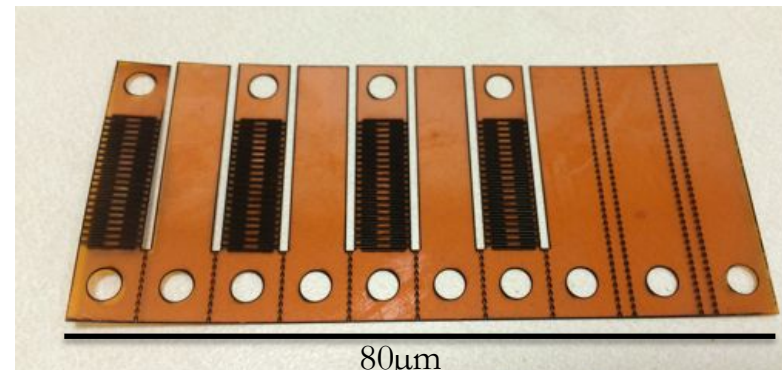
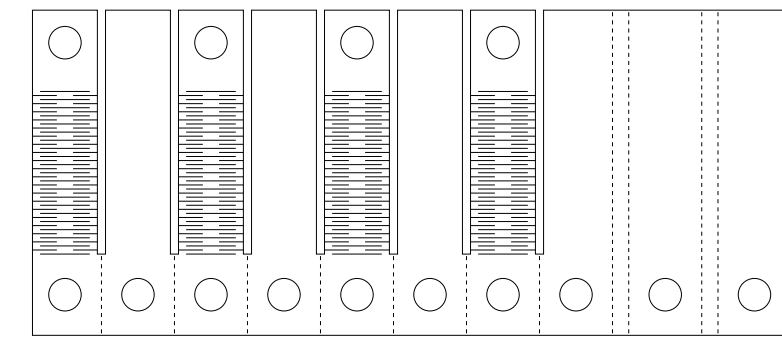
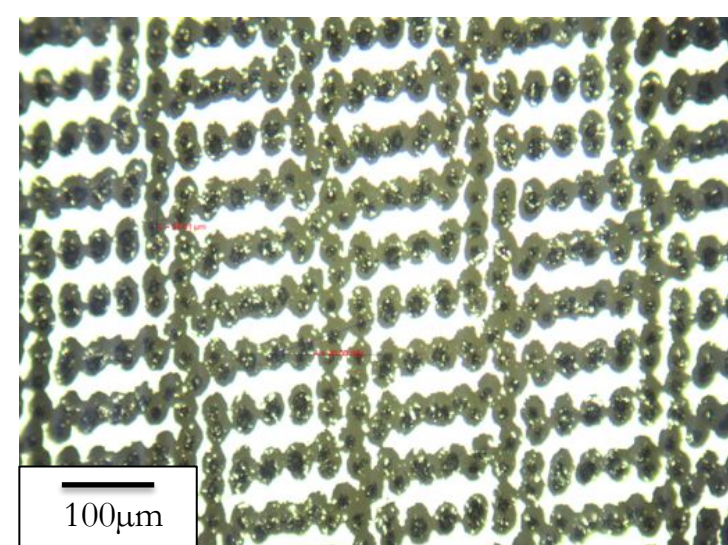


Laser Overview

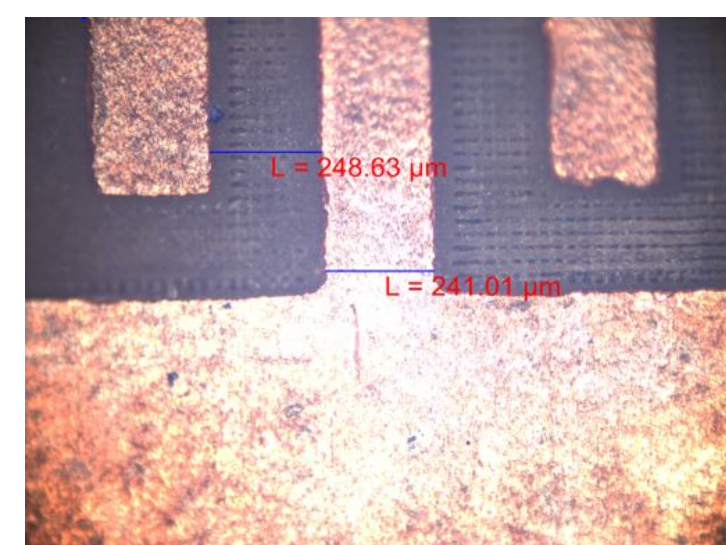
The BDML's new UV laser cutter has been central to my work this summer. The laser emits short pulses of energy (30-120kHz) to ablate material, and can cut through most materials <500µm thick. With a kerf width around 50µm and the ability to perform variable depth cuts, this tool is capable of creating remarkable designs.



