

# NRI:INT:COLLAB: Soft Active Contact Pads with Tunable Stiffness and Adhesion for Customizable Robotic Grasping

CMMI 1830362



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## Problem Statement & Motivation

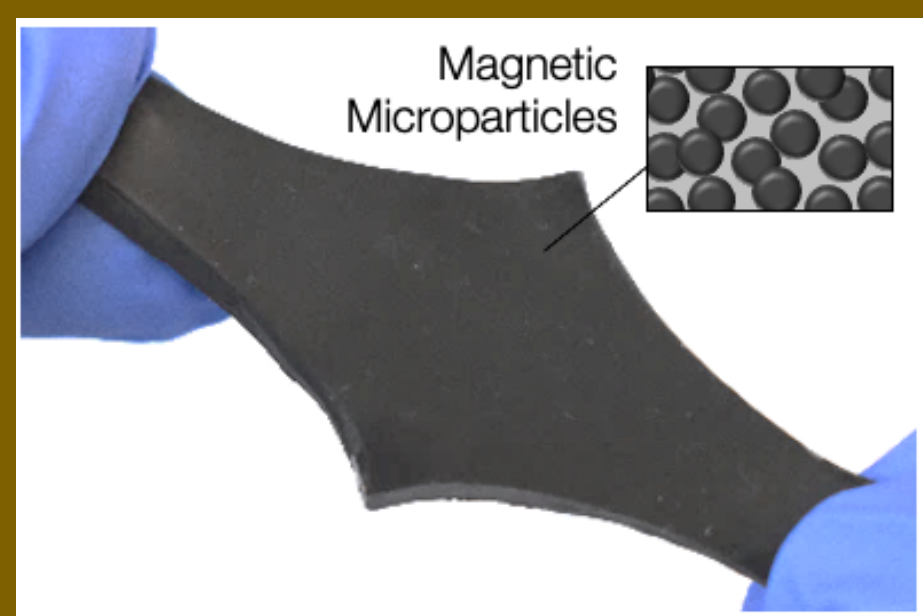
### Universal & Customizable Robot Grasping

Emerging co-robotics require *universal* gripping systems that can match the versatility of natural grippers in handling a wide variety of objects.



Objects from Amazon Picking Challenge 2015 (IEEE Spectrum)

### Our Approach: Soft Active Materials



Soft and rubbery tactile sensing skin  
Hellebrekers et al. *Advanced Intelligent Systems* (2019).

- Polymer composites that dynamically change modulus and adhesion in response to electrical stimulation
- Tactile skin capable of *in situ* sensing of contact and pressure

