

Electroadhesion and Fibrilar Adhesive Hybrid for Climbing Robots



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Existing Technology

Electroadhesion

How it works:

A strong electrostatic force between positive and negative charges can be induced by running high voltage to a pair of electrodes. The force can be used to clamp a thin flexible film tightly to almost any surface.



Figure from electroadhesion paper
*H. Prahlad, R. Pelrine

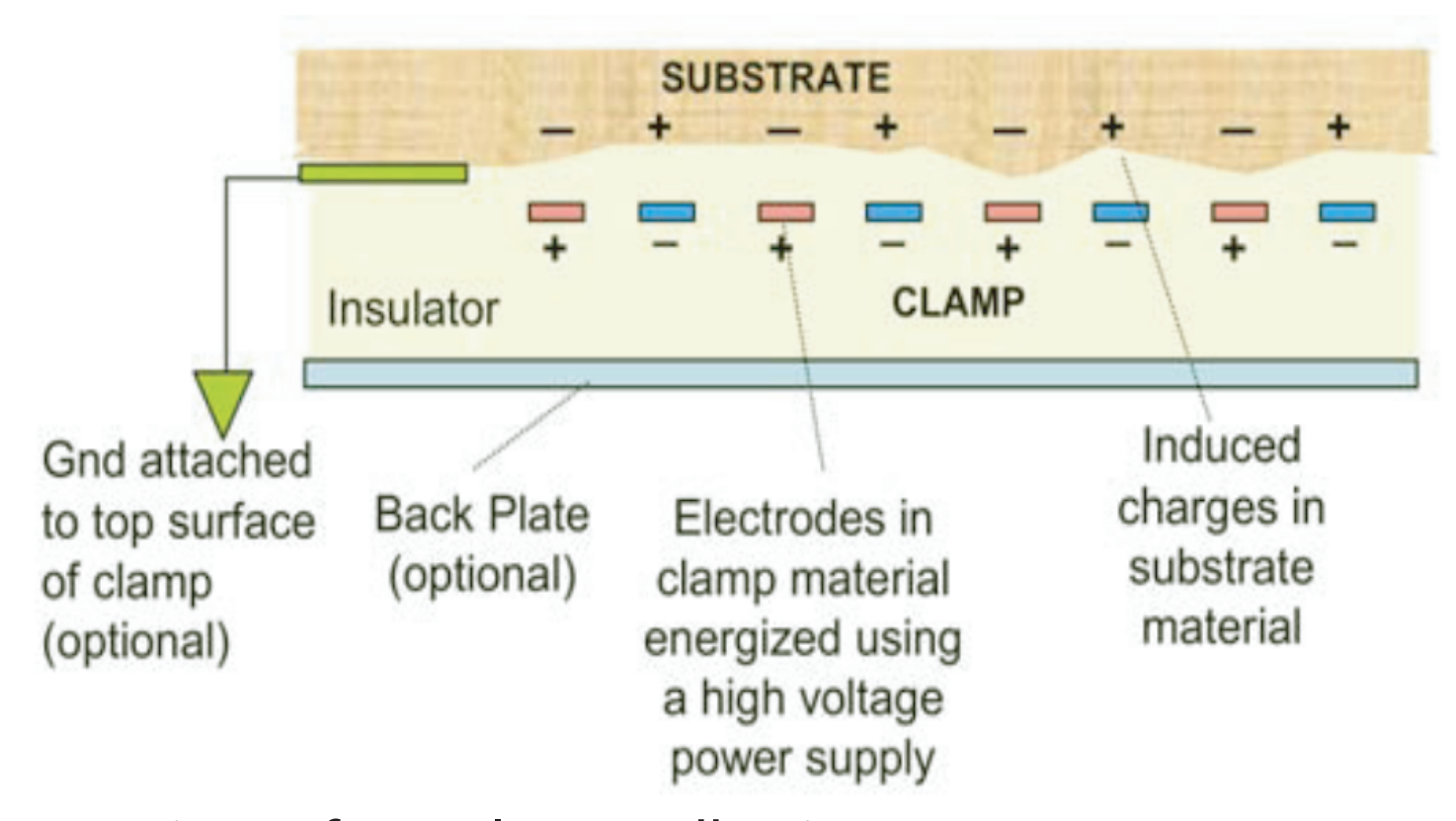


Figure from electroadhesion paper
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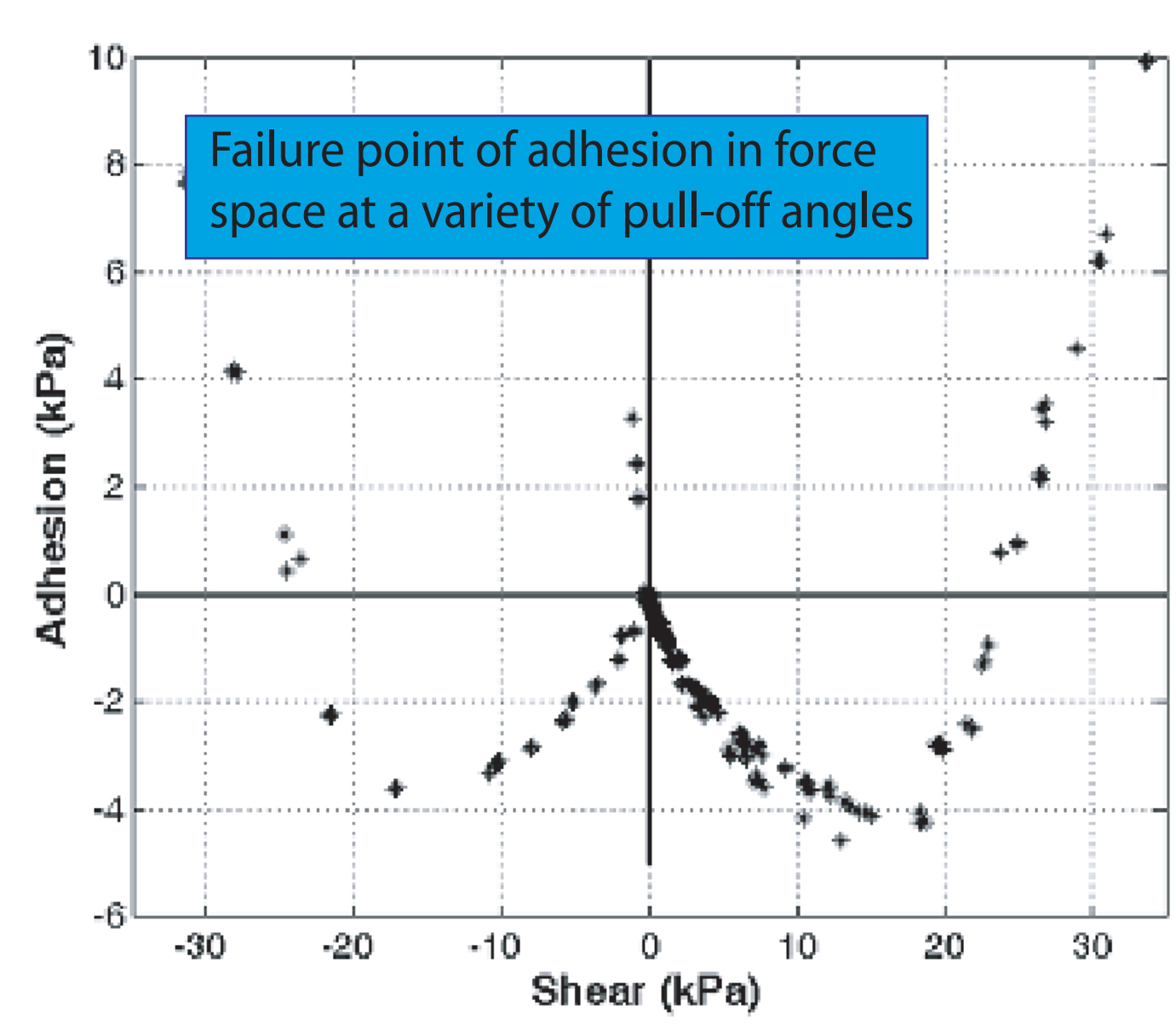
Strengths

- Adheres to any material
- Works on rough and smooth surfaces
