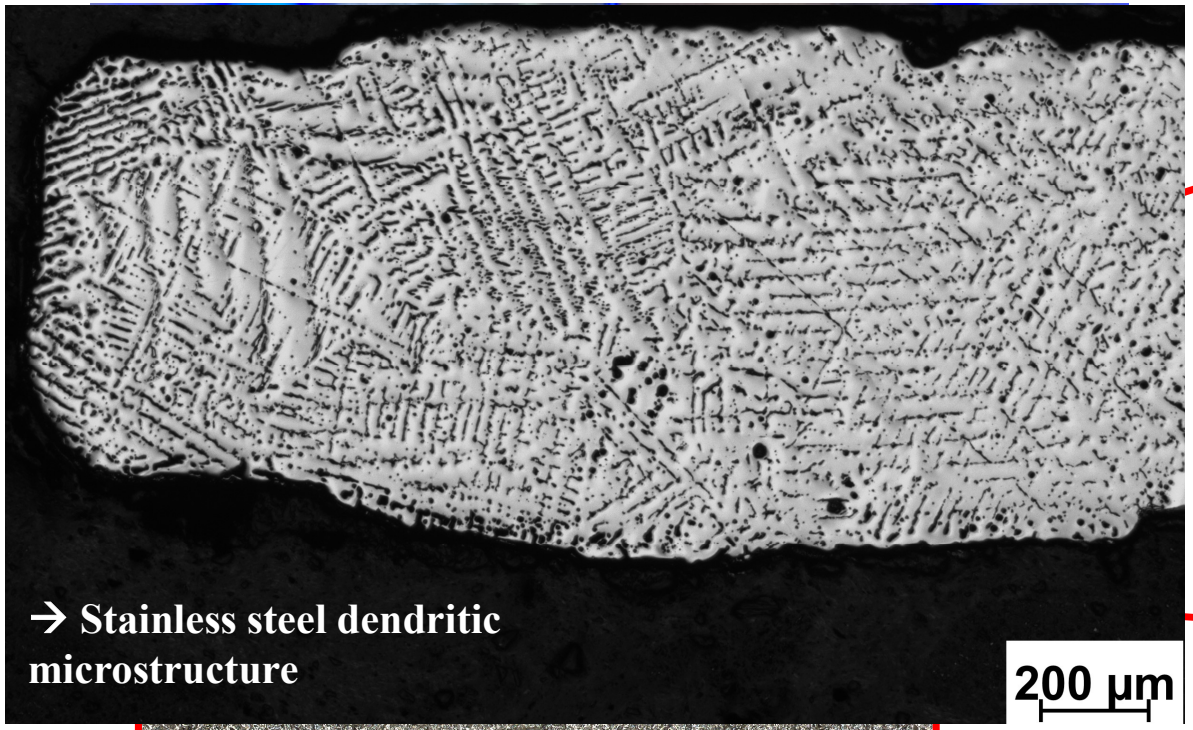
Moulding in stainless steel

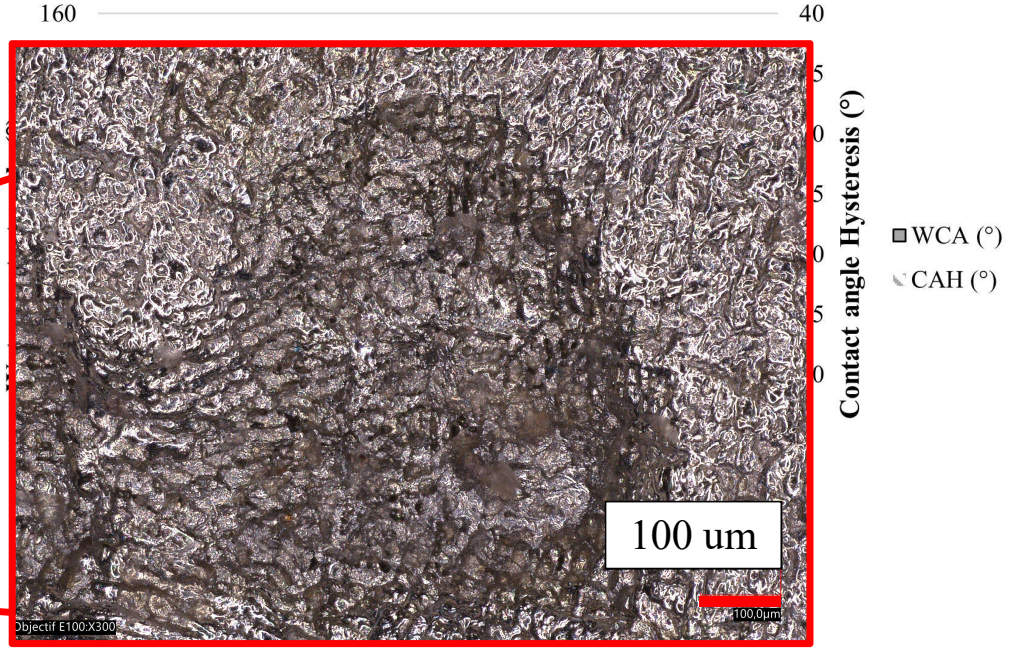


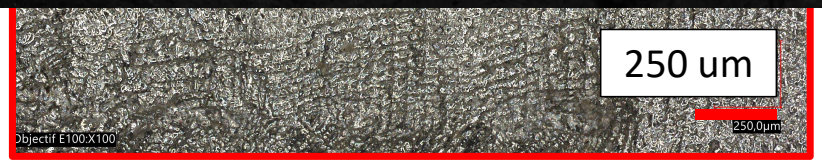




Hydrophobic behavior of the casted coupons

