Electro-Adhesive Tubular Clutch

for Variable-Stiffness Robots

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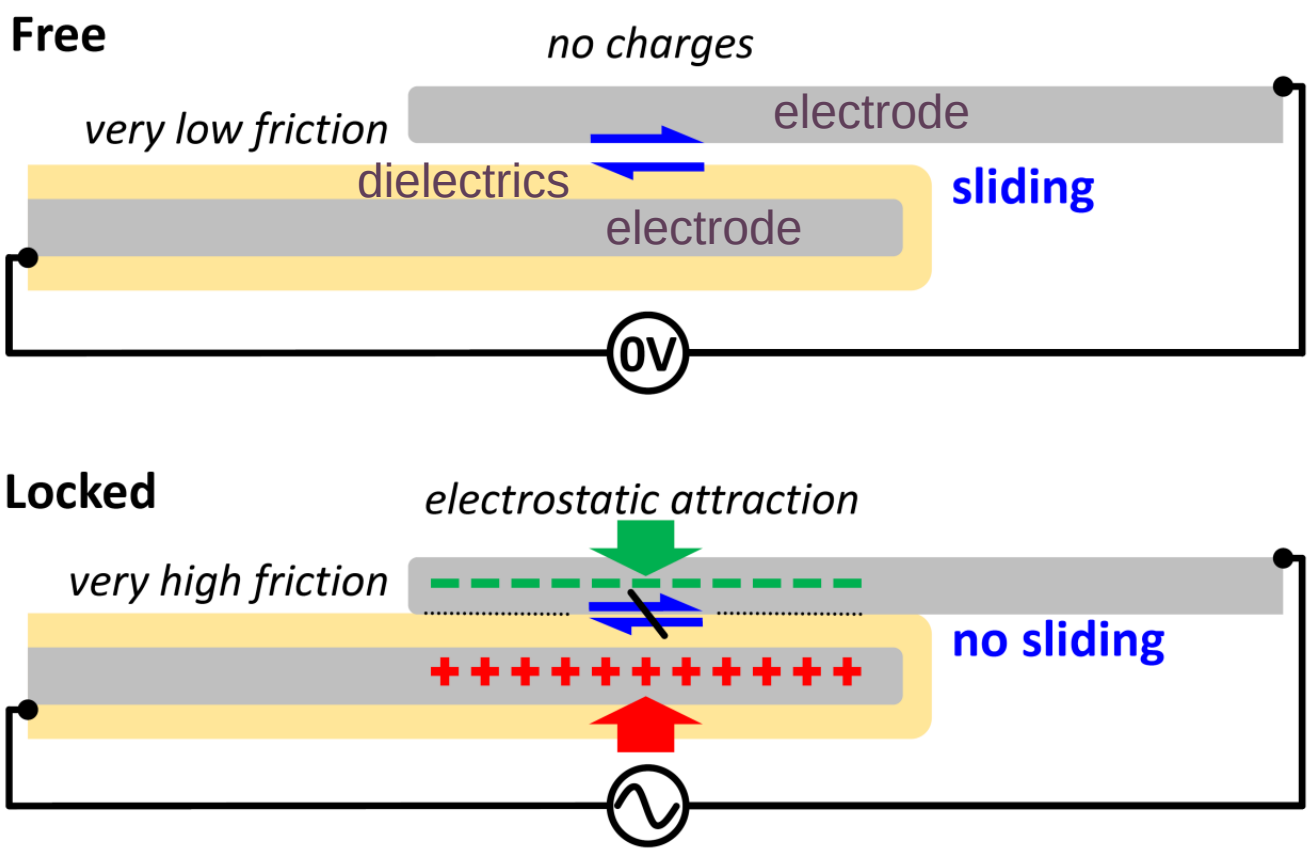
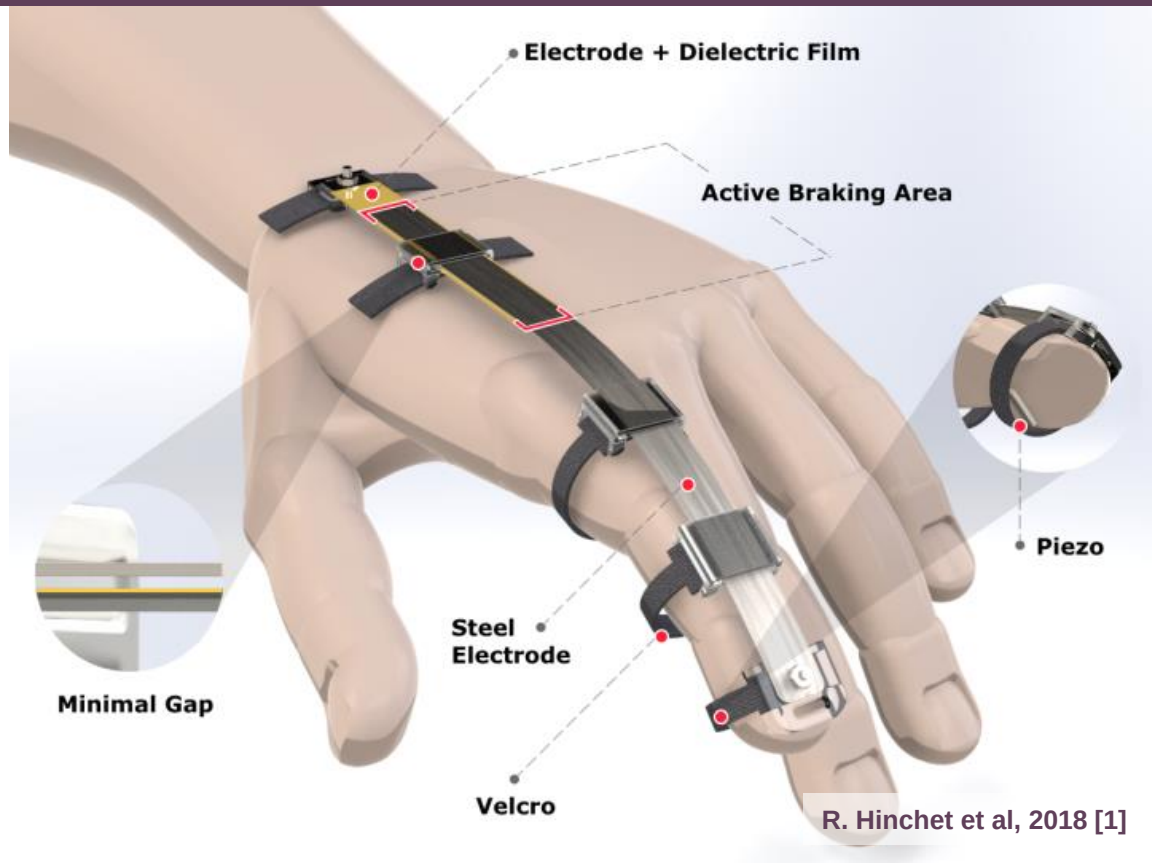
Introduction

