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Silicone based electroadhesion actuators with various electrode geometries and a modified non-sticky surface

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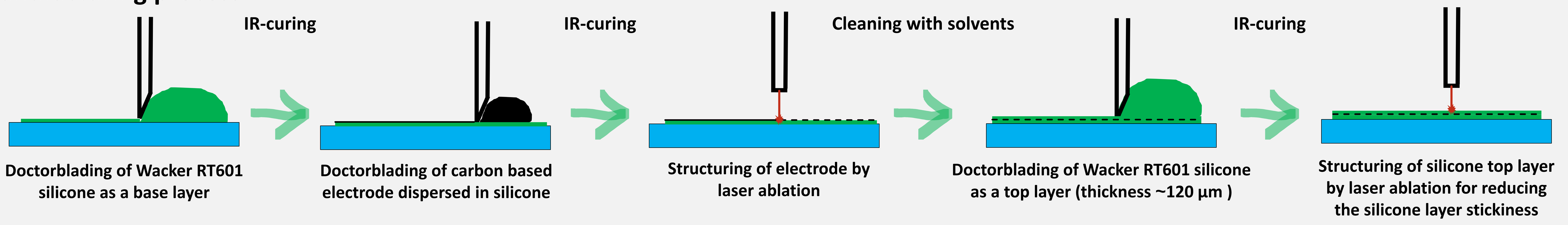
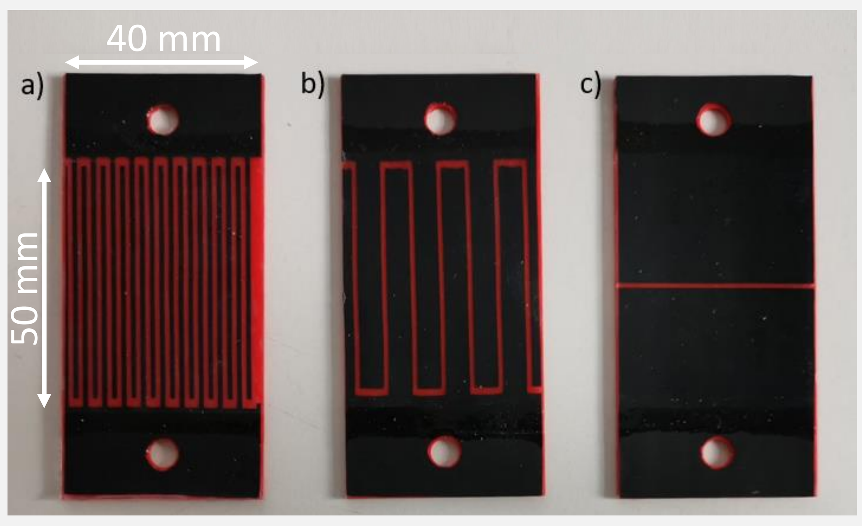
Abstract

In recent years, electroadhesion has become a prominent branch of the field of electro-active polymer (EAP) actuators. Based on stretchable silicone substrates, it supplements conventional dielectric actuators (DEA) by acting as a simple add-on to generate large holding or grasping forces on an object. As the DEA itself provides displacement possibilities, the combination of movements and adhesion inherently paves the way for soft robotic applications. Here, investigations of the electroadhesive shear force of stretchable silicone-based structures interacting with different flat objects (paper-based, metallic conductive and polymer-based objects) are presented. For each, various oscillation frequencies of the applied voltage and interdigital electrode geometries have been tested. The electrode structures on the silicone substrate are created from laser-ablating flat electrode material and subsequent coating of a 120 µm thick silicone layer, which acts as a dielectric. Surfaces have been further modified to reduce the intrinsic stickiness of silicone materials (which is detrimental to objects release) to a minimum while maintaining the electroadhesion effect. All tests are performed with a constant horizontal movement of the object from the fixed electroadhesive surface. With an overall electroadhesive electrode area of 40 x 50 mm and an applied voltage of up to 5 kV, relatively high shear forces of 3 N (polymer), 5 N (paper-based) and 12 N (metallic conductive) are reached.

