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Probing the interactions between bubbles (gas / liquid) and (bio) - interfaces at the molecular scale using FluidFM technology

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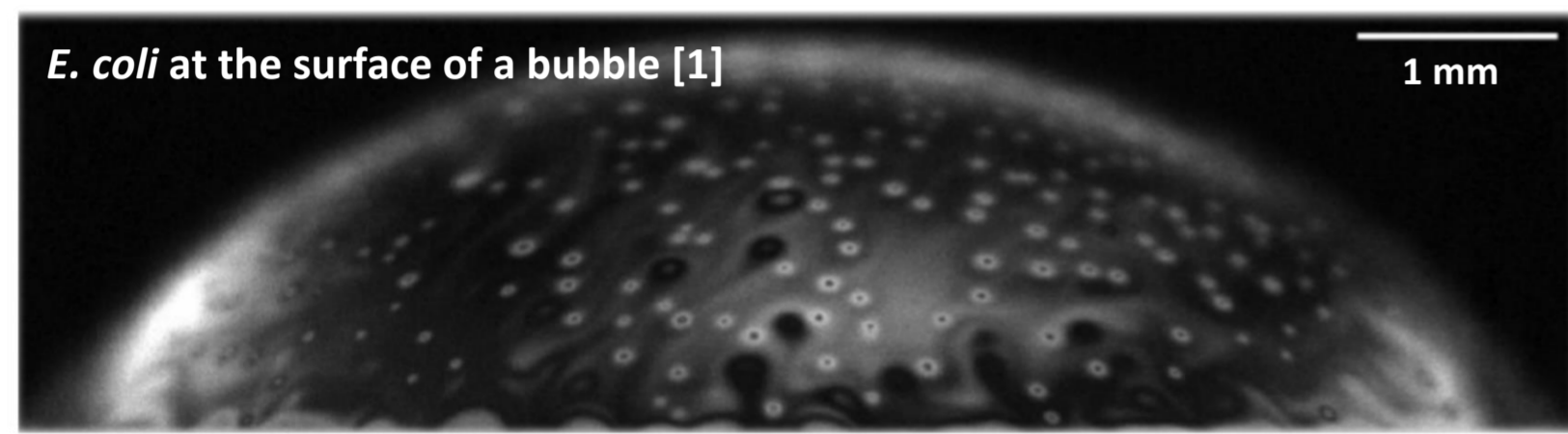
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ABSTRACT

Understanding the molecular mechanisms underlying bubble-(bio)surfaces interactions is currently a challenge that if overcame, would allow to understand and control the various processes in which they are involved. Atomic force microscopy is a valuable tool to measure such interactions, but it is limited by the large size and instability of bubbles. To overcome these challenges, we here develop a new method to probe more accurately the interactions between bubbles and (bio)-interfaces by using the fluidic force microscopy technology (FluidFM) that combines AFM with microfluidics. In this study, we use FluidFM in an original manner, to produce micro-sized bubbles. We characterized the bubbles produced using this method, and their interactions with hydrophobic surfaces were probed, showing that bubbles behave like hydrophobic surfaces. Thus they can be used to measure the hydrophobic properties of microorganisms' surfaces. Finally we developed a strategy to functionalize their surface, thereby modulating their interactions with microorganisms' surfaces. This new method provides a valuable tool to understand bubble-(bio)surfaces interactions but also to engineer them.

INTRODUCTION

Our aim is to understand the biological and physico-chemical nature of the bubbles and (bio)-surfaces



Lack of efficient techniques
Challenges !!!

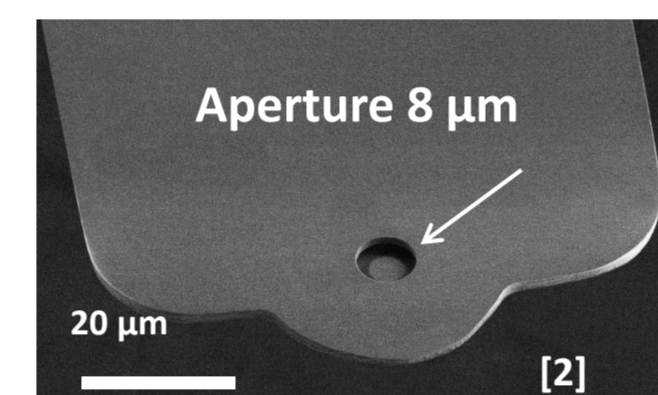
New tools to measure the interactions with bubbles

Develop strategies to functionalize bubbles

Technological challenges:

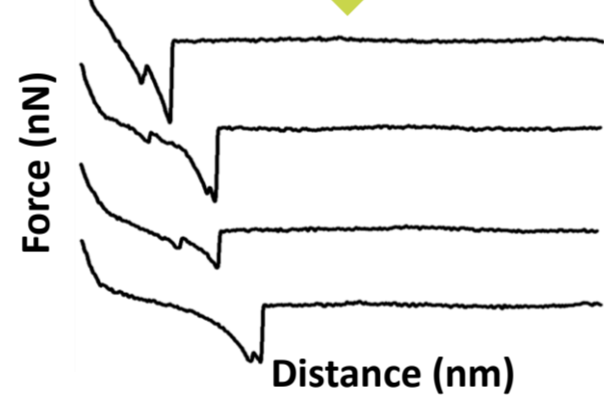
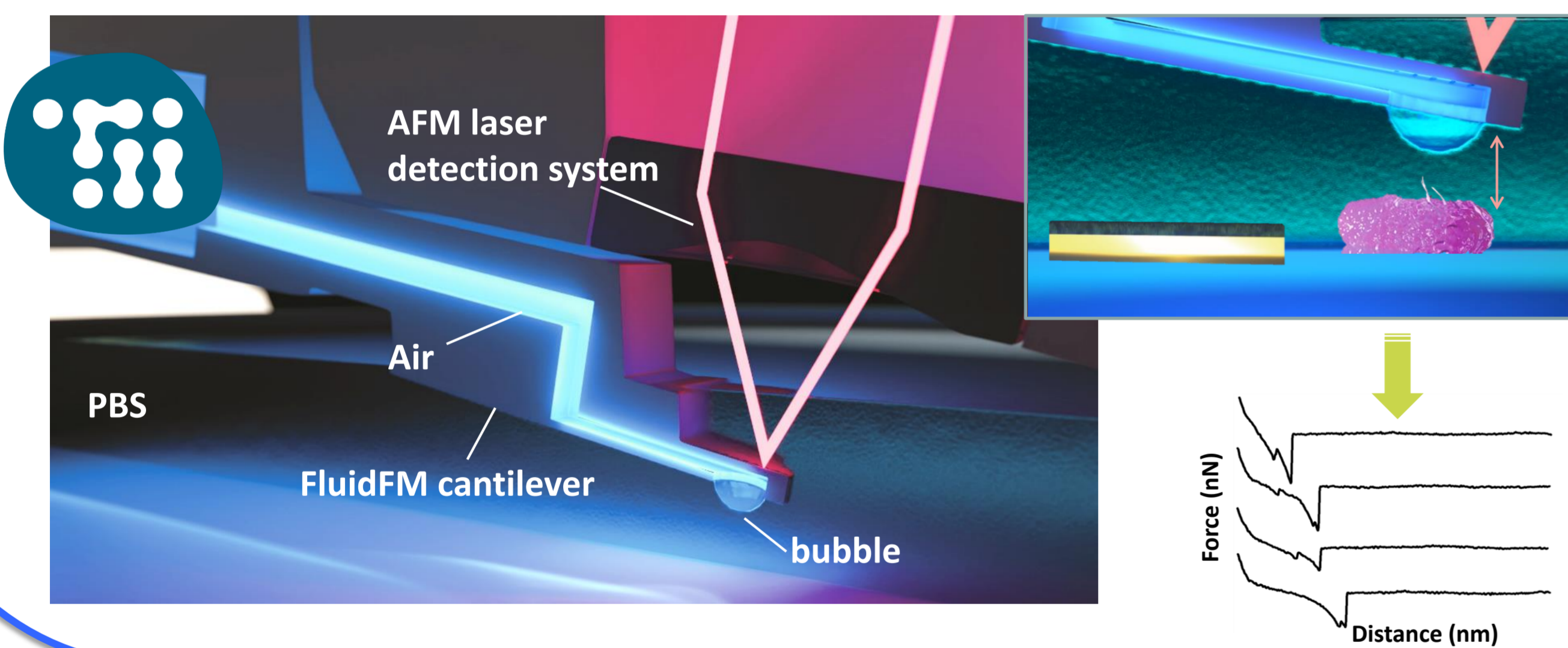
- Produce stable microbubbles
- Functionalize bubbles with surfactants
- Measure interactions with cells at the molecular level