UV laser example cut on Kapton (polyimide film)



Microscope image of fill pattern on metallized Mylar (polyester film)



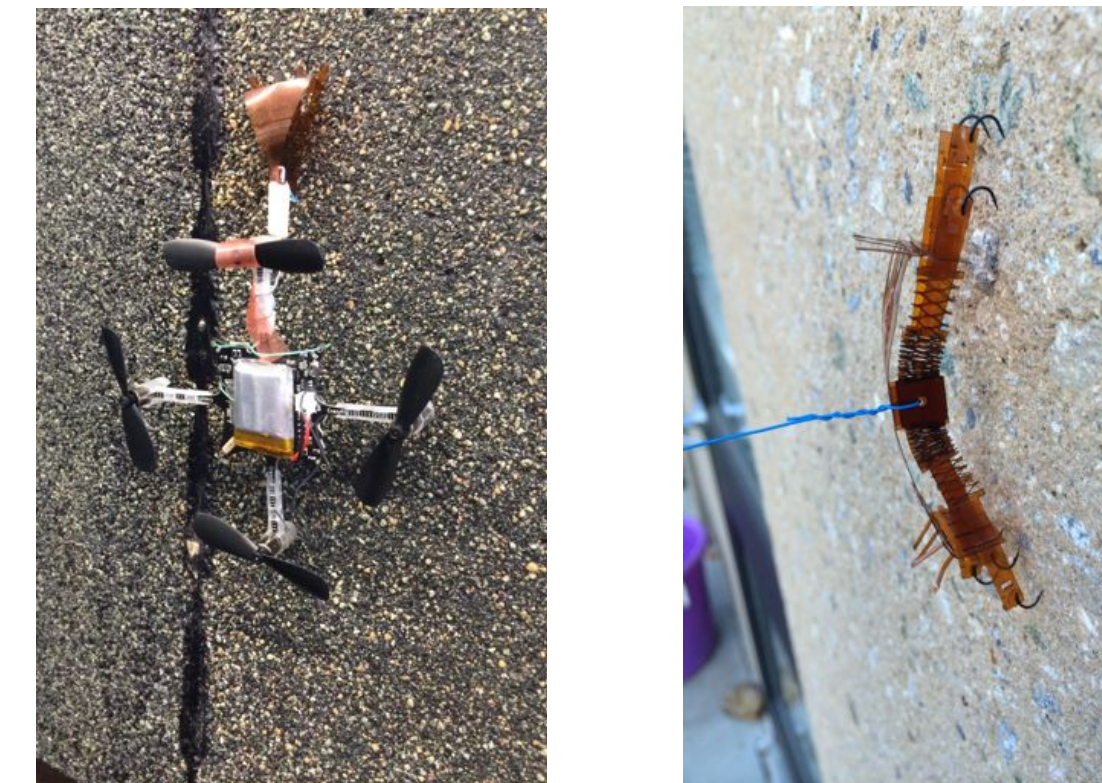
Microscope image of laser-etched copper-coated Kapton

The Crazyflie

At just 19 grams and 9 cm from motor to motor, the Crazyflie quadrotor is a great platform to attempt perching on rough vertical surfaces. Fully open source software/firmware allows us to program custom flight maneuvers. I used the UV laser to cut small, lightweight perching grippers out of Kapton film, with spines (fishhooks) attached on the ends.