Manufacturing process



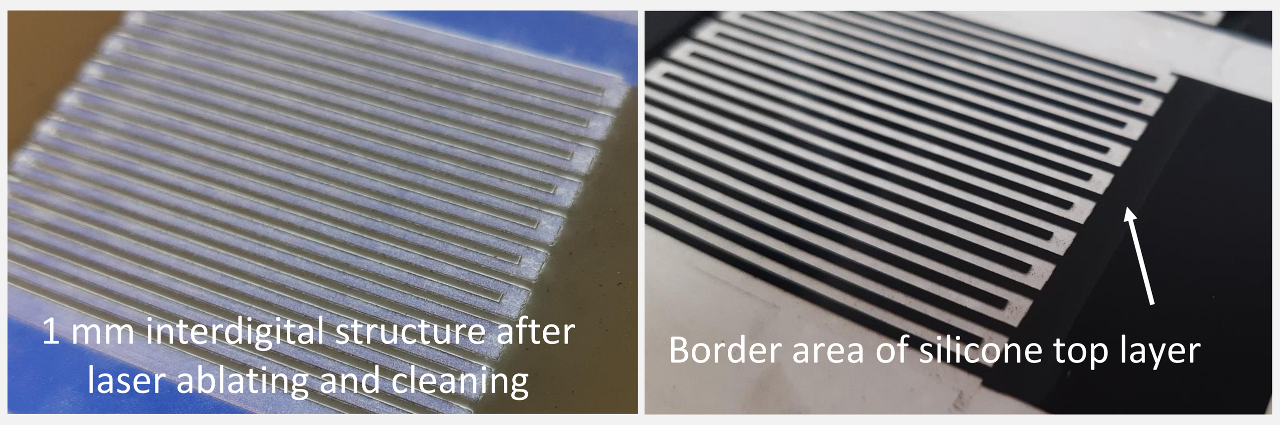
Produced structures



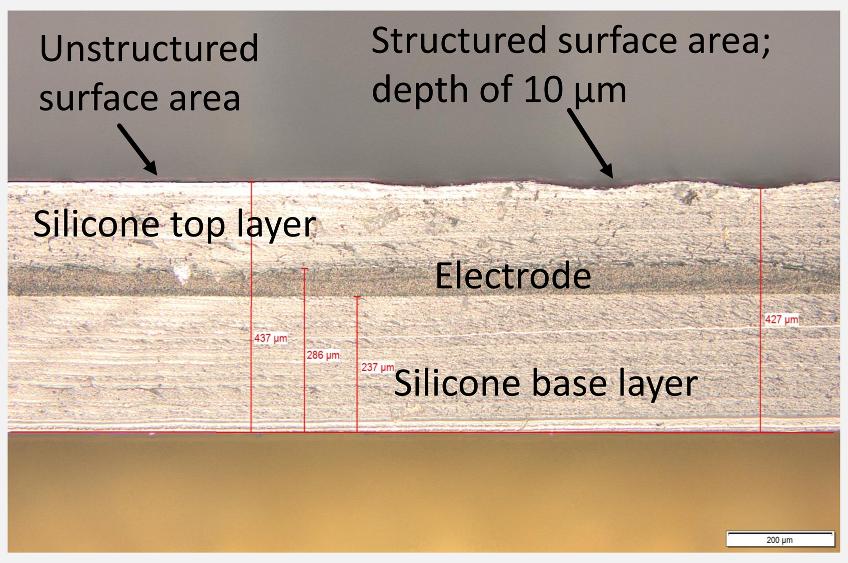
a) Interdigital electrodes with 1 mm electrode width and 1 mm gap between electrodes

b) Interdigital electrodes with 5 mm electrode width and 1 mm gap between electrodes