- Very strong in shear
- Scales well to hold more weight
- Easily Cleaned
- When turned off, very small release force

Weaknesses

- Requires some power to run
- Weak in normal direction
- Weak in peel

Fibrilar Adhesive: Microwedges

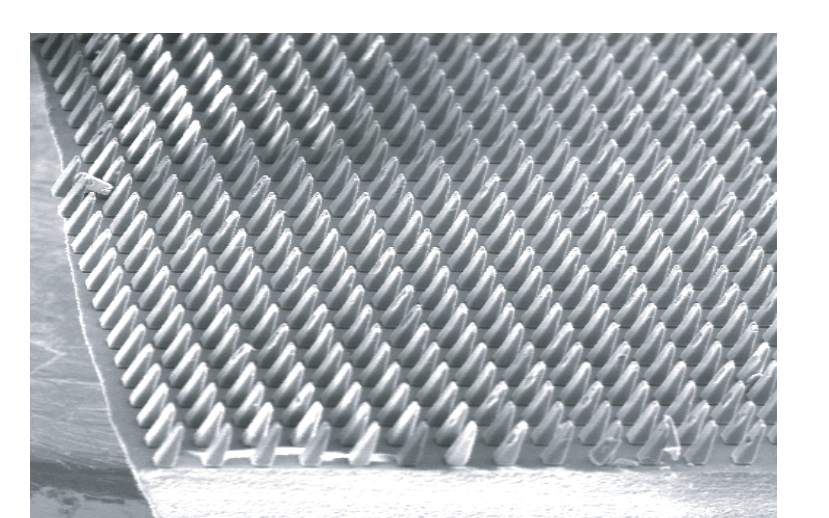


Strengths

- Controllable adhesion allows easy release
- Strong for small patch sizes
- Passive, requires no energy to hold

How it works:

When the patch of wedges are pressed lightly against a surface and then loaded in shear they bend over and present more surface area. The more shear the more surface contact and the more contact the more adhesion due to Van der Waal's Forces.