FluidFM technology



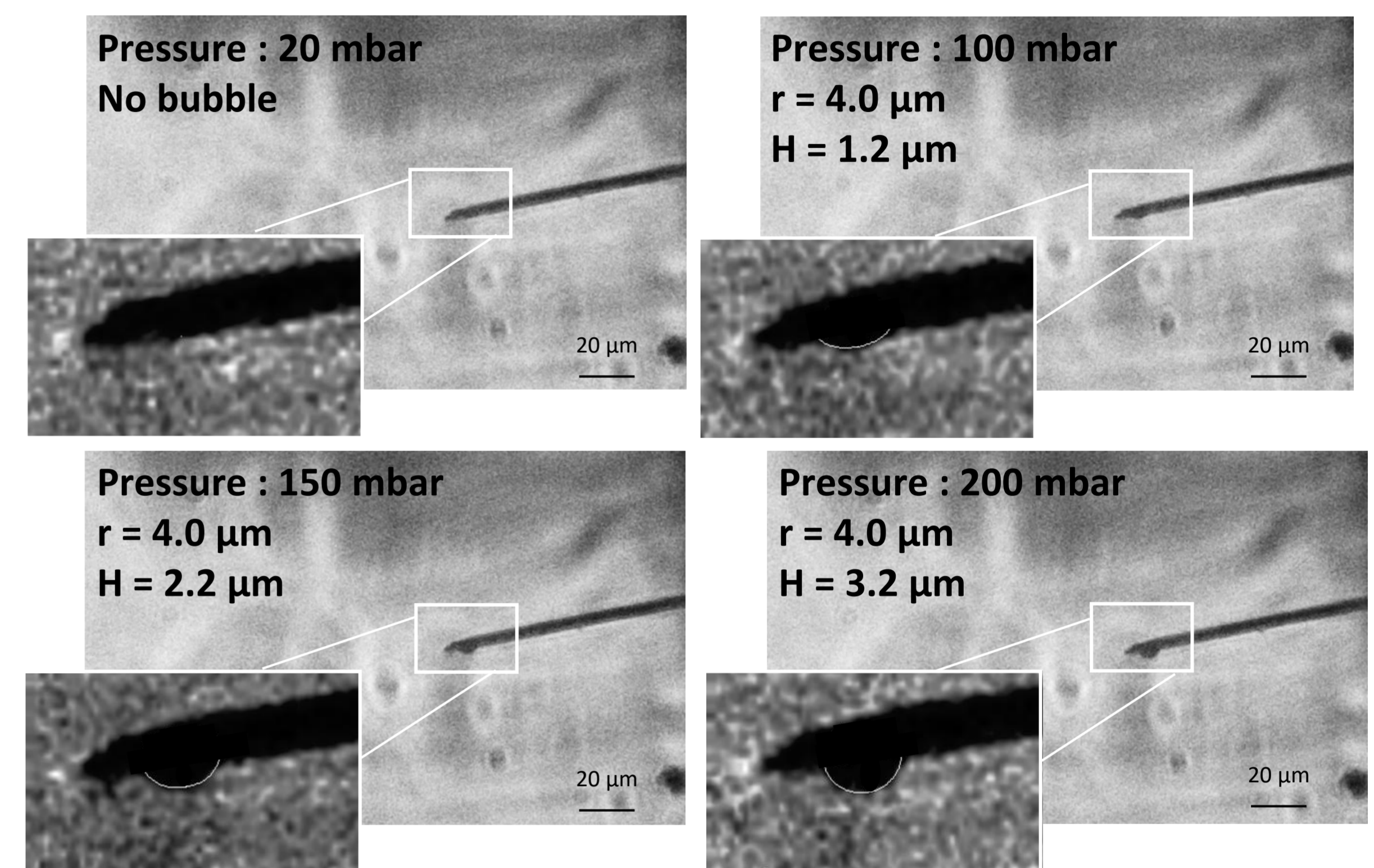
We used FluidFM in an original manner to produce bubble

