MANCHESTER 1824

The University of Manchester

Webswinging Robot

Introduction

- Traditional locomotion techniques such as legged, wheeled robots and drones, get stuck in certain environments. Which was the motivation to introduce new locomotion technique.
- Webswinging robot move by producing a rope with a hook that can attach to objects. If the hook does not adhere to the object, this will limit the rope attachment to only pipes or similar objects. With no ability to attach to flat surfaces like a wall.
- If the hook has an adhesion mechanism, the rope can be attached to flat surfaces. Using the same principle the robot it self can adhere to the objects which means a wall climbing robot.

Aims and Objectives

The aim of the project is to have a robot that can climb vertical surfaces. Electroadhesion was chosen as the adhesion mechanism to the wall.

Objectives

- Optimize the pad to improve the force generated.
- Fabricate the pad since it is not commercially available.
- Build a test rig to test the pad.
- Analyse the forces on the robot, to predict the area required by the electroadhesive pad.
- Design the robot using SolidWorks.
- Build the robot and test it.

Electroadhesion

What is electroadhesion?

It is the ability to produce a force when high voltage (>1kV) is applied to an electroadhesive pad. The force in conductive substrates is caused by charges in the pad attracting their opposite charges in the substrate. In non conductive substrates, because charges are locked in the atoms, the force is based on polarization.

Why electroadhesion?

Work on almost all surfaces, needs low power, does not cause noise, has fast response and easy to control.

2D and 3D electrostatic simulation

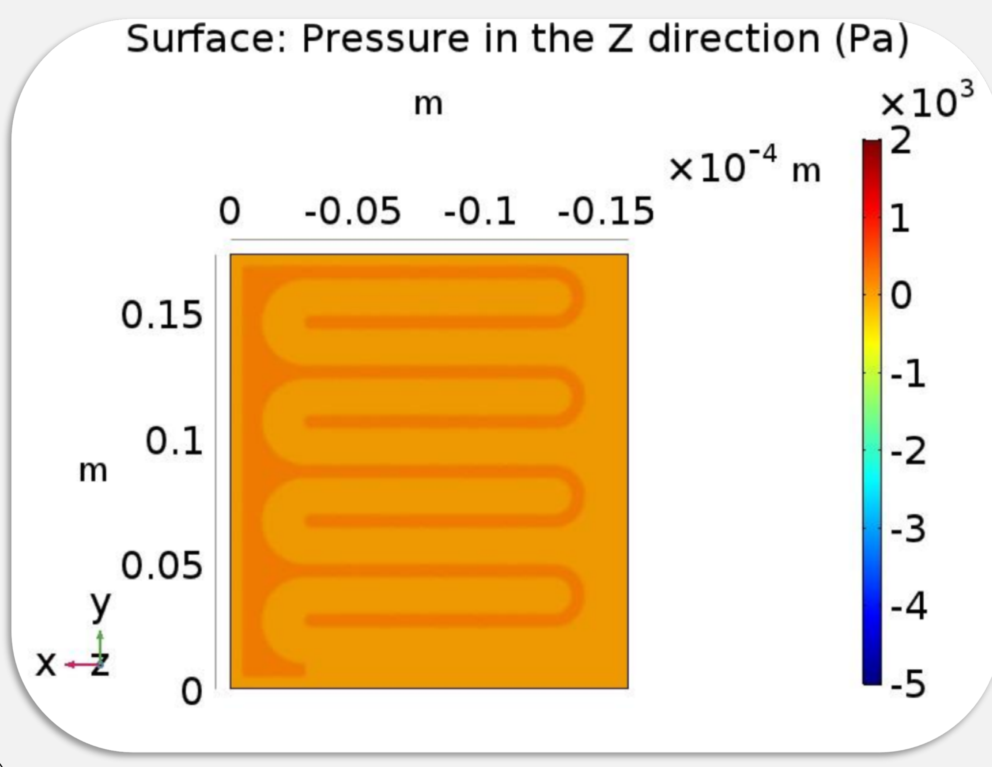

Figure 1: Maxwell stress in the substrate

- Electroadhesion has more than 33 variables affecting the force generated.
- Some of theses variables such as the electrode width, gap between electrode, etc are chosen during the design process.
- 2D and 3D electrostatic simulation was developed in Comsol Multiphysics for pad variables optimization.