- Electro-adhesive (EA) clutch



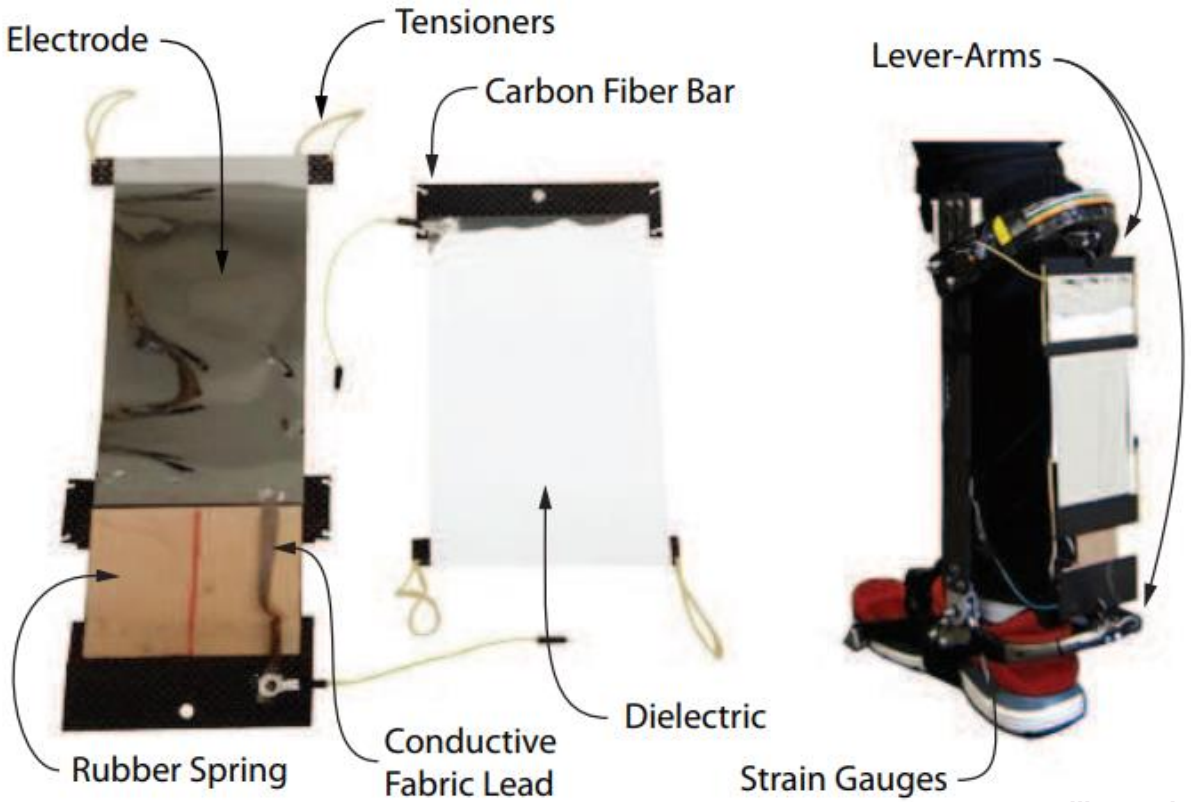


R. Hinchet et al, 2018 [1]

[1] R. Hinchet, V. Vechev, H. Shea, and O. Hilliges, "Dextres: Wearable haptic feedback for grasping in vr via a thin form-factor electrostatic brake," Proceedings of the 31st Annual ACM Symposium on User Interface Software and Technology, pp. 901–912, 2018.

Introduction

- Disadvantages of EA clutches



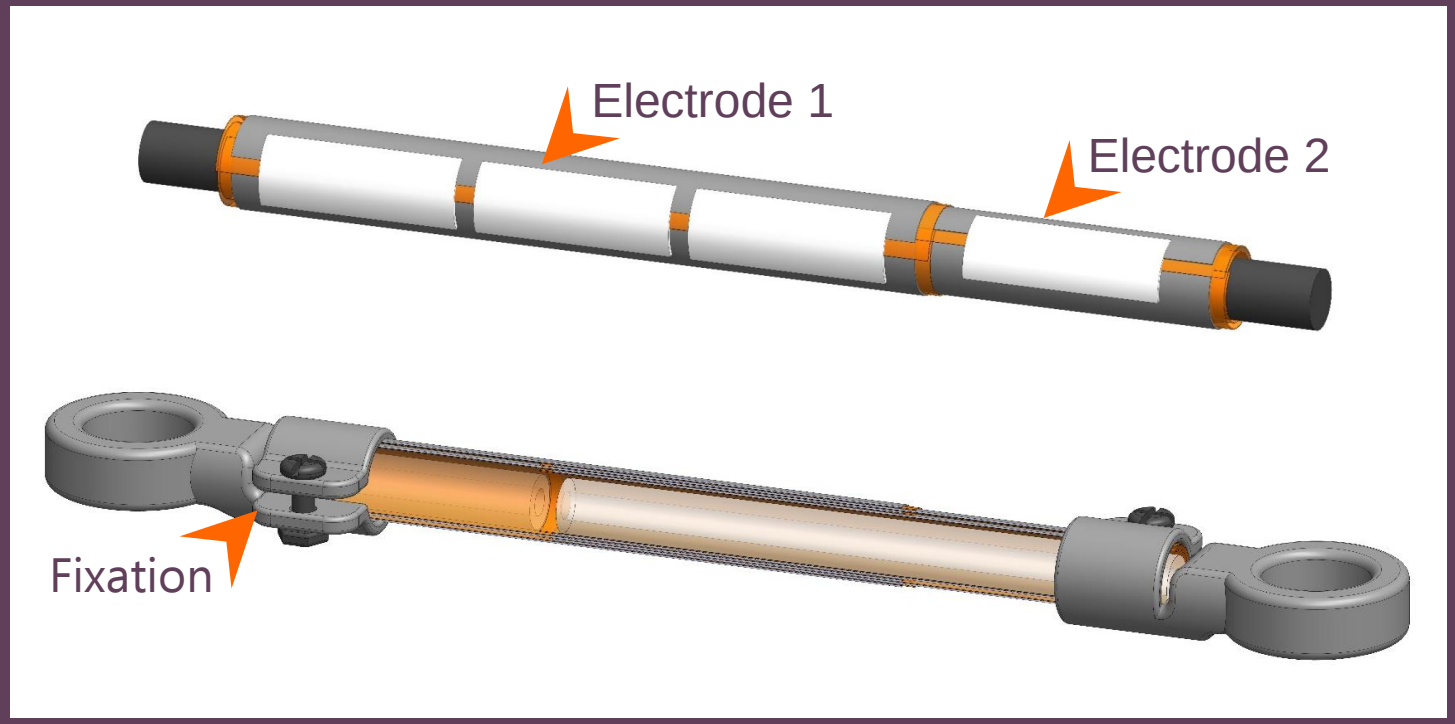
S. B. Diller et al, 2016 [1]