## Methodology

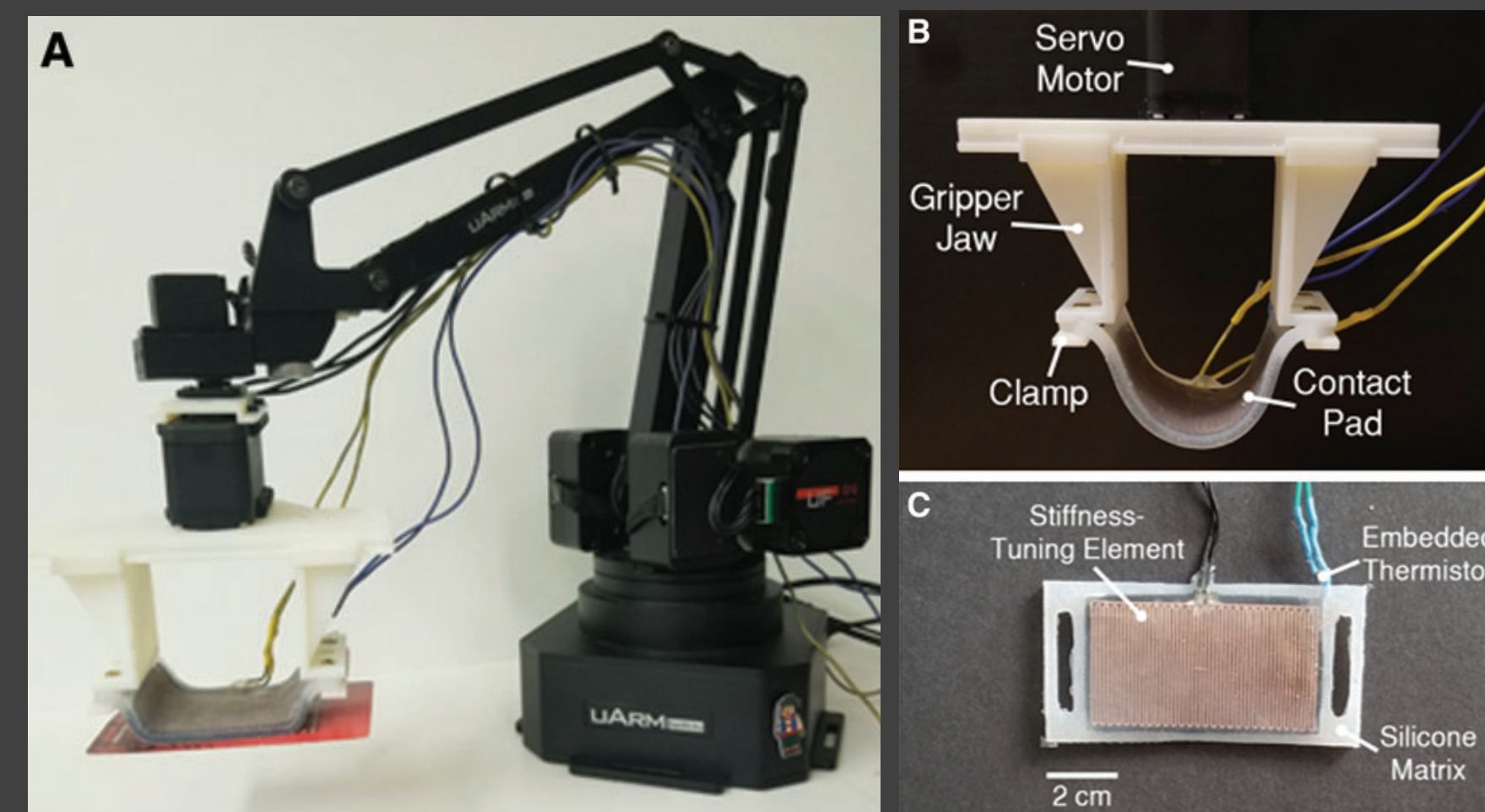
### Robotic Gripper Systems

- Adhesion/stiffness-tuning contact pads mounted on robot end effector.
- Robot grasping tests performed with a conventional wide-face parallel gripper

### Sensing Skin for Monitoring Interfacial Traction

- Objects covered with a tactile skin that will map surface tractions.
- These same materials can also be incorporated into the gripper for contact detection and pressure/force measurement