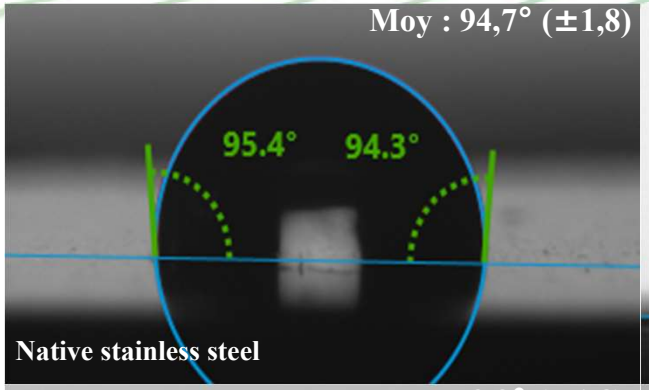


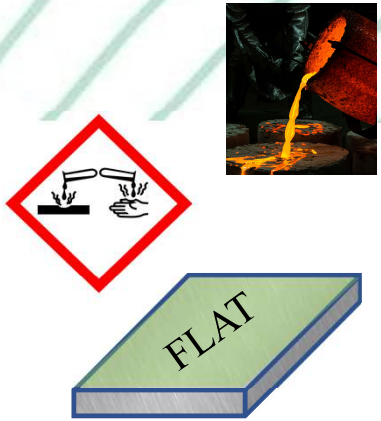


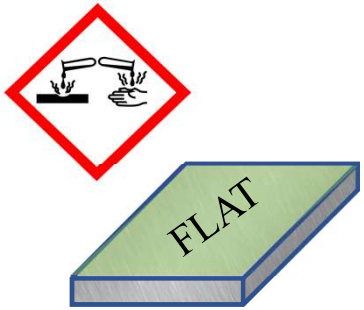


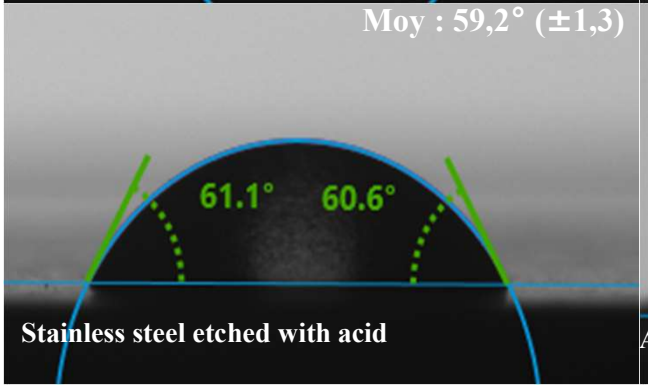
→ Quantify the chemical etching contribution