Pad Structure and Fabrication

- The electrode layer is designed in Altium designer.
- Based on UV light etching techniques the electrode and insulator layers are fabricated.
- The coating layers are then adding using Polyurethane spray.
- The pad is then dried in vacuum oven to remove air bubbles from the coating.

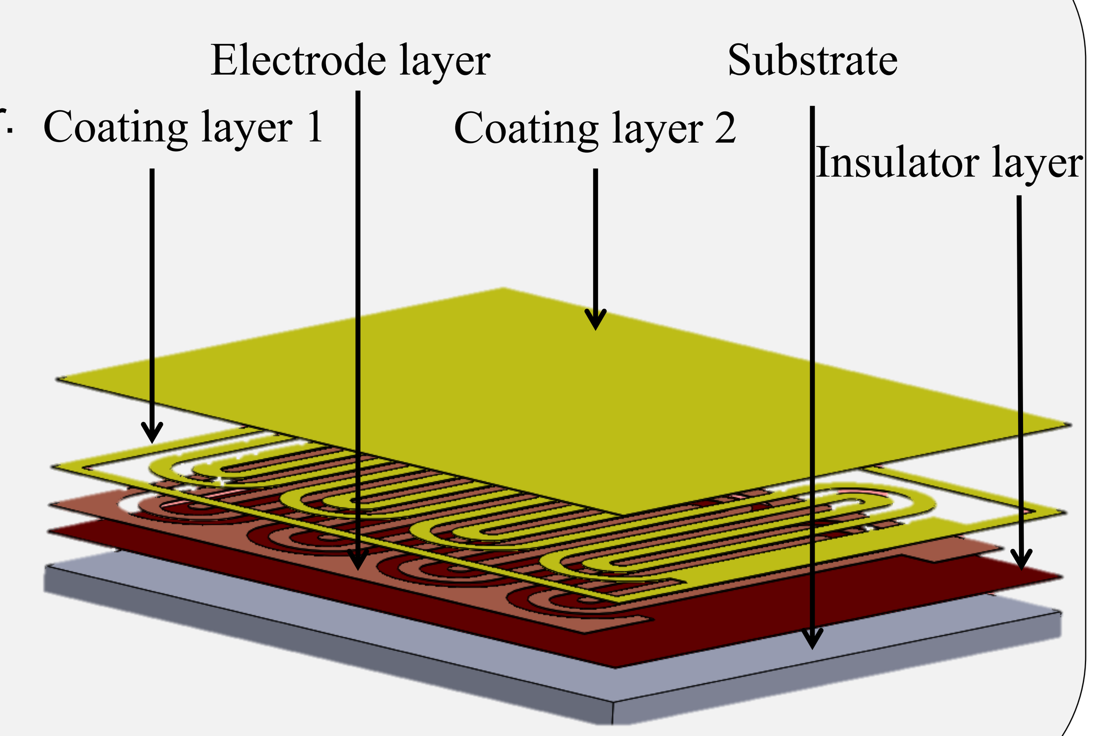

Figure 2: Pad Structure

Test

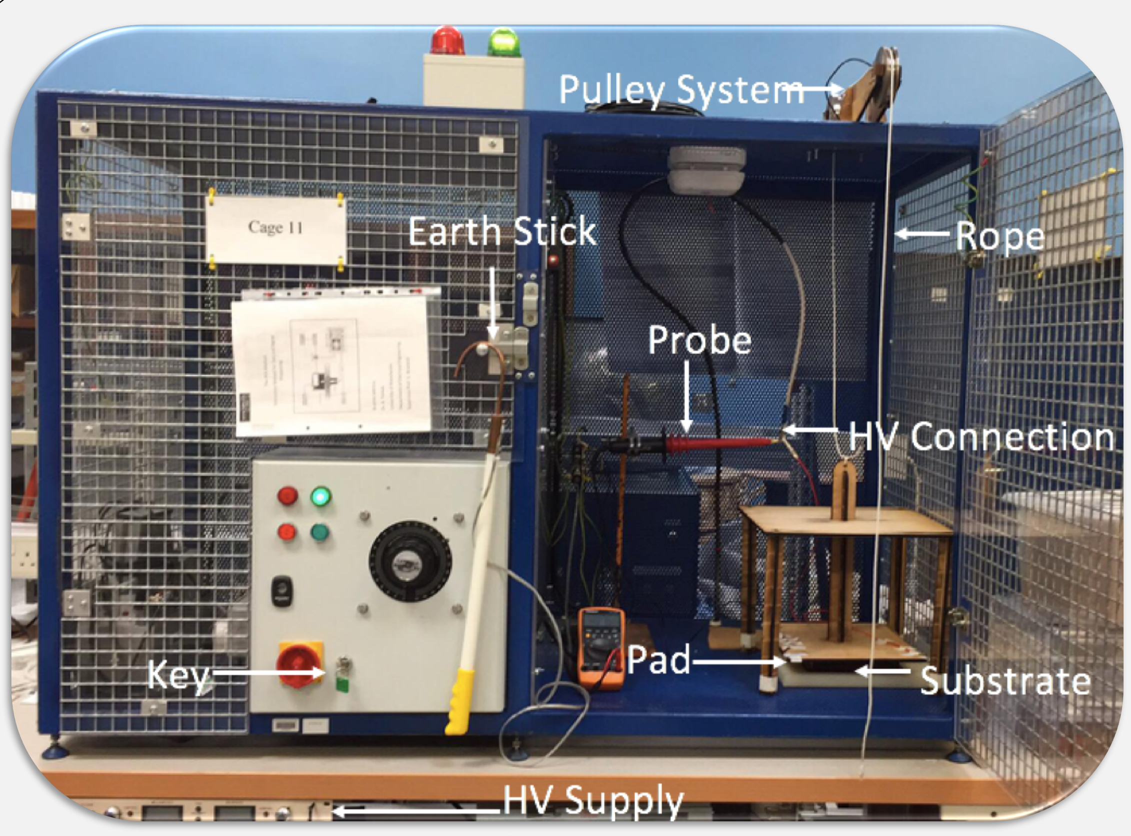

Figure 3: Test rig

Because of the high voltage applied to the pad, safety interlock system was used to test the pad.

Pulley system was used to allow the pad to be moved from outside the cage, the purpose of the test is to quantify the force generated by the pad. This was done by indirect force measurement, where samples of different masses are used to know the maximum force that can be generated by the pad.

Test Procedures