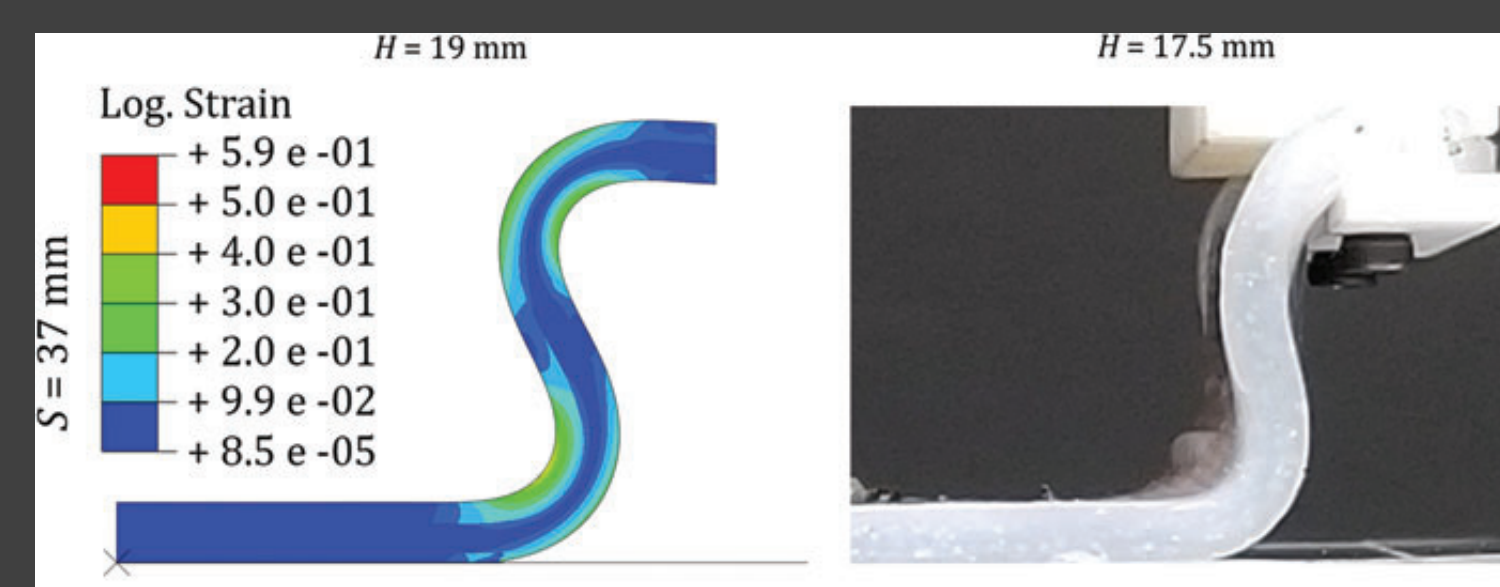
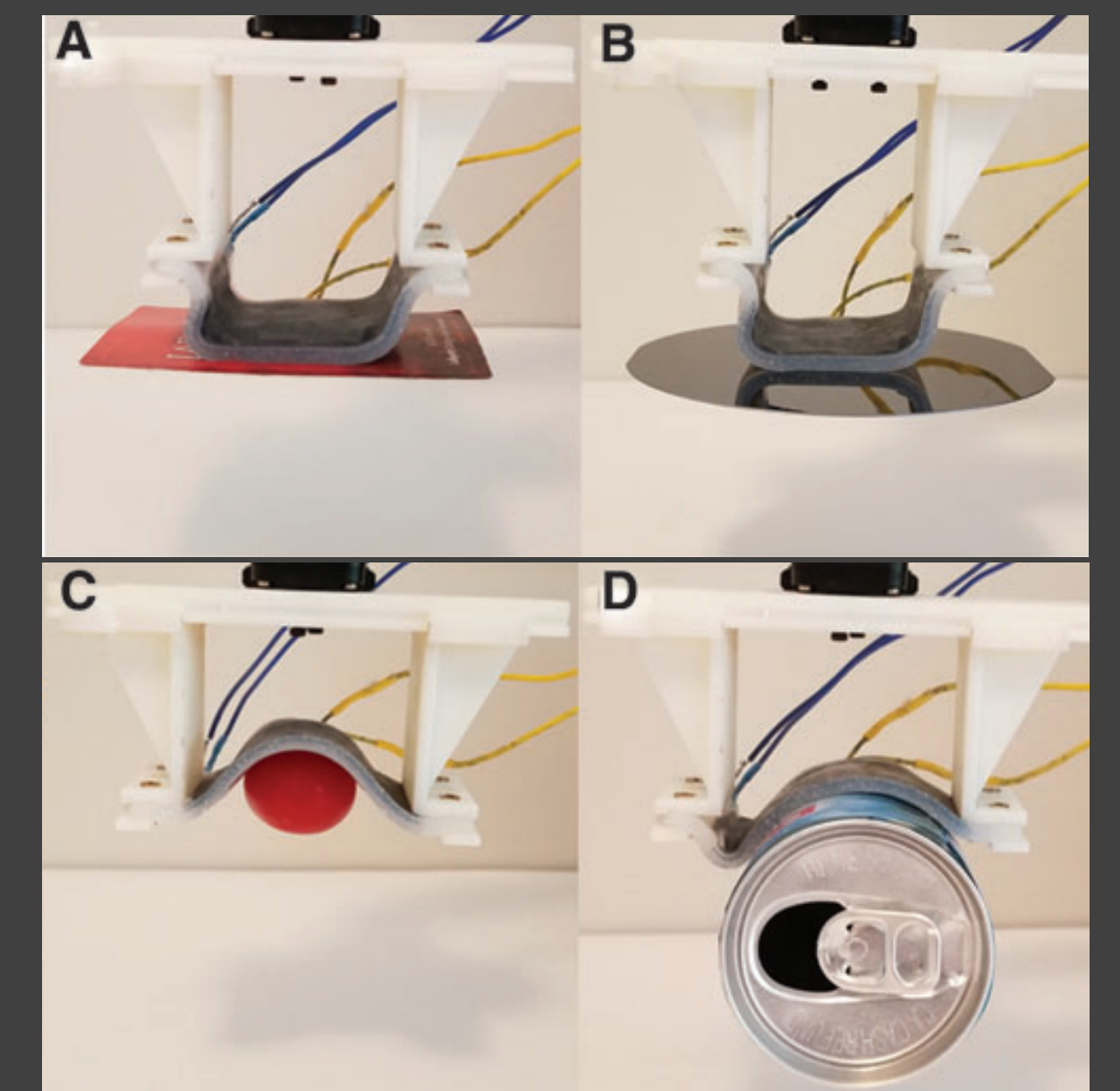
## Research Results