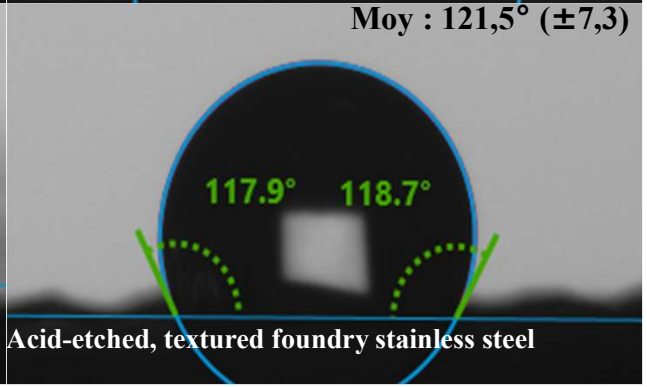
Characterize surface properties

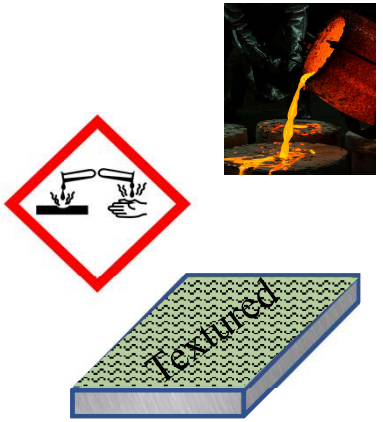






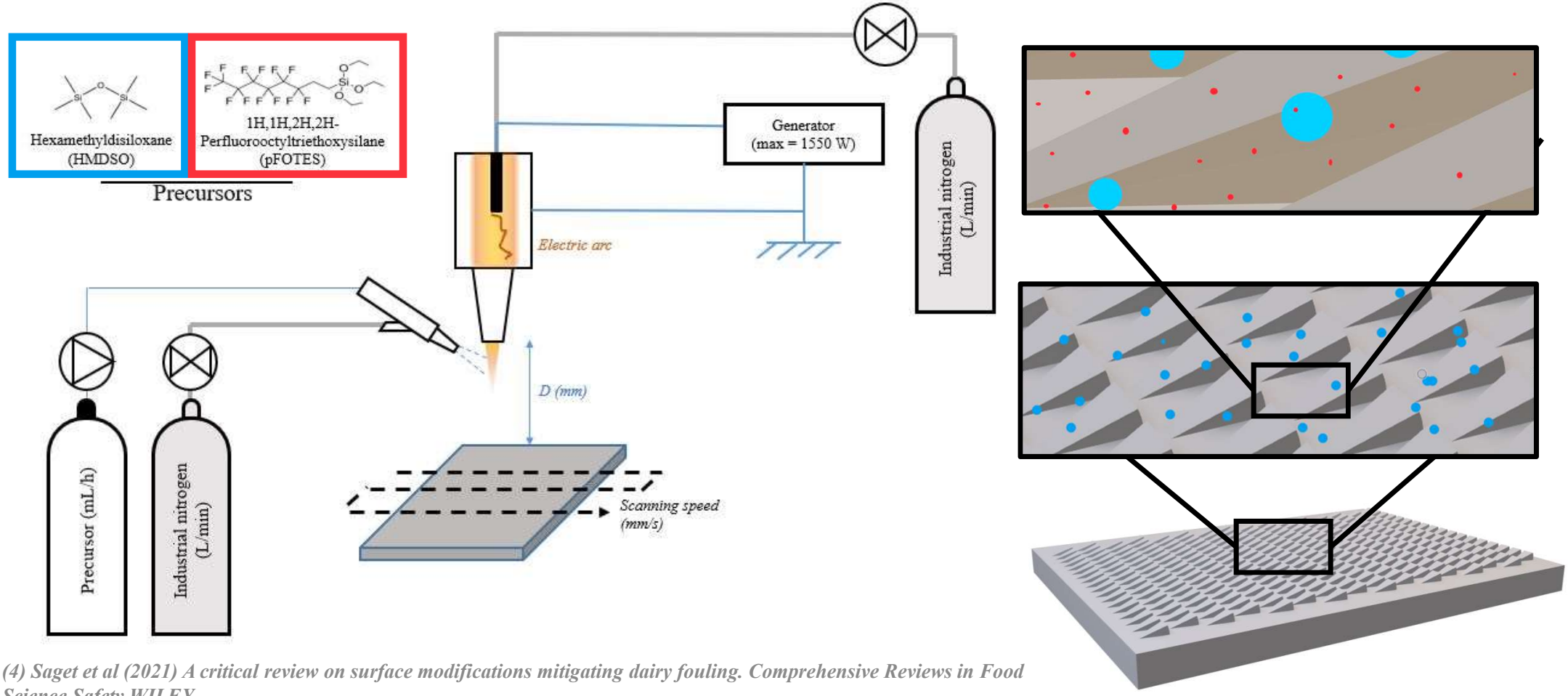






→ Discerning the contributions of microtexturing in surface hydrophobicity

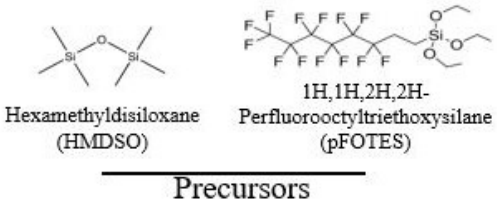
