In-Situ Characterization of Dry Microstructured Surfaces for Human Skin Adhesion

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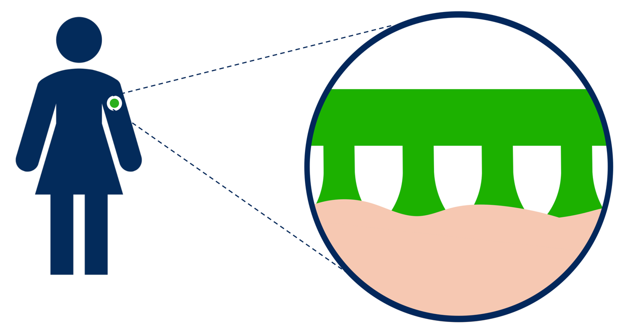
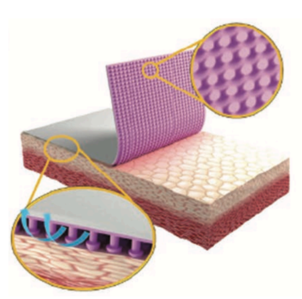
Background

As the use of wearable sensors in a more personalized healthcare system increases, the need for a reliable, reusable, and clean adhesive mechanism to skin is critical.



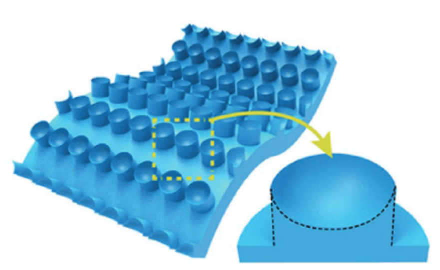
Skin adhesive patches enable[1,2]:
- Monitoring vital signs (EEG, ECG, EMG)
- Body motion & vibration sensing
- Controlled drug delivery

Current state of the art in bioinspired dry adhesive for skin vary from mushroom-shaped pillars to octopus-inspired suction cups. The highest reported normal adhesion to skin is ~2 N/cm^2.



Mushroom-shaped pillar array by Kwak et al. in 2011[3]