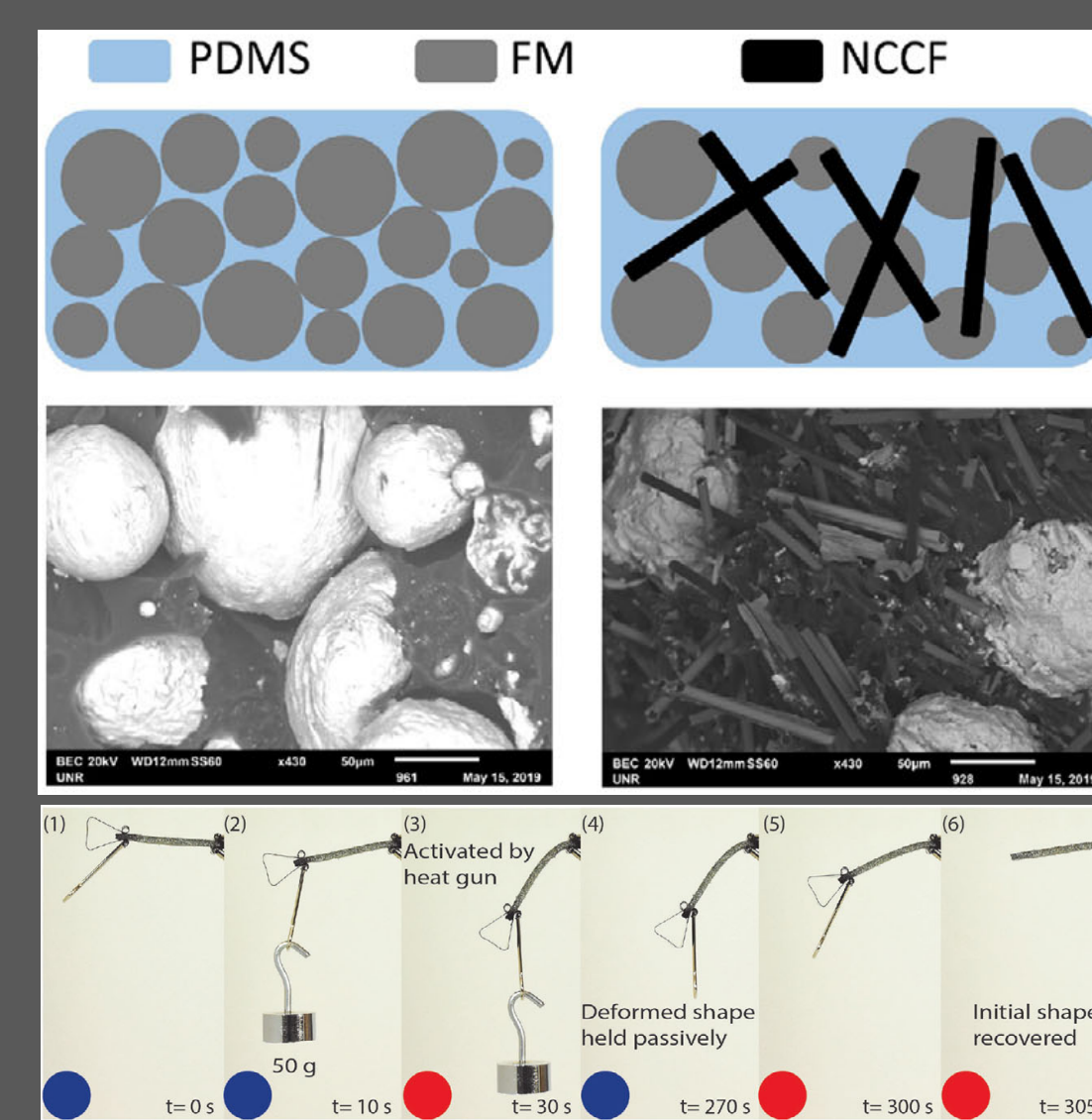
Adhesion & stiffness-tuning material mounted to parallel-plate end effector