FluidFM Technology to produce bubbles and measure interactions



METHODS

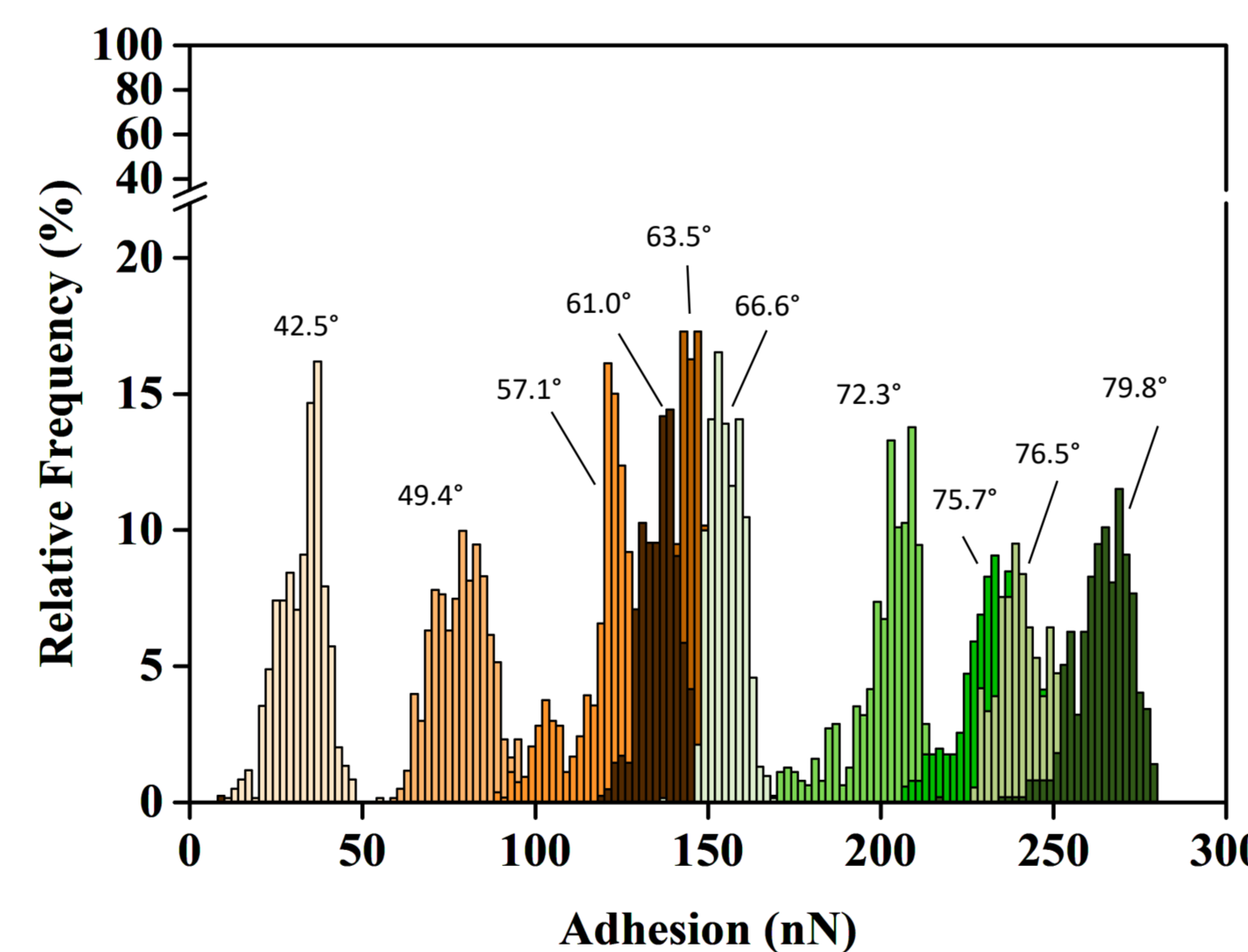
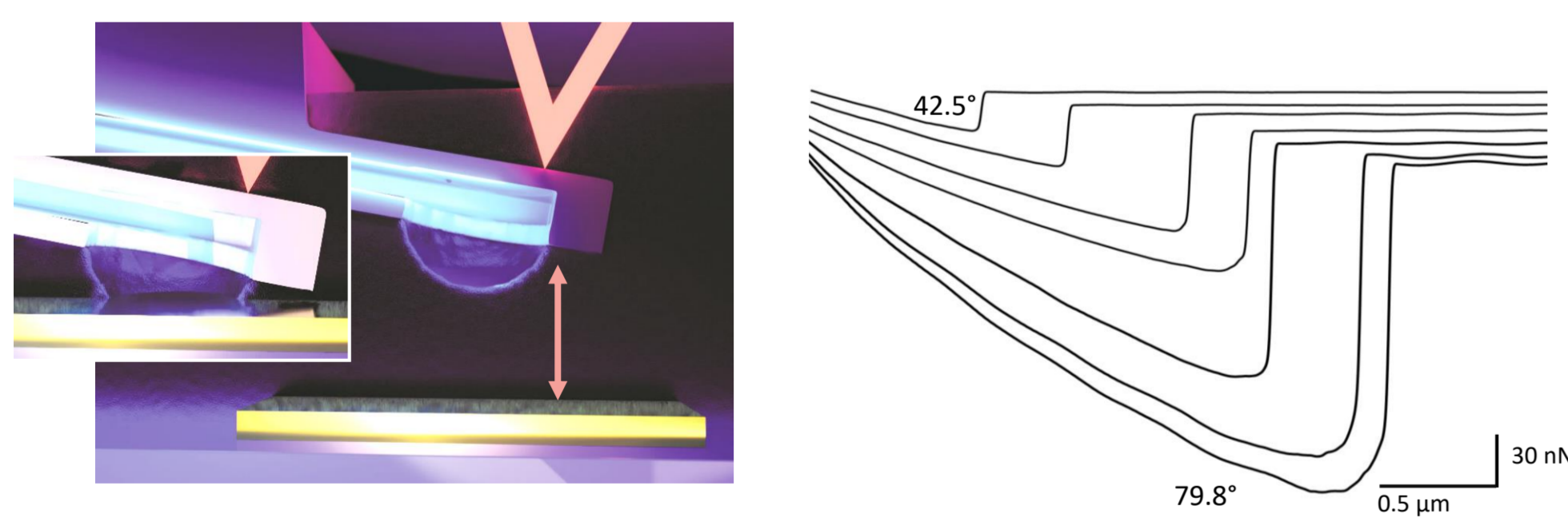
Production of stable microbubbles