- The pad is placed on the substrate as shown in figure 3.
- The cage door is closed, and the interlock system is turned on.
- The voltage is increased to the required voltage.
- The rope is pulled to check if the pad lifted the substrate.
- Figure 4 shows an electroadhesive pad raising wood substrate.

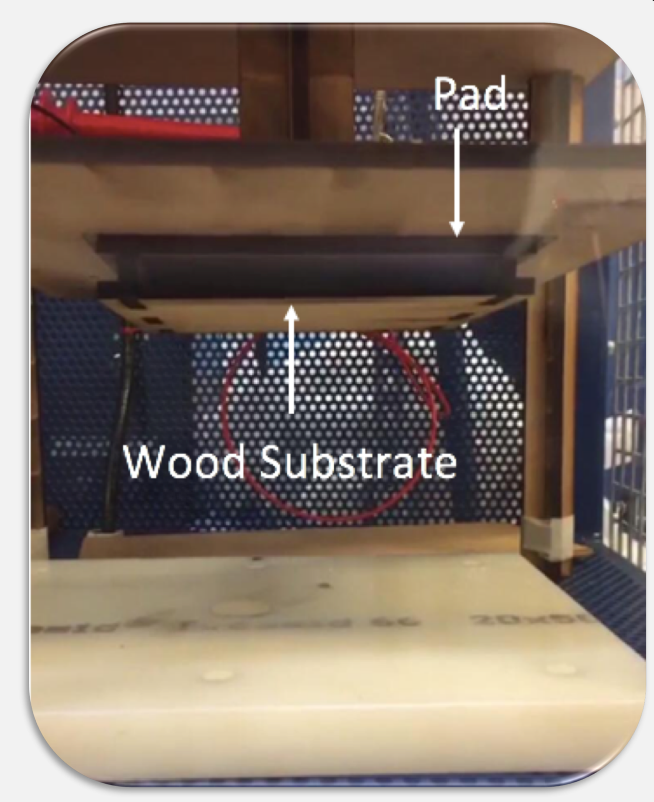

Figure 4: Pad lifting a substrate

Achievements

- Developed 2D and 3D electrostatic simulation for pad optimization and breakdown voltage expectation.
- Designed the pads using Altium designer, two layers were done based on UV light etching techniques, The coating layer was then added using polyurethane spray.
- Tested 7 pads using safety interlock system, the components needed were designed using SolidWorks.
- Developed force analysis on the robot this was used to predict the area required by the pad.
- Designed the robot using SolidWorks as shown in figure 5.