Sheet of silicone Microwedges with 50 micron square bases

Weaknesses

- Very sensitive to alignment with surface
- Do not scale well because of alignment problems
- Only work on smooth surfaces

Electroclamped Microwedges

Why Combine the Two?

A hybrid may allow for a combination of the strengths and cancelling of the weaknesses of the two existing technologies on their own:

1. The sensitivity of microwedges to alignment can be addressed with the ability of the electroadhesive force to conform tightly to almost any surfaces.
2. While resting power could be saved by shutting off the electroadhesion and relying only on microwedges.

Adhesive Force Testing

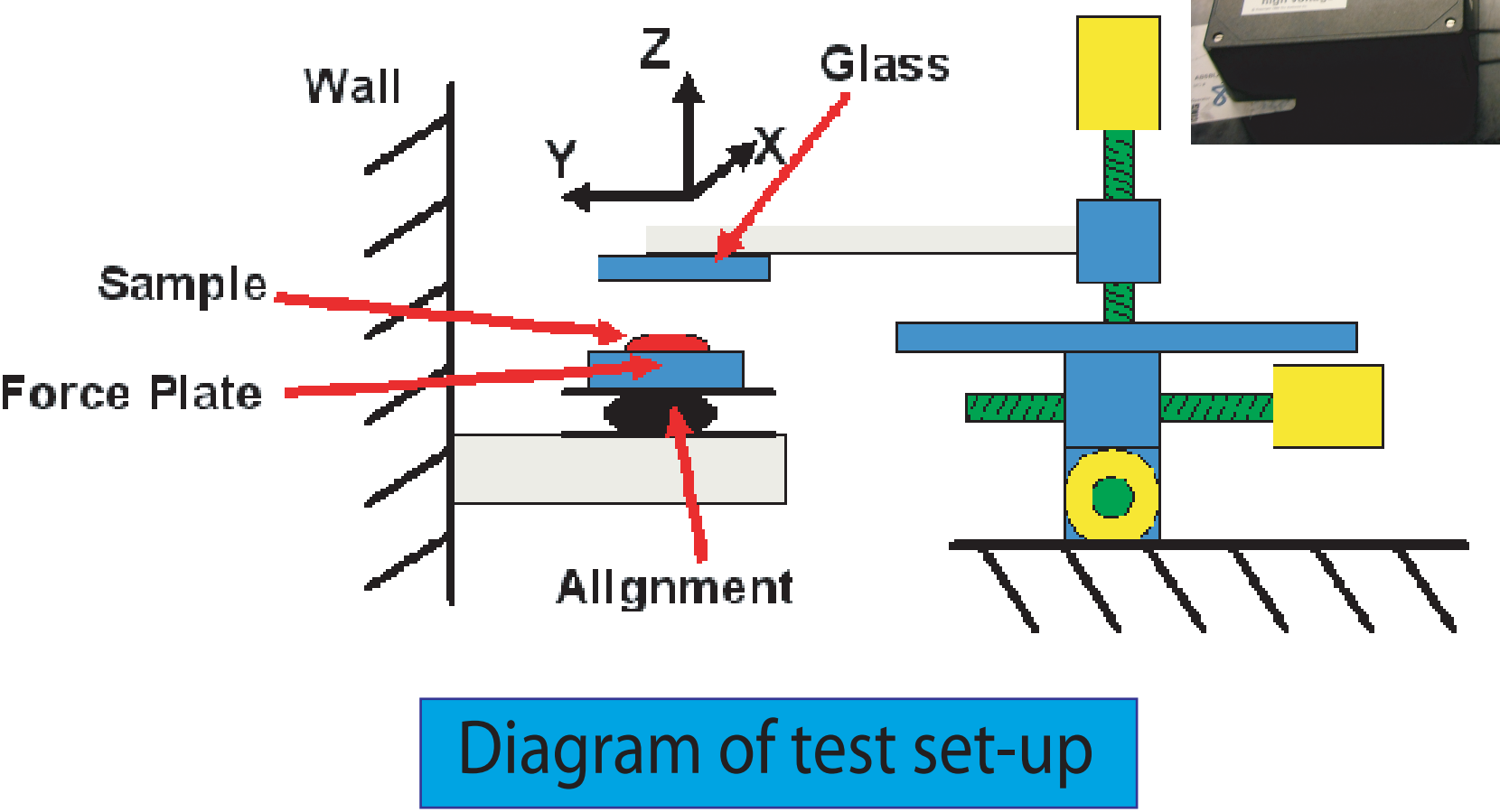
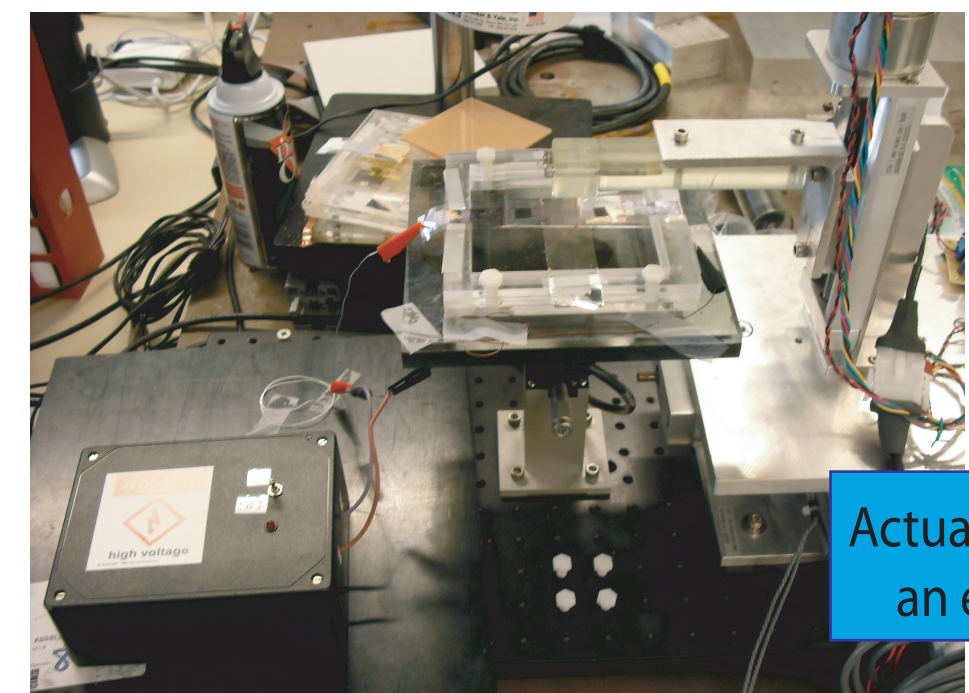
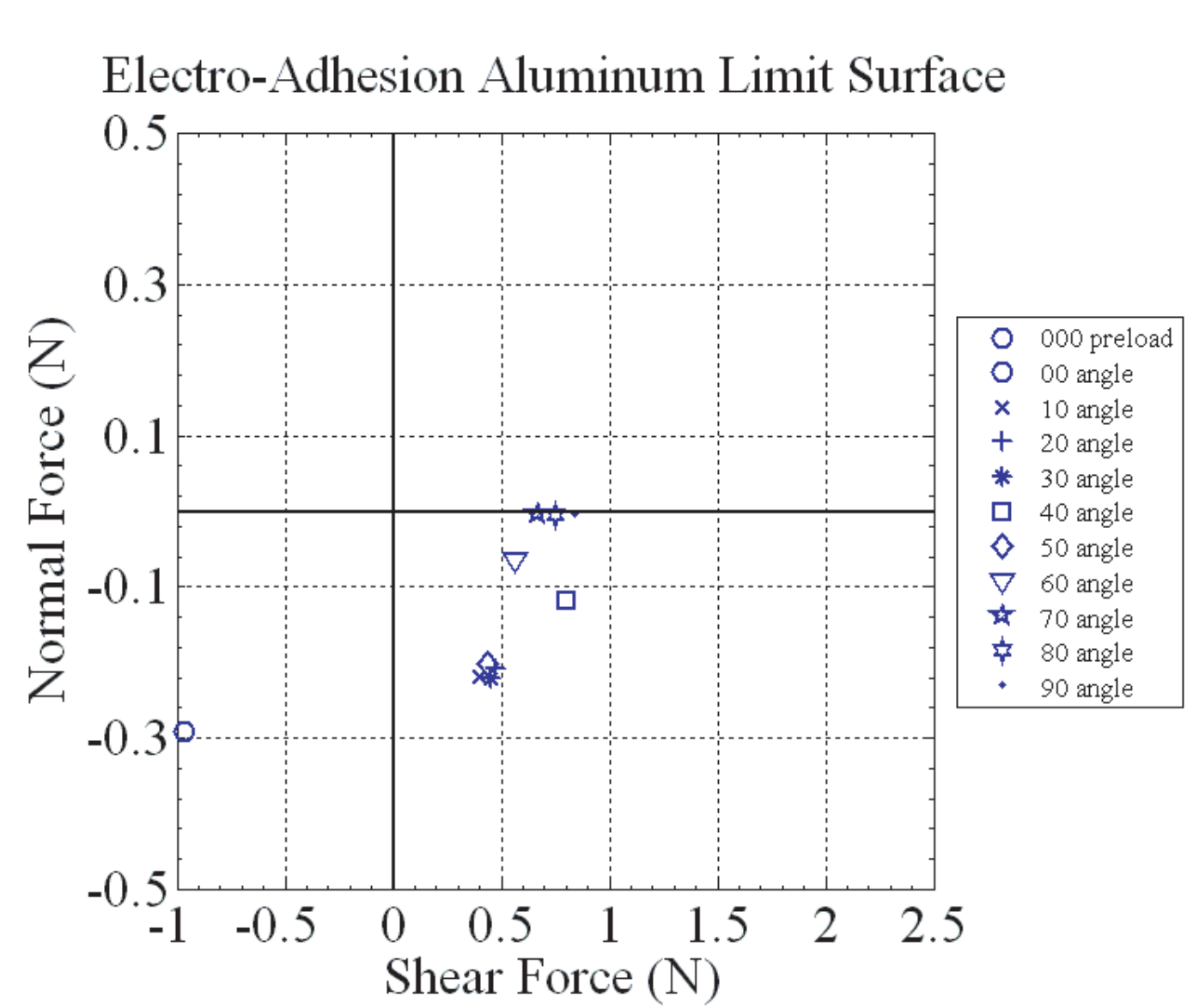
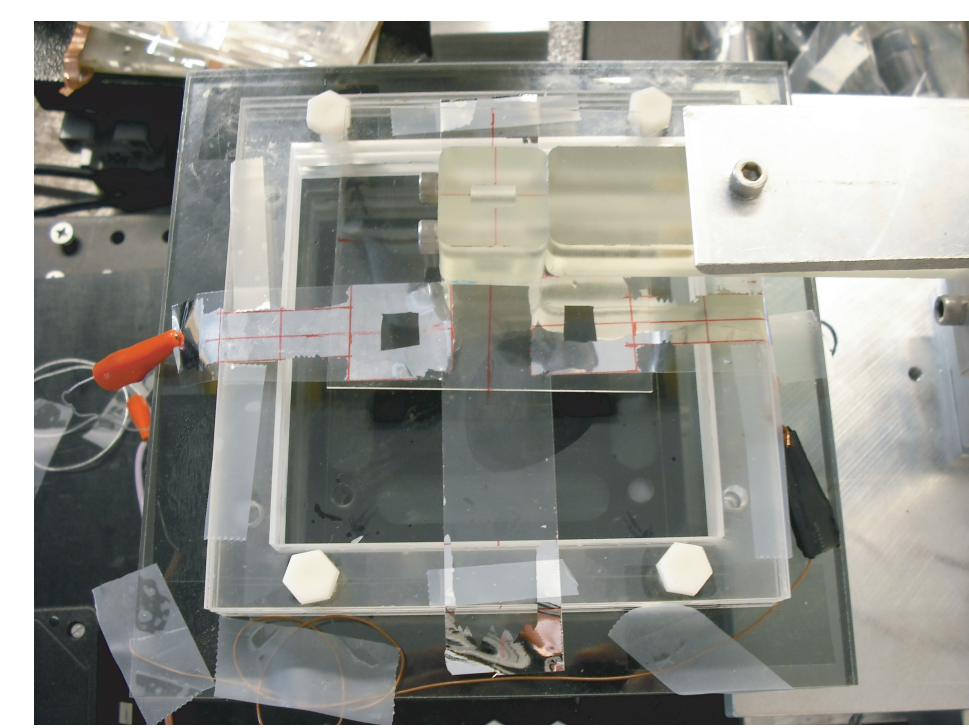