V. Ramachandran et al, 2019 [2]

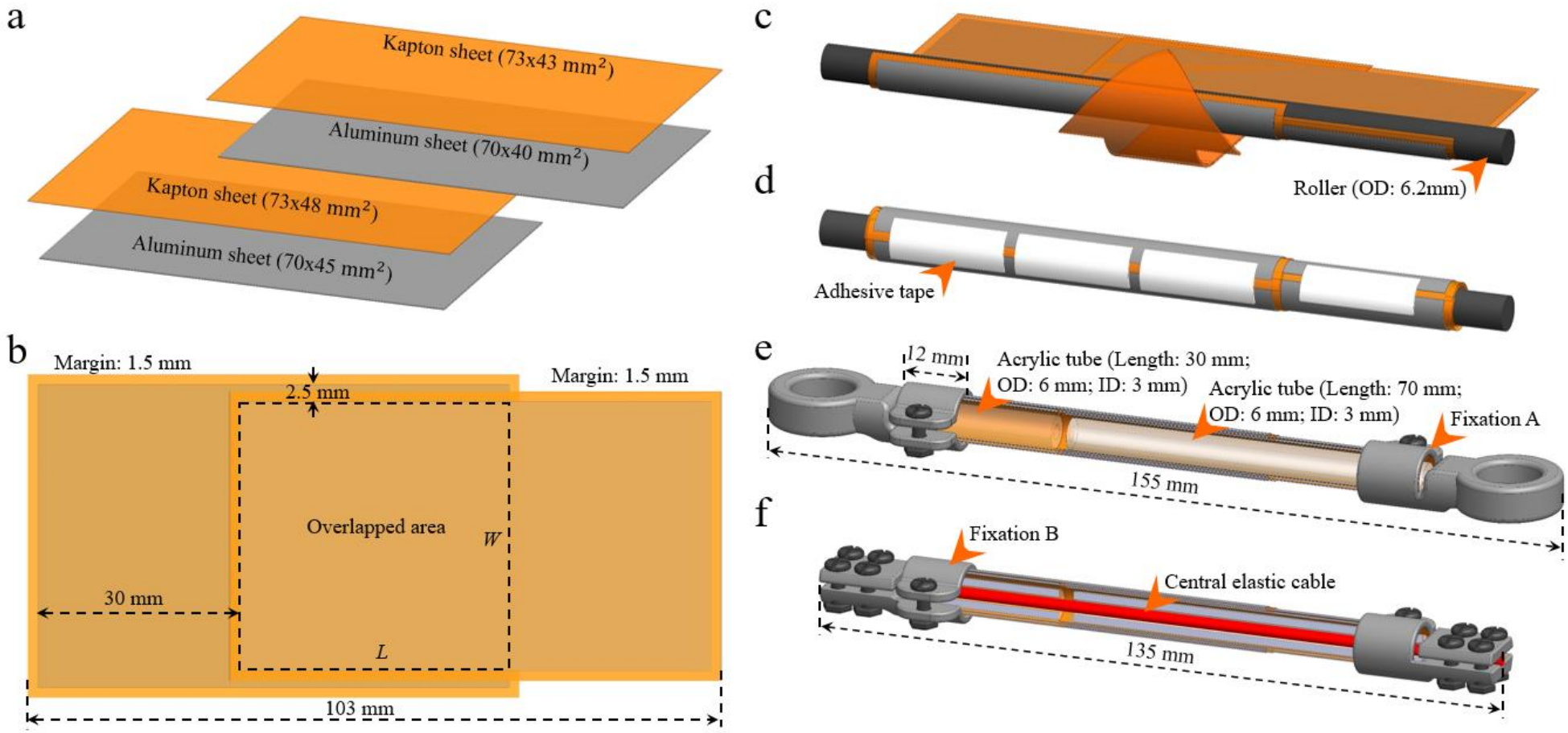
[1] S. Diller, C. Majidi, and S. H. Collins, “A lightweight, low-power electroadhesive clutch and spring for exoskeleton actuation,” 2016 IEEE International Conference on Robotics and Automation (ICRA), pp. 682–689, 2016.
[2] V. Ramachandran, J. Shintake, and D. Floreano, “All-fabric wearable electroadhesive clutch,” Advanced Materials Technologies, vol. 4, no. 2, p. 1800313, 2019.