The size of the bubble depends on the pressure applied

RESULTS [3]

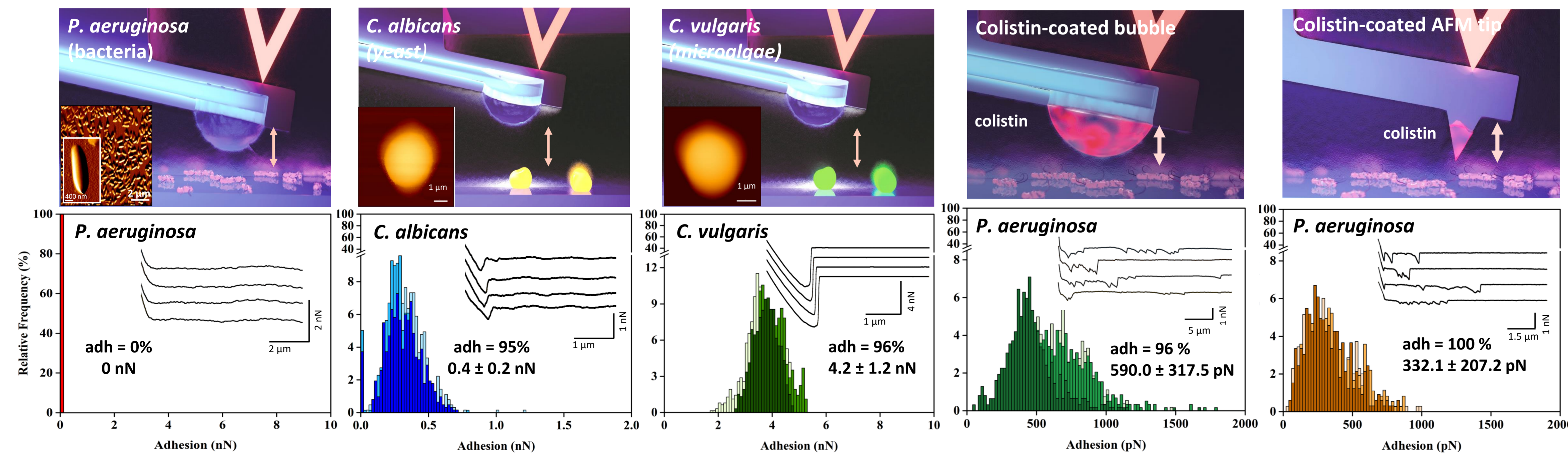
Probing the hydrophobicity of surfaces



Bubble behave like hydrophobic surface

Bubble probe method can be used with reliability to measure the hydrophobicity of complex surfaces

Probing the interaction with living cells



Different type of microorganisms show different hydrophobicity.

Interactions of cells with bubbles are controlled by bubble functionalization

We developed an original process where the interactions of cells with bubbles are controlled

CONCLUSIONS

Here we provide the possibility to (i) modify easily the surface of the bubbles produced using FluidFM, and (ii) to show in what way the modification of the bubble surface influences the nature and strength of the interaction with cells. In future projects, this strategy could also be used to specifically separate cell populations from each other; for example to separate bacterial cells from human blood cells in the case of sepsis, but many other applications can now be envisioned.

REFERENCES

- [1] Poulain *et al.*, Physical Review Letter, 2018
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- [3] Demir *et al.*, Journal of Colloid and Interface Science, 2021