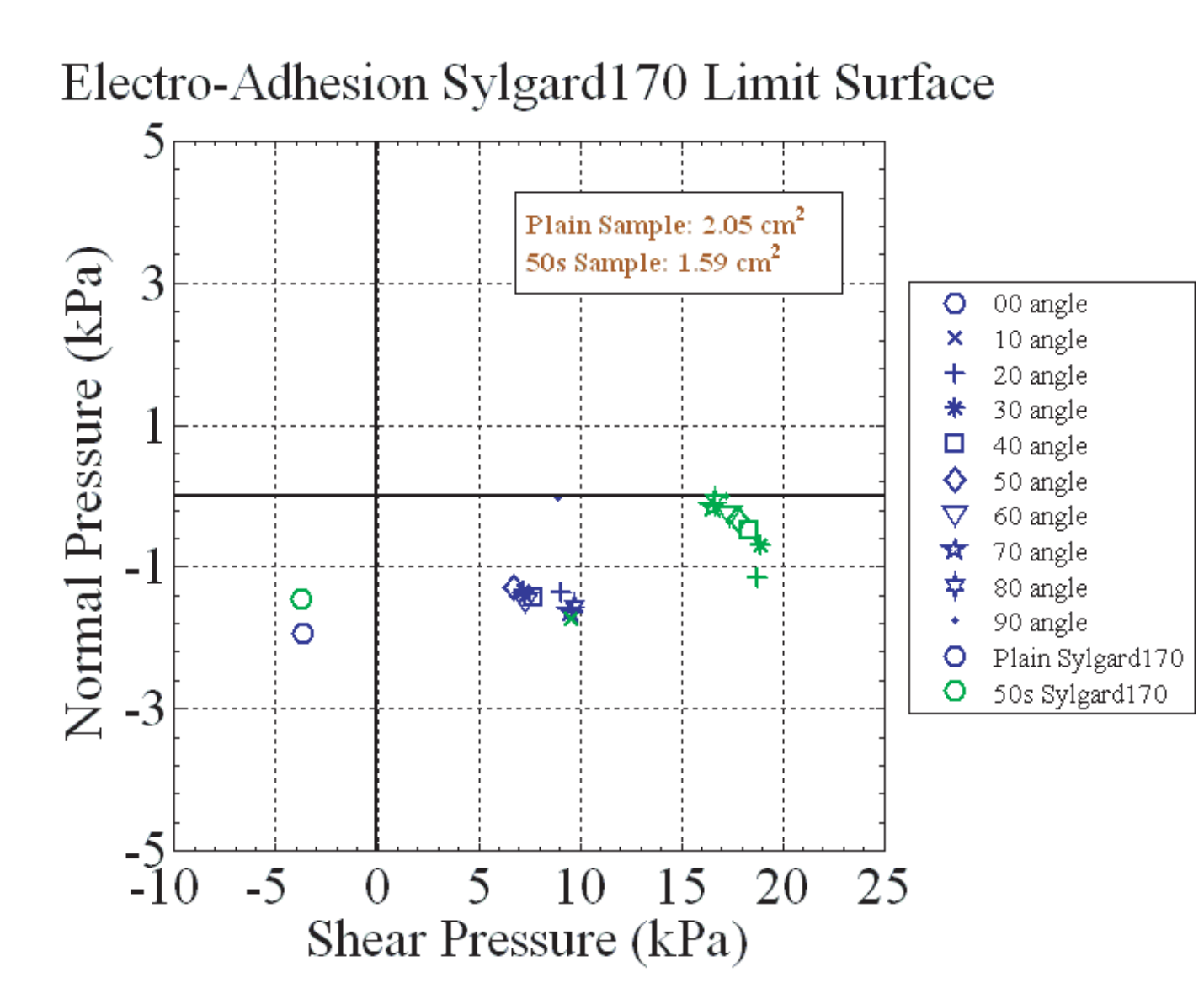
Diagram of test set-up



Actual test set-up with Microwedges on an electroadhesive flexible backing

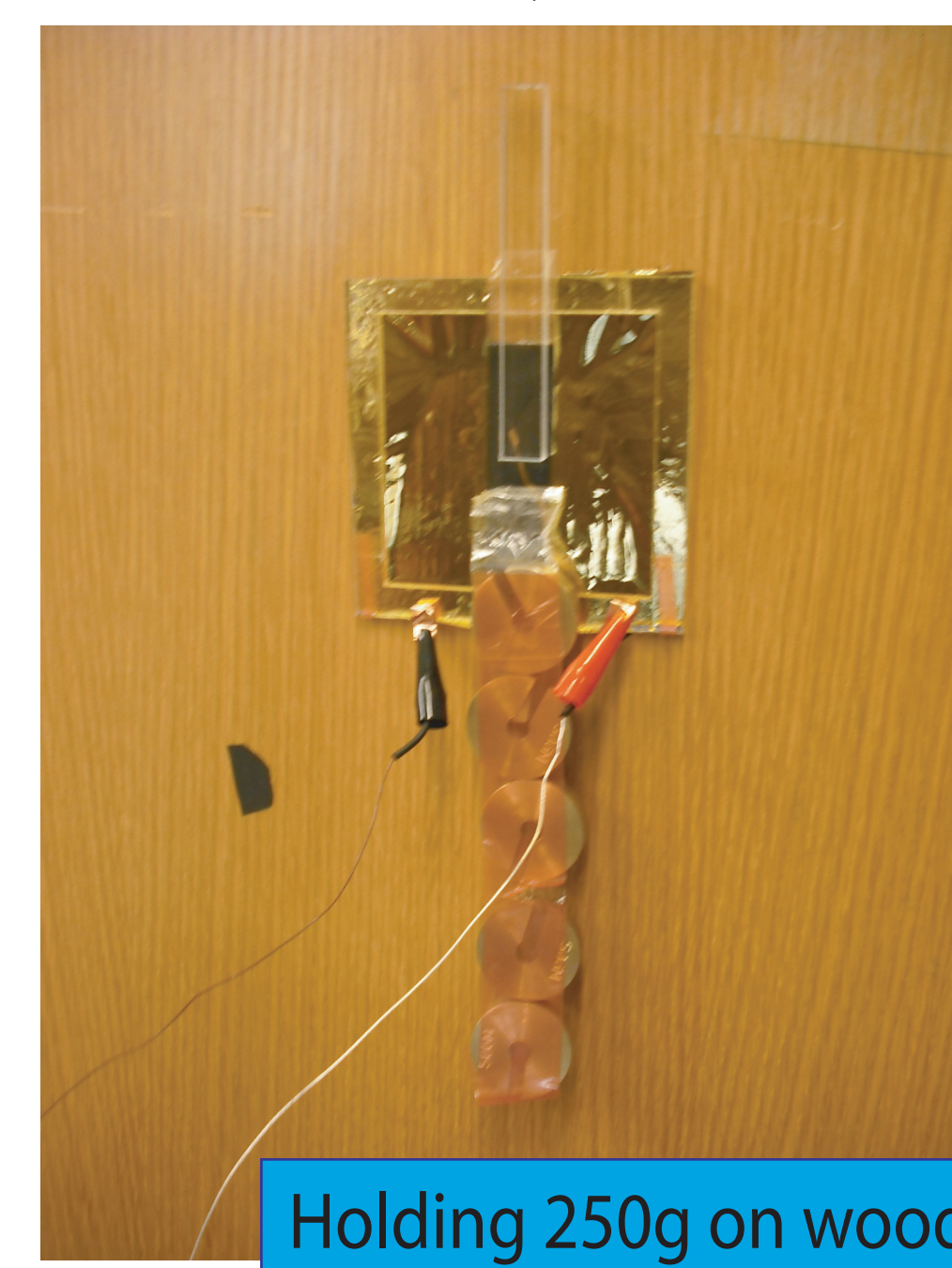


Adhesive failure points of a thin film with two aluminized patches charged at 10kV at various pull-off angles



Adhesive failure points of a flat silicone (blue) and a Microwedge (green) sample mounted on the aluminized film at various pull-off angles