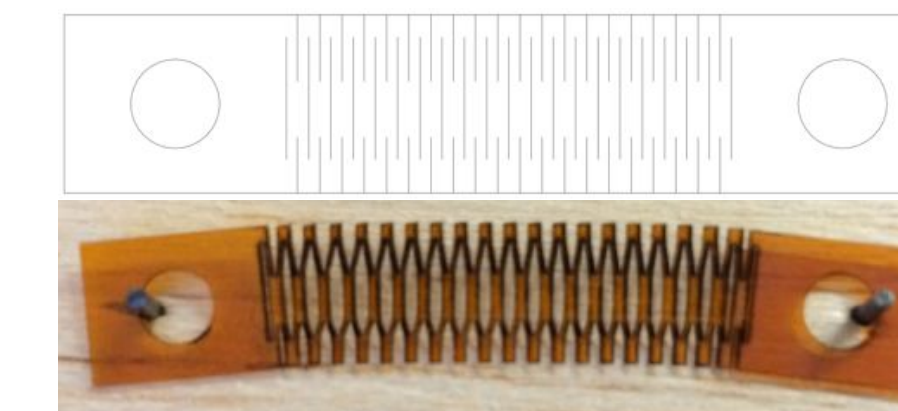
Quadrotor Perching on Rough Surfaces



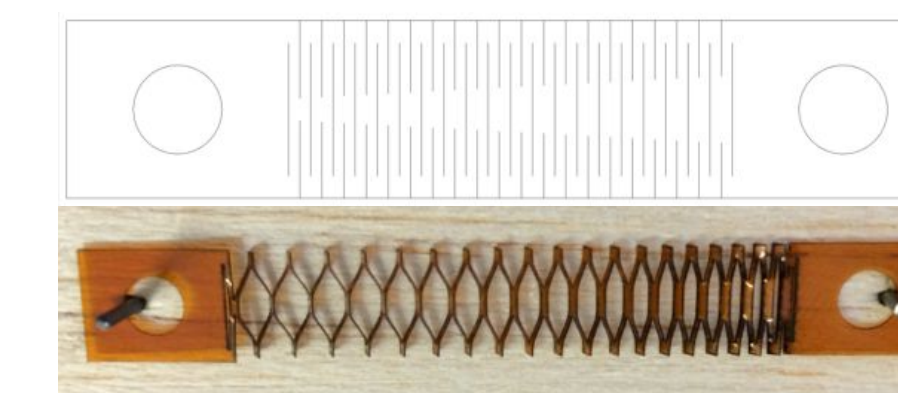
Pictured above are two versions of the perching system. Both designs include a spring for each spine, allowing them to engage with the surface independently. Both designs are cut from a single piece of film and folded into shape. The opposed gripper (right) can withstand additional normal force, making it well suited for overhangs but more difficult to detach.

Experimental Springs

Inspired by the Kapton perching systems I made for the Crazyflie, I tried out some novel laser-cut spring designs.



(Top) Variable lateral strength in the plane of the spring; (Bottom) Variable longitudinal strength