Adhesion: 1.3 N/cm^2

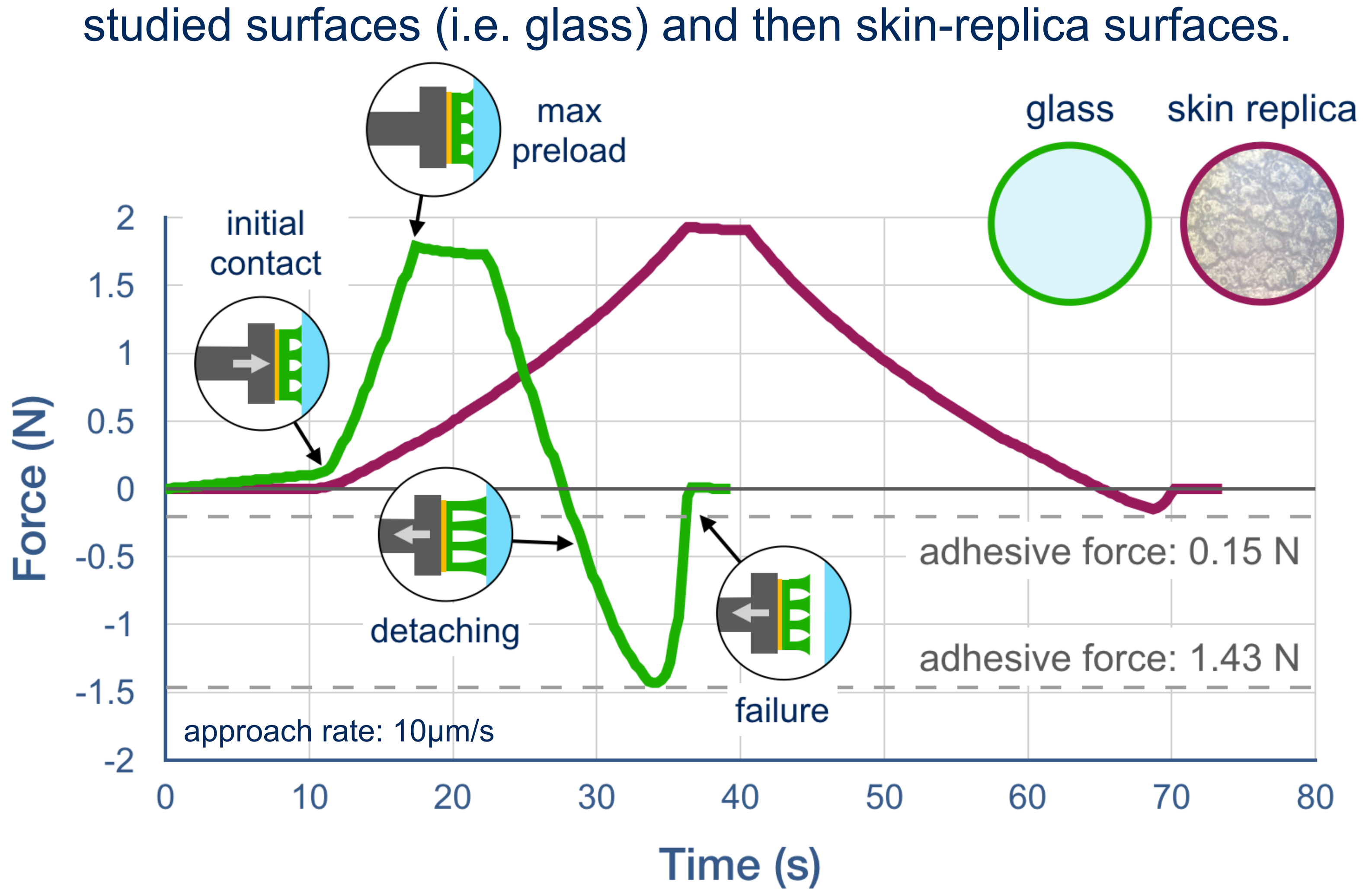


Suction cup array adhesive by Baik et al. in 2018[4]

Adhesion: 1.8 N/cm^2

Approach

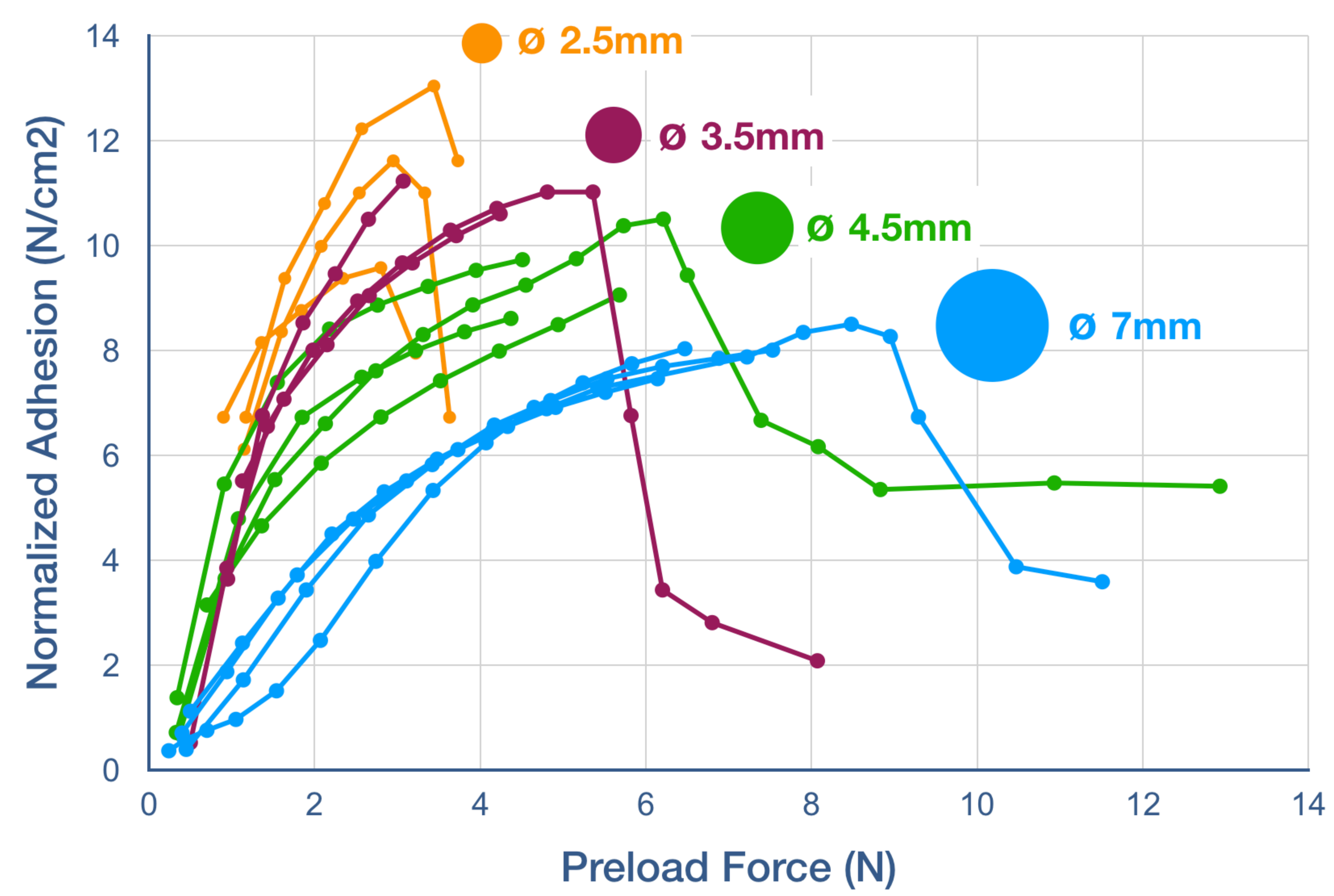
To improve upon dry microstructured adhesion to skin, the mechanisms of adhesion are first understood on commonly studied surfaces (i.e. glass) and then skin-replica surfaces.