Coulson, R., Stabile, C.J., Turner, K.T. and Majidi, C., "Versatile Soft Robot Gripper Enabled by Stiffness and Adhesion Tuning via Thermoplastic Composite," *Soft Robotics* in press (2021).

Soft active material allows the gripper to conform to objects of varying geometry for controlled pick-and-place

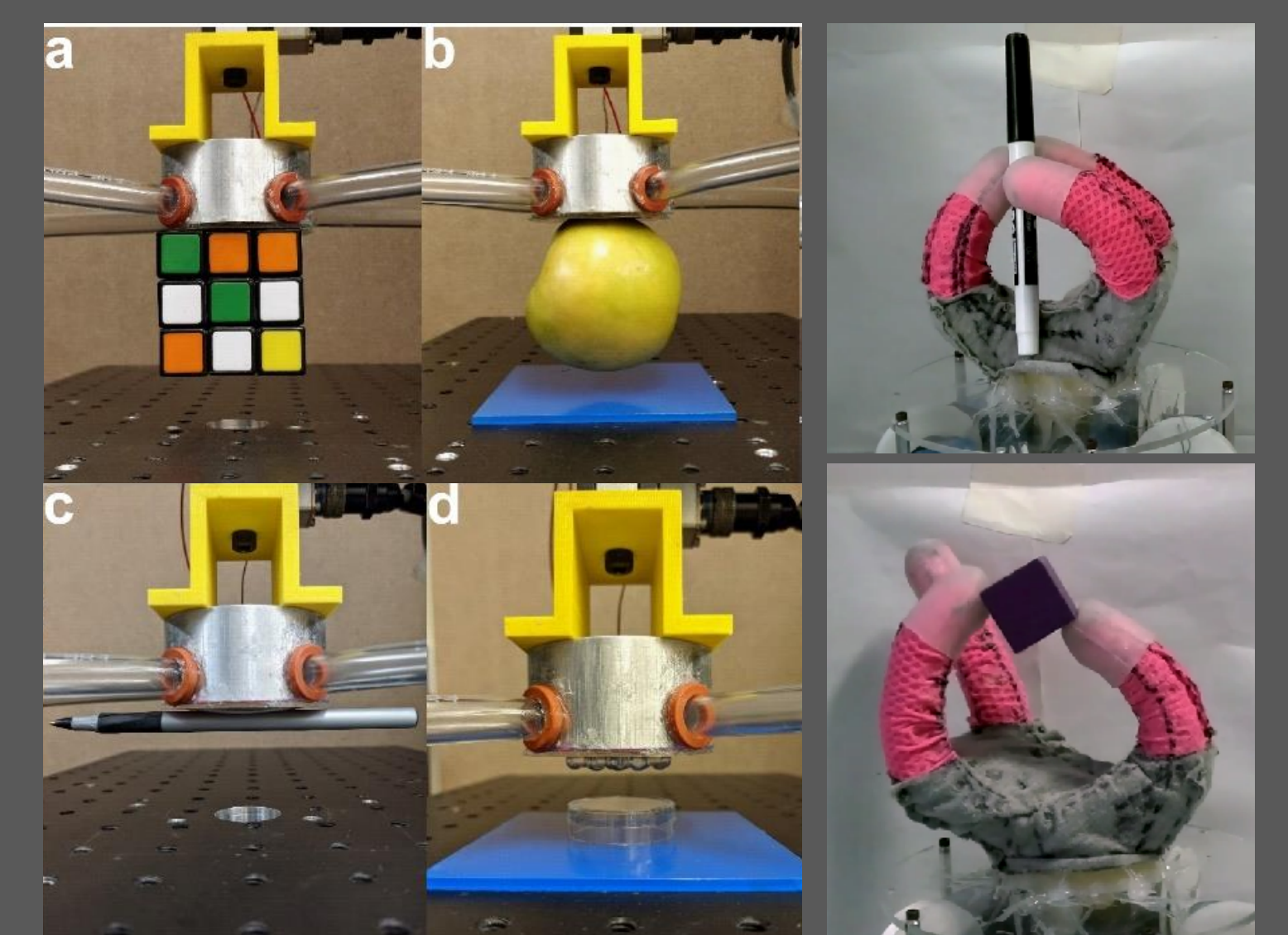