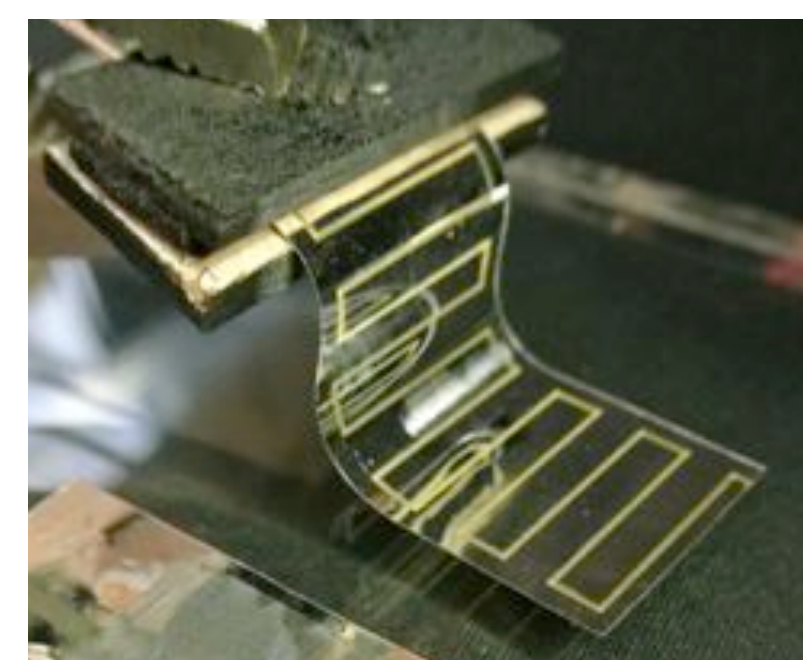
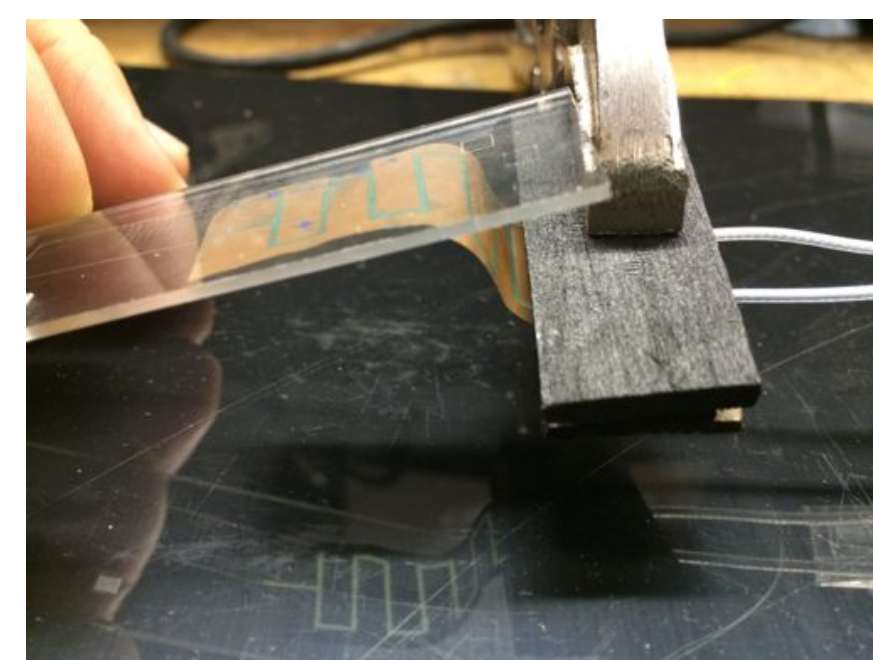


Pictured above is a self-supported spring with integrated spines, cut from a single piece of Kapton film. This design is noteworthy as it demonstrates the ability to achieve three distinct features (rigid body, spring, and spines) with one material and one cut.

Electrode Patterning for Adhesion and Sensing

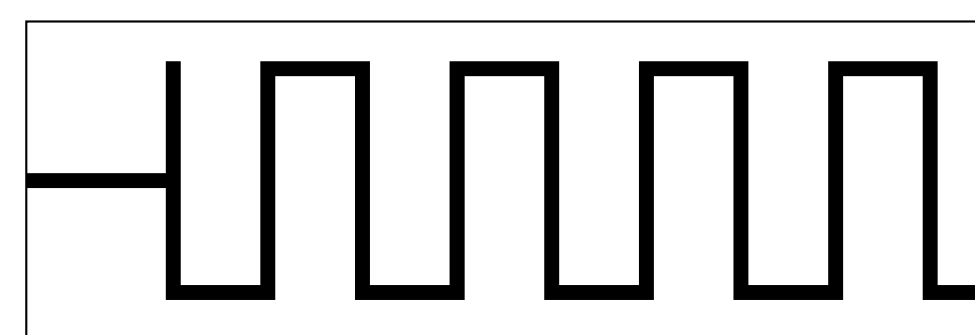
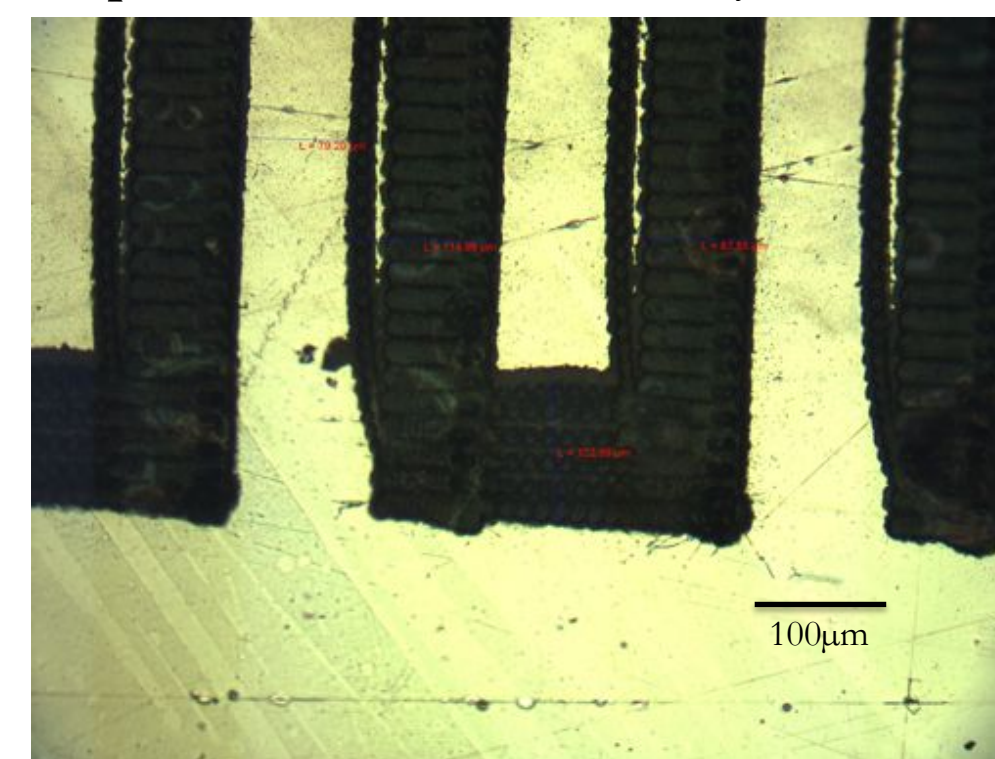
Electrostatic Adhesion