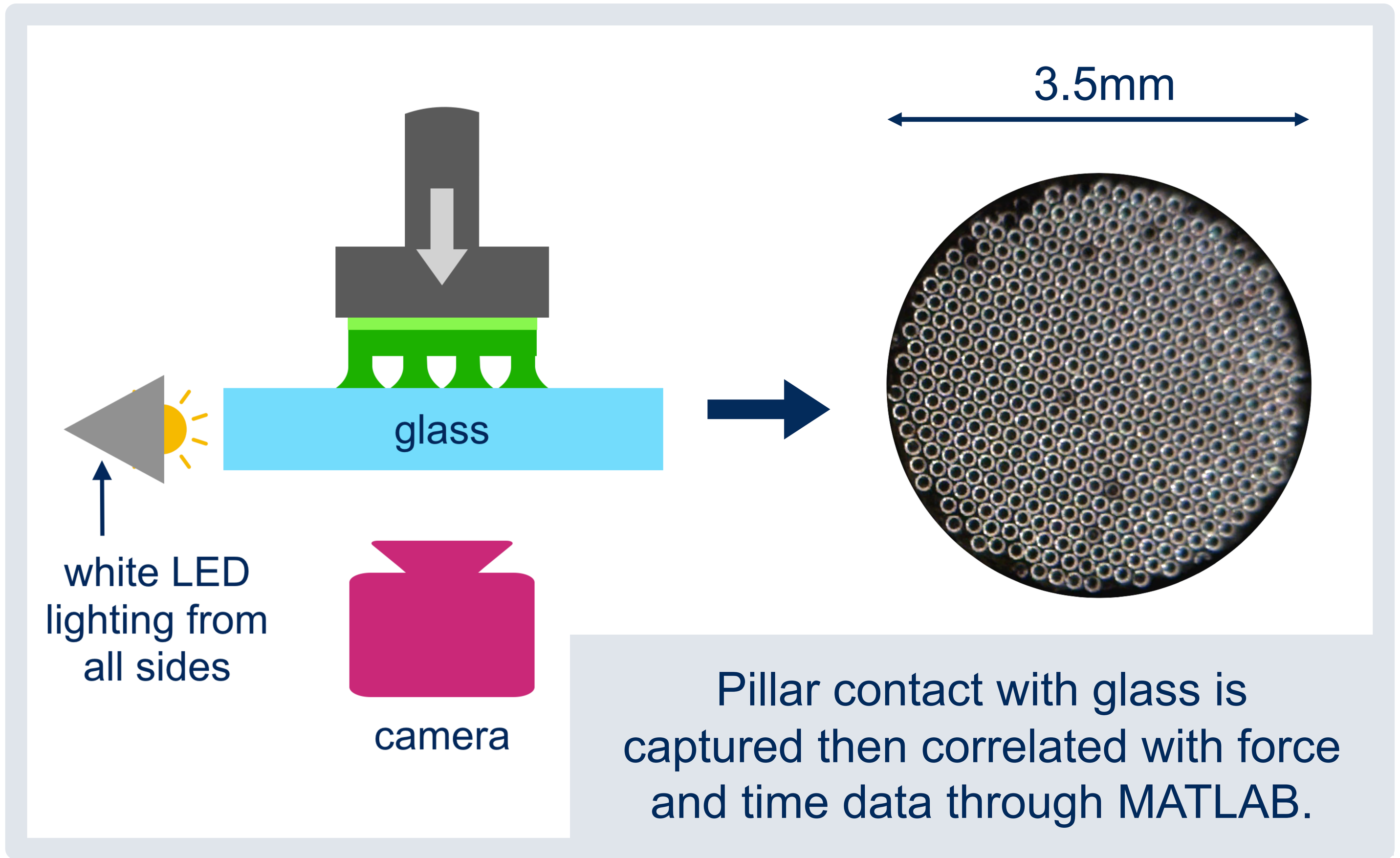
The dry microstructured surfaces show a significant drop-off in adhesion when moving from a hard, smooth glass surface to a soft, rough surface (skin replica).