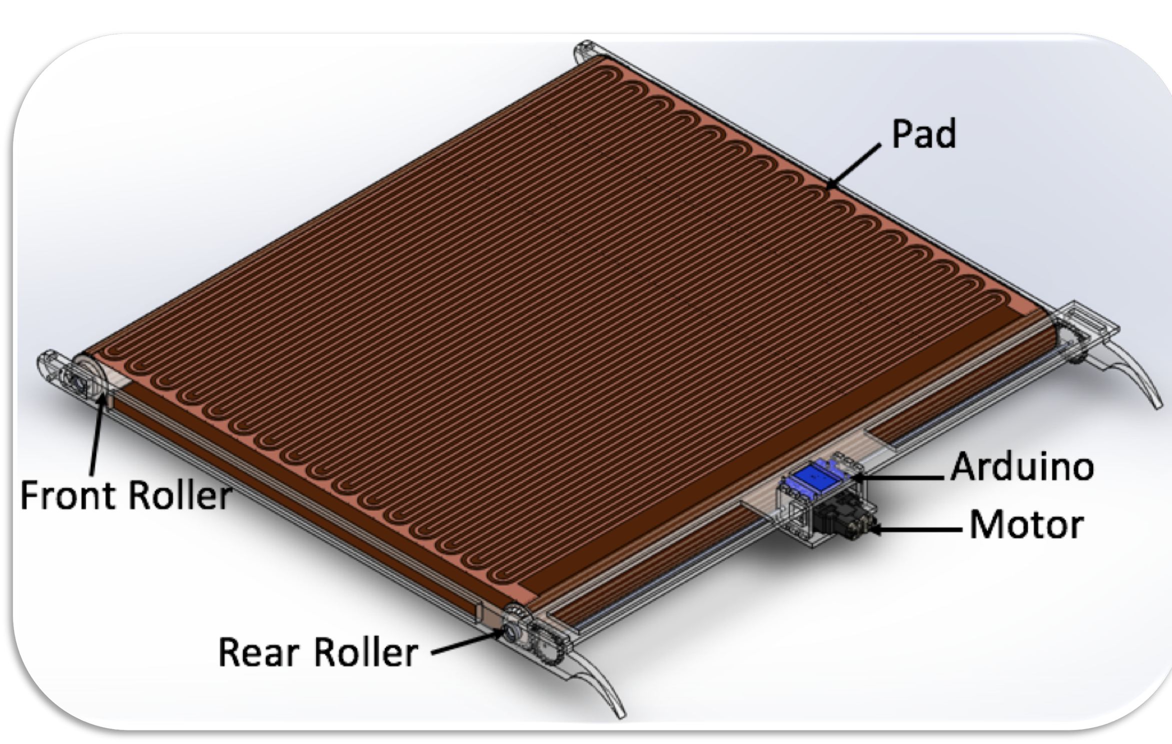

Figure 5: Tracked Robot using Electroadhesion

Conclusion

- UV light etching fabrication produce very sharp edges which can cause dielectric breakdown.
- The pad does not provide any force when the coating layer is not added.
- 46 percentage increase in the flashover voltage was found when vacuum oven was used.
- Vacuum oven does not completely remove air bubbles from the coating layers.
- The pad can provide force up to 86.8 Pa on Wood.
- Different pad sizes do not provide the same force.
- For a tracked robot with 1391 grams, the area required by the pad will be 536000 mm^2.

Meng Mechatronics Engineering (WIE)
School of Electrical and Electronic Engineering
The University of Manchester

Student Name: Nour Elghazawy
Student Email: nour.elghazawy@student.manchester.ac.uk
Supervisor name: Dr. Simon Watson
Supervisor Email: simon.watson@manchester.ac.uk