A few years ago, the BDML developed a gecko-inspired directional adhesive made famous by the StickyBot. New research has shown that the gecko adhesive technology can be enhanced with electrostatic adhesion. I was able to achieve adhesion using two composite materials with custom designed and manufactured electrodes.

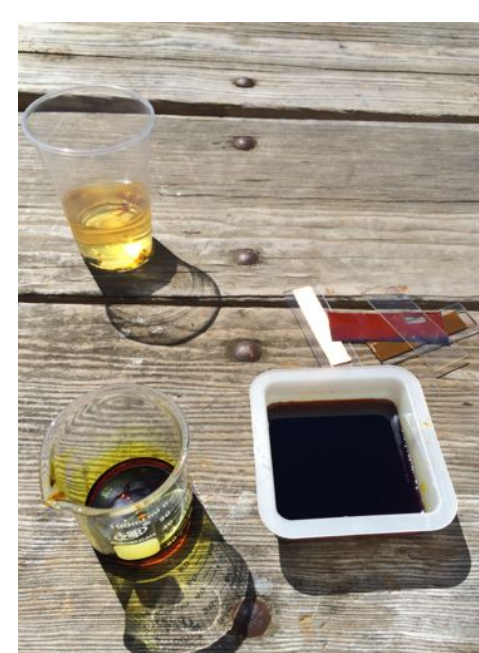


Capacitive Sensing

Capacitive sensing works when an object causes the sensor's equilibrium capacitance to change. I recreated this effect by etching a fine electrode pattern on metallized Mylar film. Preliminary testing showed slight changes in capacitance, but further analysis and experimentation is necessary.



(Above) Electrode design informed by existing research on optimizing geometry; (Right) Chemically etching copper-coated Kapton using ferric chloride



The copper-coated Kapton (upper left) electrode is manufactured as follows:

- apply paint to mask the copper
- selectively remove the paint with the laser
- chemically etch the exposed copper
- remove the remaining paint with acetone

The metallized Mylar electrode (upper right) is directly patterned with the laser.

Future Work

Electrostatic Adhesion

- refine and streamline the manufacturing process
- integrate the electrodes into the silicone-casted gecko adhesive.

Capacitive Sensing

- Experiment with varied electrode designs in controlled settings

Quadrotor Perching

- refine the design for consistent perching with broad initial conditions
- integrate with sensing to detect successful and failed perches
- capture a video demonstrating a robust quadrotor perching system

Experimental Springs

- continue to experiment with the laser and push the limits of what designs are possible with this powerful tool

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