Nanotexturing process

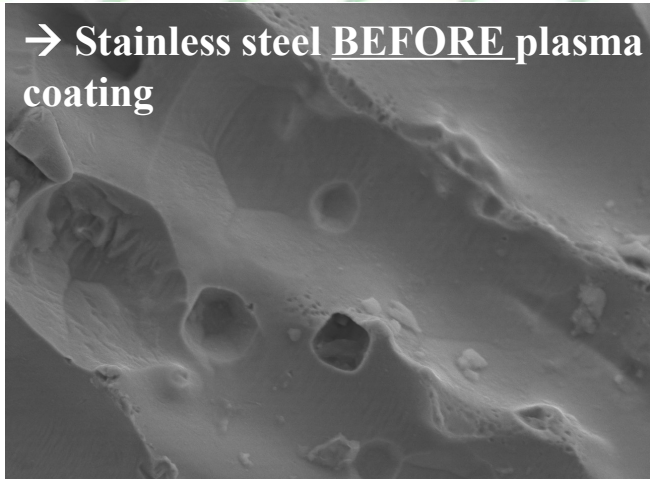


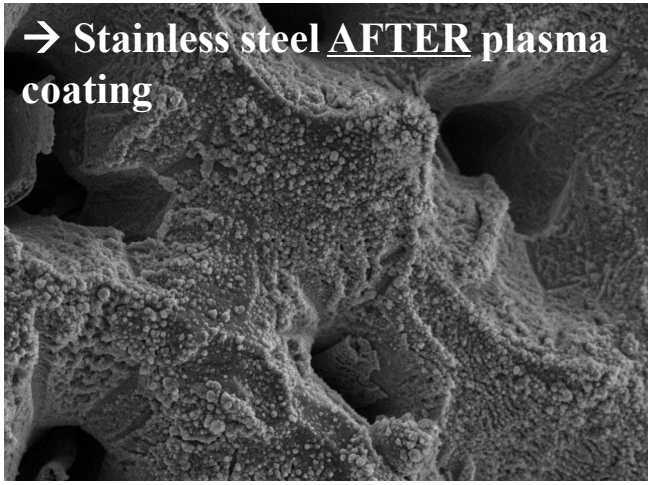
(4) Saget et al (2021) A critical review on surface modifications mitigating dairy fouling. Comprehensive Reviews in Food Science Safety WILEY