### Continued discovery of stiffness tuning materials



Mohammadi Nasab, A., Sharifi, S., Chen, S., Jiao, Y. and Shan, W., "Robust Three-Component Elastomer-Particle-Fiber Composites with Tunable Properties for Soft Robotics," *Advanced Intelligent Systems*, p.2000166 (2020).

### Exploration of new soft gripper architectures

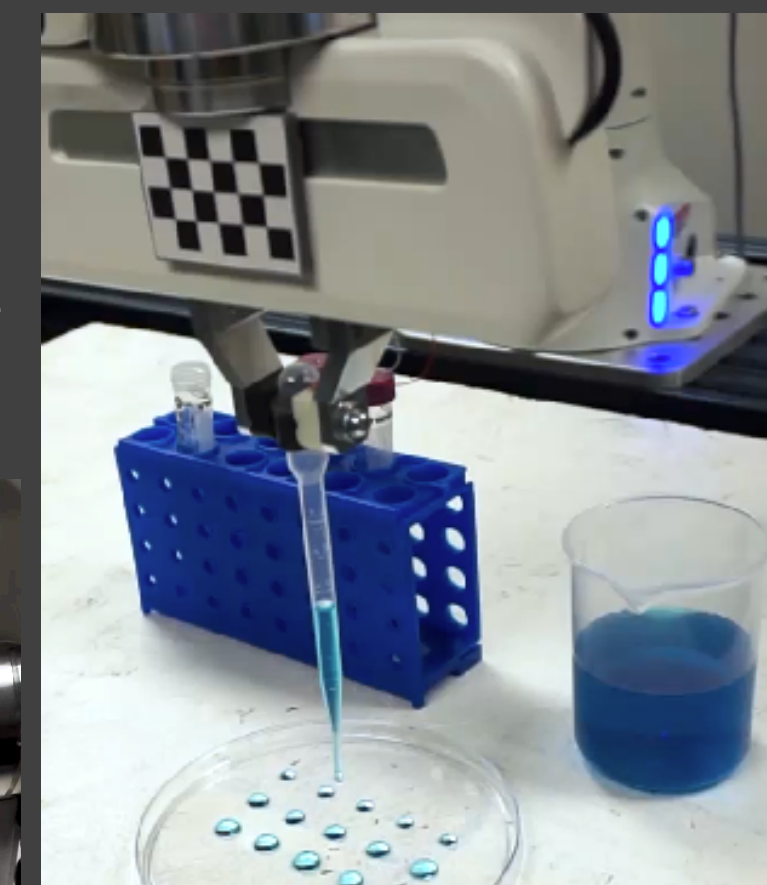
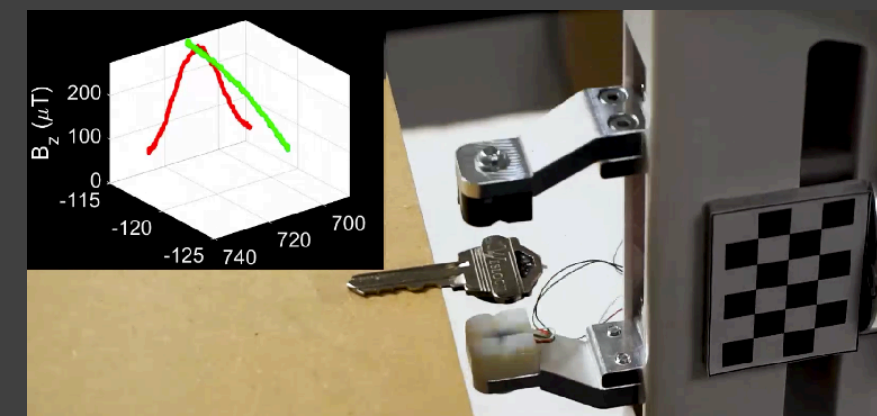