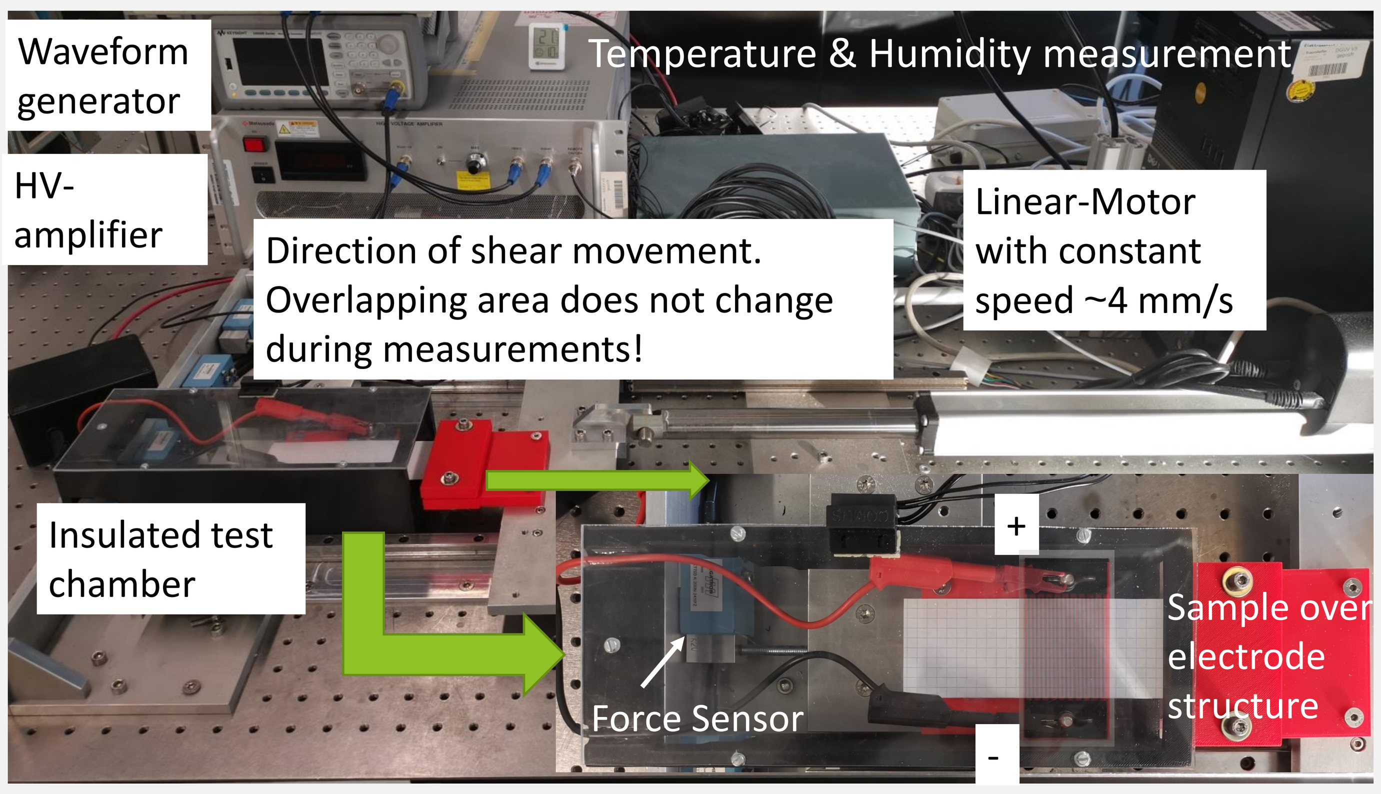
c) Flat electrode areas with 1 mm gap

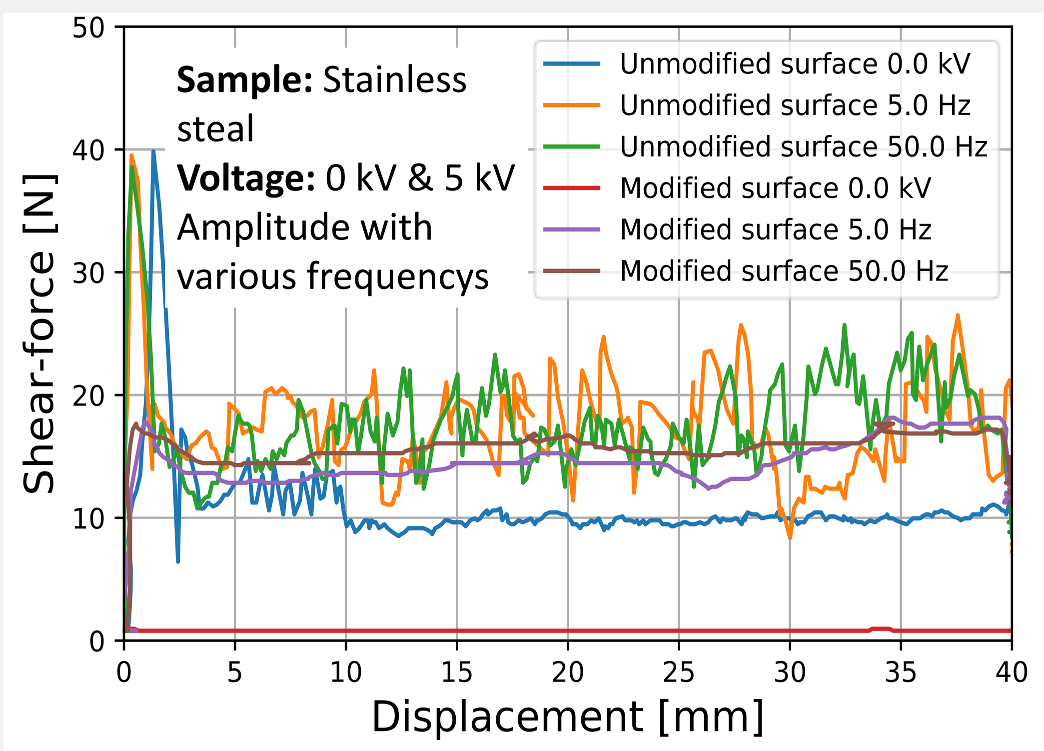


Cross-section after laser structuring



Test equipment and stick slip test

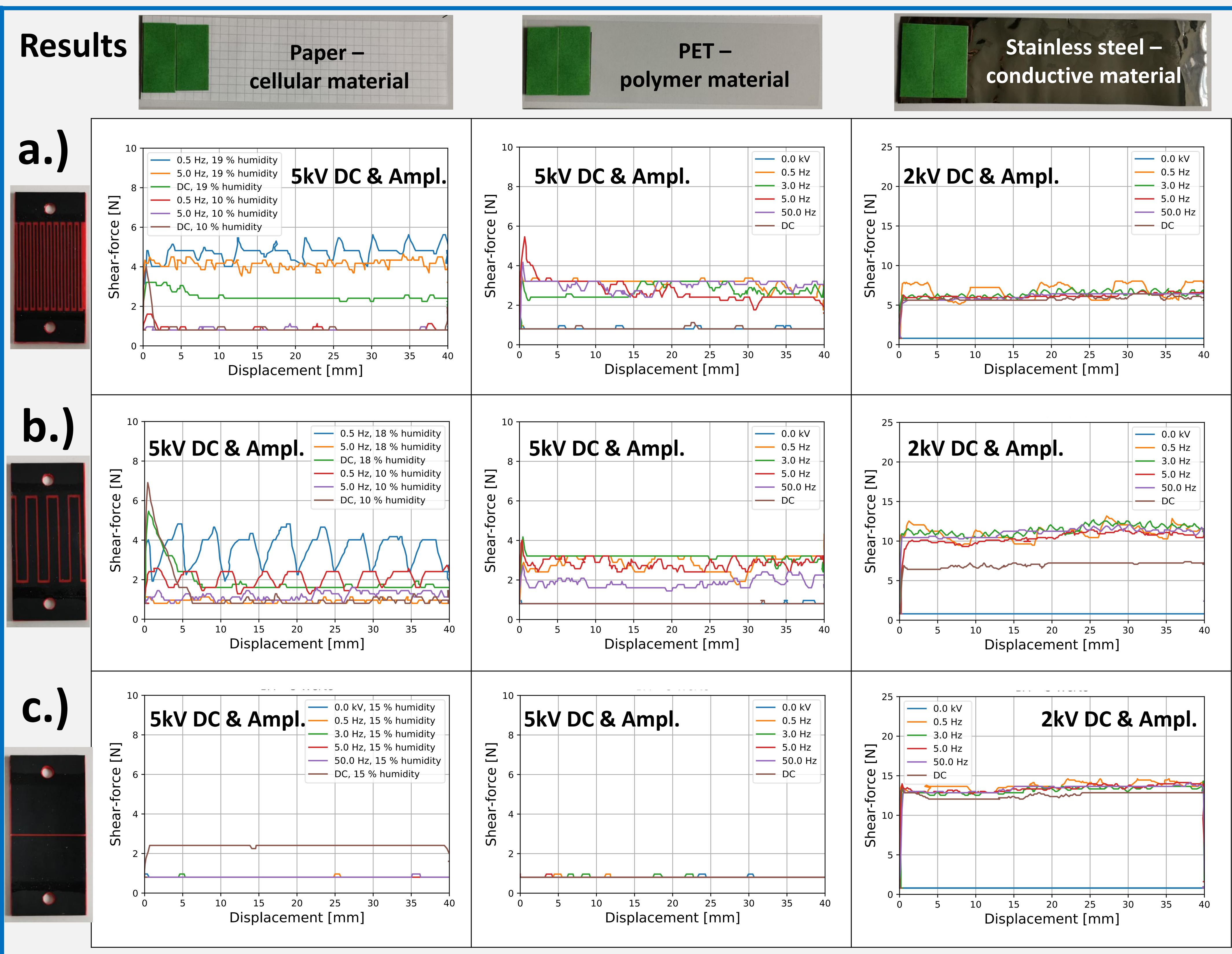




Success!

Noise caused by sticky slippering effect successfully reduced by surface modification!

Results



Conclusion

General: Laser structuring of the silicone top layer reduces the stick slip effect dramatically and has no negative influence on the electroadhesion effect!

Paper – cellular material:

- Massive influence of humidity on the electroadhesion effect!
- Better performance for *finer electrode structures* and *low AC frequencies* of the applied electric field.

PET – polymer material:

- Better performance of *finer electrode structures* and *low AC frequencies*
- Lower shear forces measured when compared to paper and stainless steel.
- Optimization necessary.

Stainless steel – conductive material:

- Better performance for *flat electrode structure* performs best.
- *Shear force independent from tested frequencies of the applied field.*
- Highest shear force with lowest applied voltage.

Acknowledgments

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References

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