Microwedges pressed against surface by electroadhesive clamping



Holding 250g on wood door

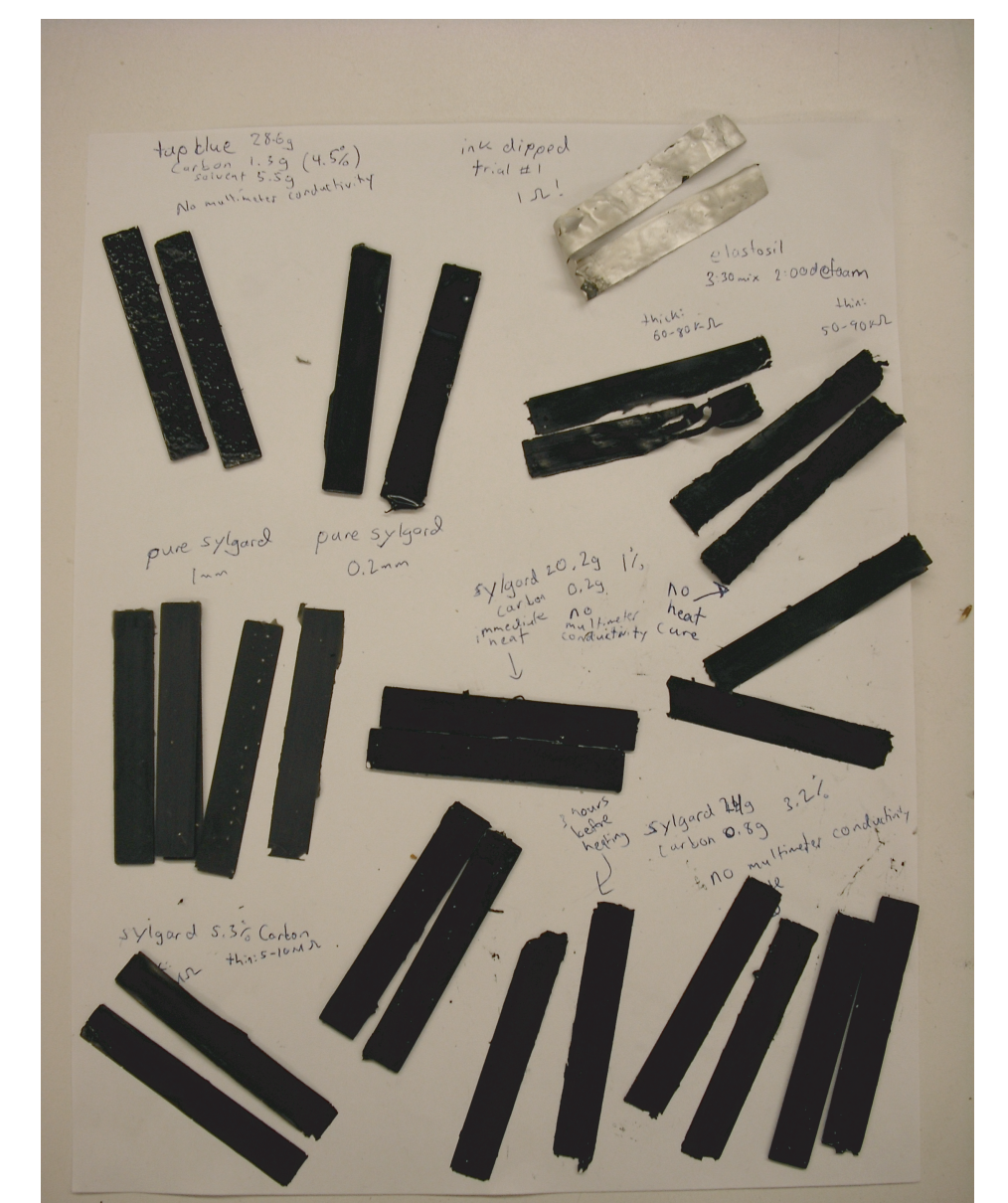


Holding 300g on glass

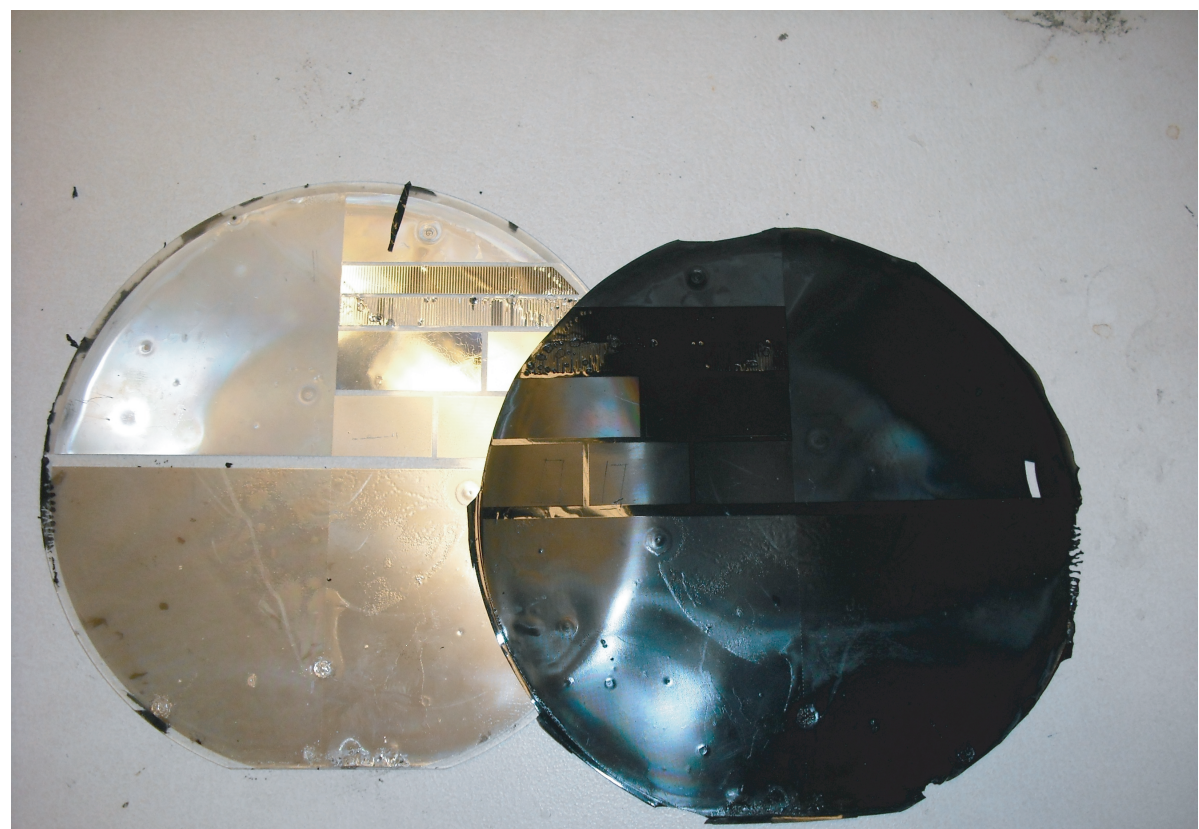
Conductive Microwedges could adhere even better than just a conductive backing



Electroadhesive strength test



Developing conductive silicone for conductive microwedges



Successful casting of conductive microwedges with 3% carbon doped sylgard 170

*H. Prahlad, R. Pelrine, S. Stanford, J. Marlow, R. Kornbluh. "Electroadhesive Robots – Wall Climbing Robots Enabled by a Novel, Robust, and Electrically Controllable Adhesion Technology" in 2008 IEEE International Conference on Robotics and Automation Pasadena, CA, USA, May 19-23, 2008.