Aoyi Luo, Sumukh Shankar Pande, Kevin T. Turner, "Versatile adhesion-based gripping via a tunable stiffness membrane," manuscript in preparation (2021).

Ryan Coulson, Chao Li, Carmel Majidi, Nancy Pollard, "The Elliott and Connolly Benchmark: A Test for Evaluating the In-Hand Dexterity of Robot Hands," under review (2021).

### Soft magnetic skin for tactile sensing

Hellebrekers, T., Zhang, K., Veloso, M., Kroemer, O. and Majidi, C., "Localization and Force-Feedback with Soft Magnetic Stickers for Precise Robot Manipulation," *IEEE/RSJ IROS 2020*

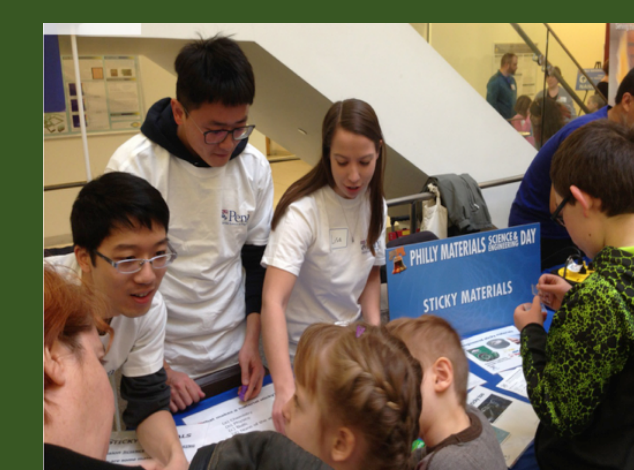


## Educational Outreach

(Pre-COVID)



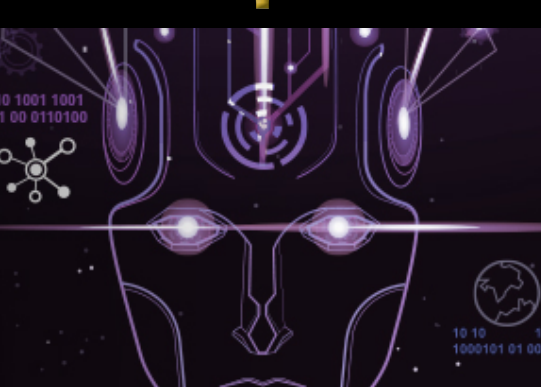
Shan group member Amir Mohamamdi Nasab doing research project demo at Engineer's Day at UNR



Turner group members doing demo of "Sticky Materials" at Philly Materials Science and Engineering Day.



Majidi group members hosting a hands-on demo at the 2019 SciTech Festival for Pittsburgh-area middle school students



2021 NRI & FRR  
Principal Investigators'  
Meeting  
March 10-12, 2021