Results

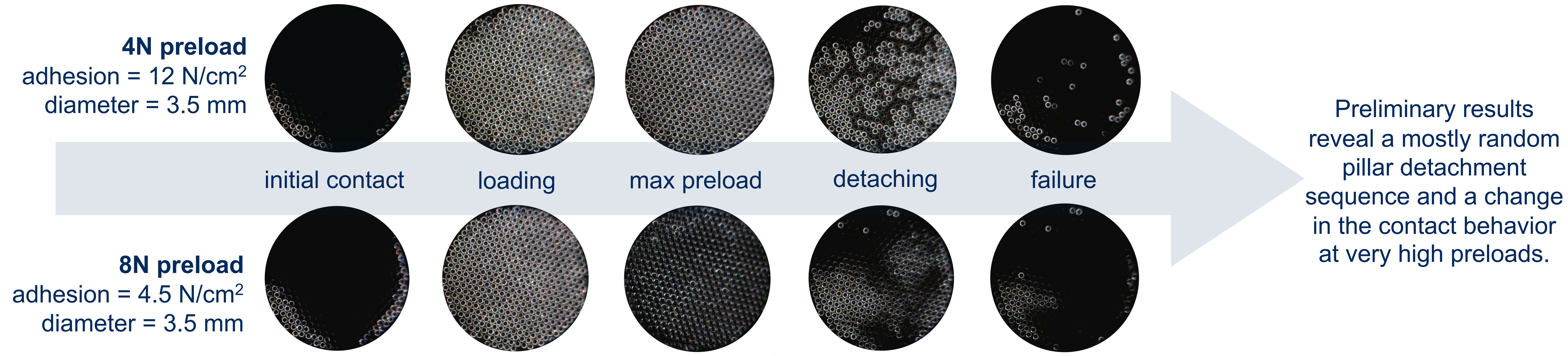
Commercial mushroom-shaped pillar arrays (nanogriptech, tip diameter 150μm, AR ~2) were tested on glass surfaces and showed normal adhesion of up to 13 N/cm^2 with significant dependence on preload. Normal adhesion testing on samples of varying diameters revealed a size-scale effect: smaller samples had higher adhesion per unit area. In-situ characterization was also enabled through frustrated-TIR[5].



in-situ characterization setup



Pillar contact with glass is captured then correlated with force and time data through MATLAB.



Preliminary results reveal a mostly random pillar detachment sequence and a change in the contact behavior at very high preloads.

Conclusions & Next Steps

- Preliminary results show a random detachment mechanism in most cases, but this needs further statistical analysis.
- Contact appears to change under high preloads, however the nature of this drop in adhesion remains unclear.
- A size-scale effect was observed where smaller samples achieved higher adhesion per unit area.
- Future work will include understanding changes in the contact mechanism with size-scale effect and on skin replica samples.

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