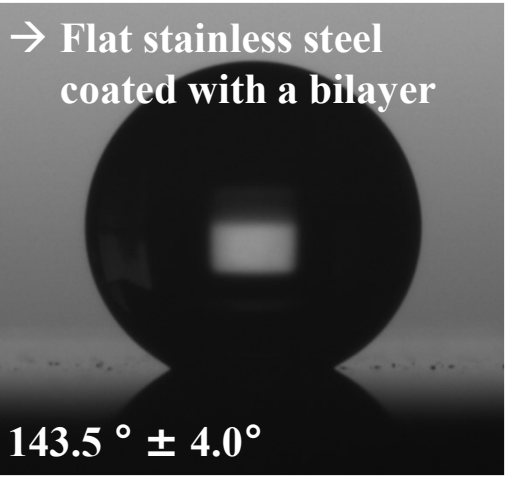
(5) Thèse de Manon Saget : Surface Engineering of Stainless Steel for Dairy Fouling Management (2022)

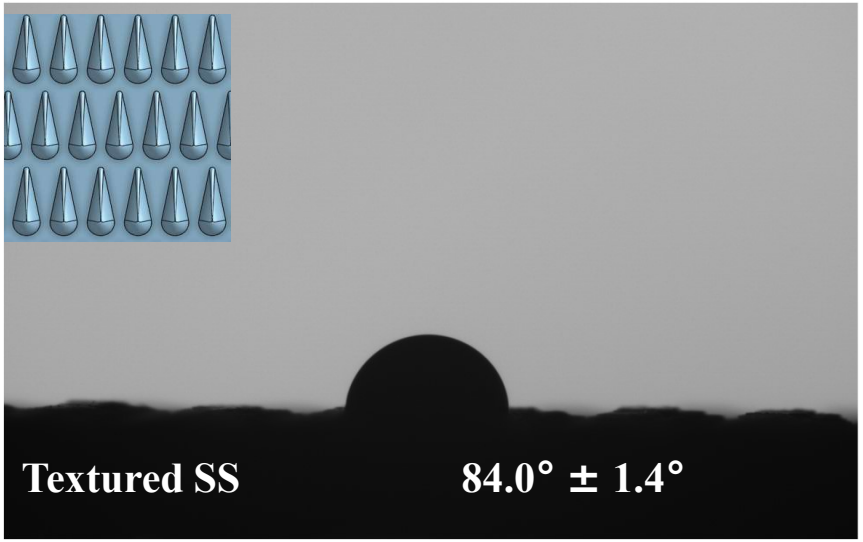
Nanotexturing process : wettability

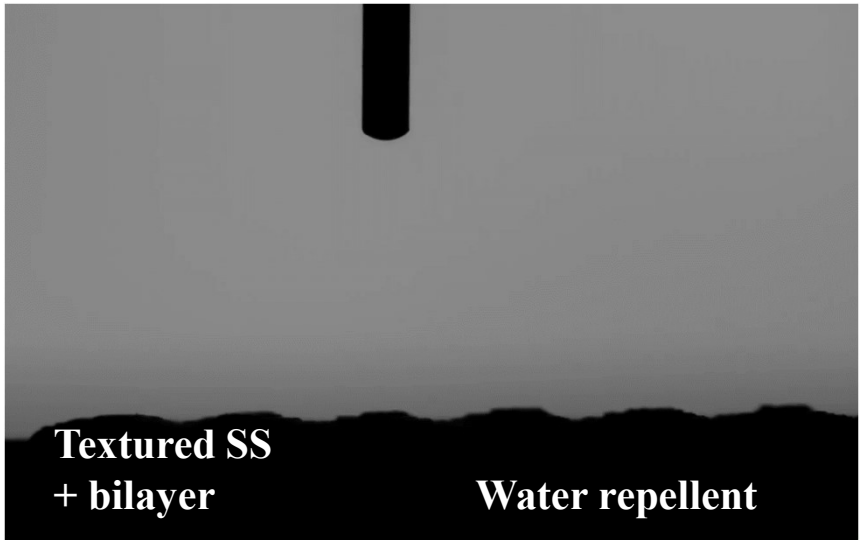












Conclusion

- Microtextured surfaces in lost-wax foundry are interesting in terms of wettability
- The super-hydrophobic coating manufactured by atmospheric pressure plasma is a promising result

Perspectives:

→ Application as anti-icing coatings

→ Application as antifouling / anti-adhesion coating

Thank you for your attention !

Any question ?

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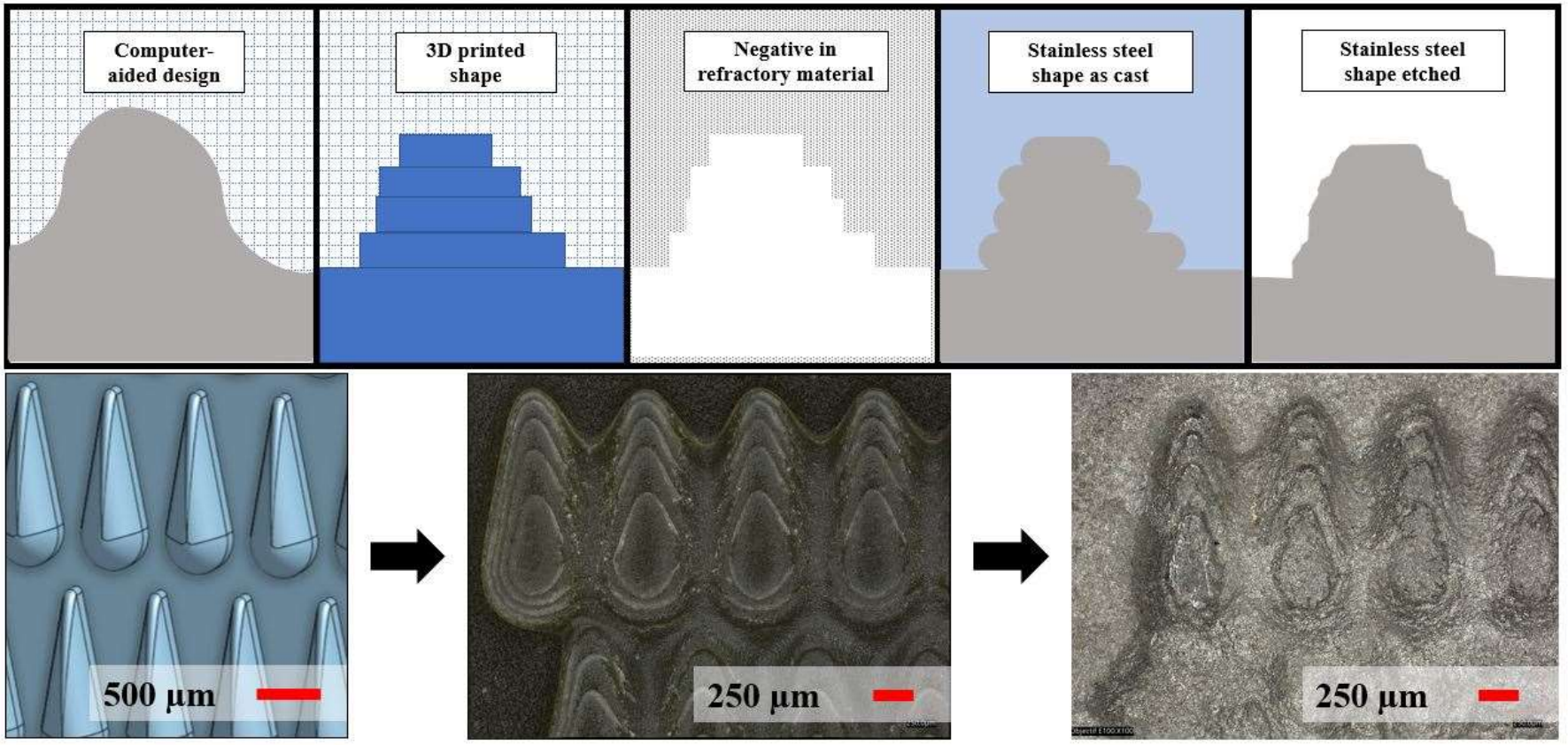
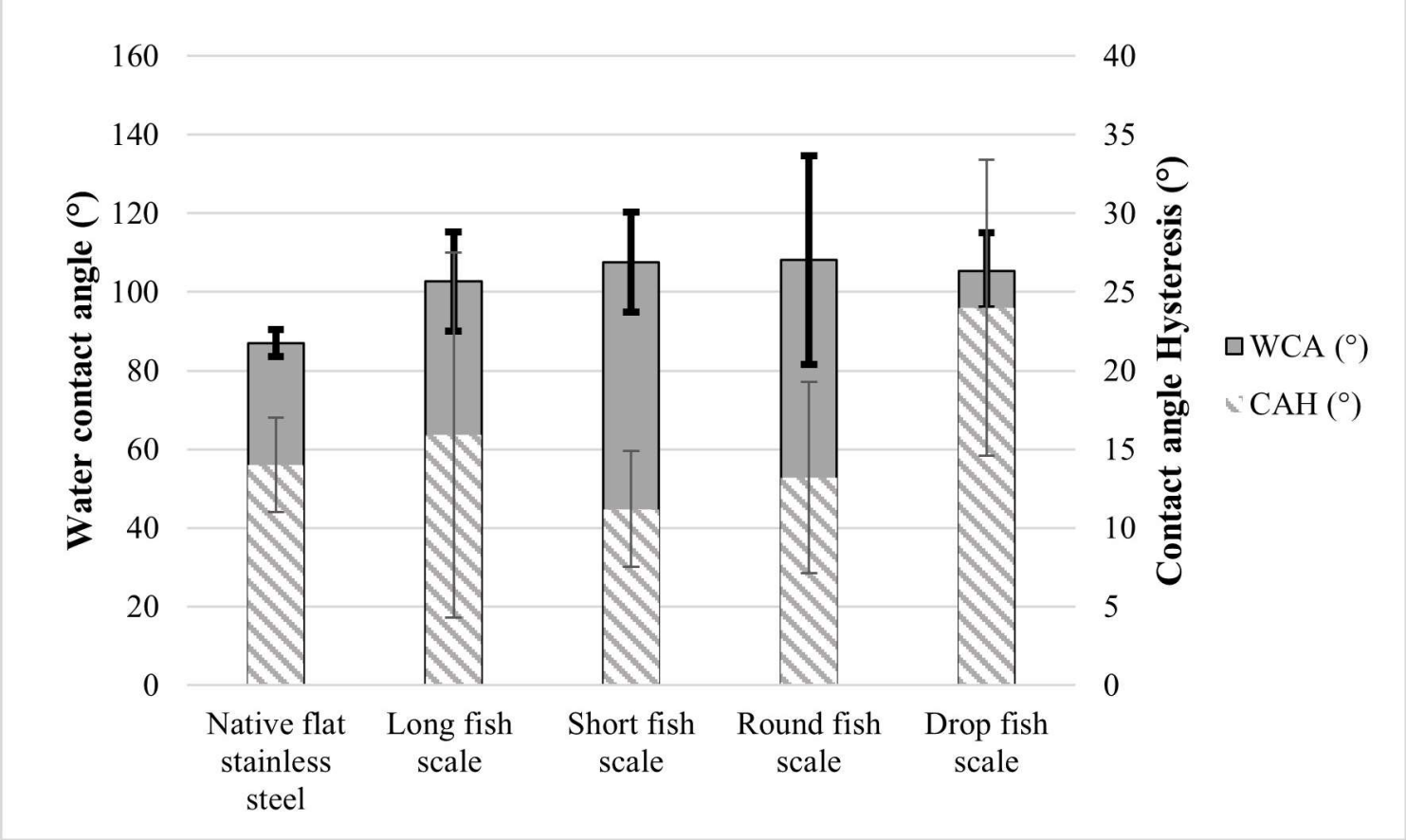
Information loss along the process



→ Roughness and waviness measurement to assess the information loss

Wettability measurement



→ No correlation have been made between roughness and wettability