EA Tubular Clutch (EATC)

- EATC benefits
  - Higher forces is achieved with minimum size increase
  - Requires no guiding parts for directional sliding
  - The roll serves as a natural encapsulation to avoid dust contamination
  - Stress in the roll keel the electrode layers in firm contact for reliable performance



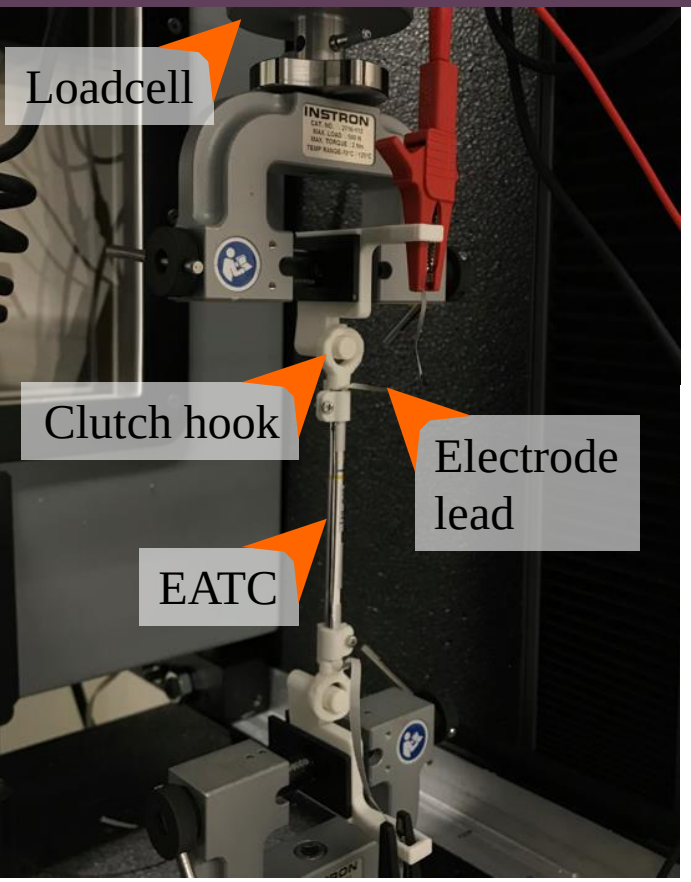
EATC Fabrication

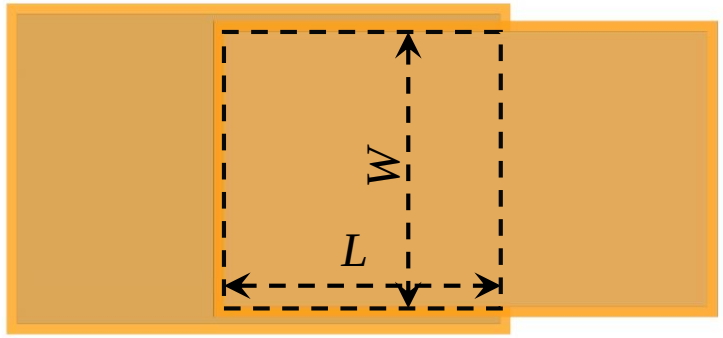


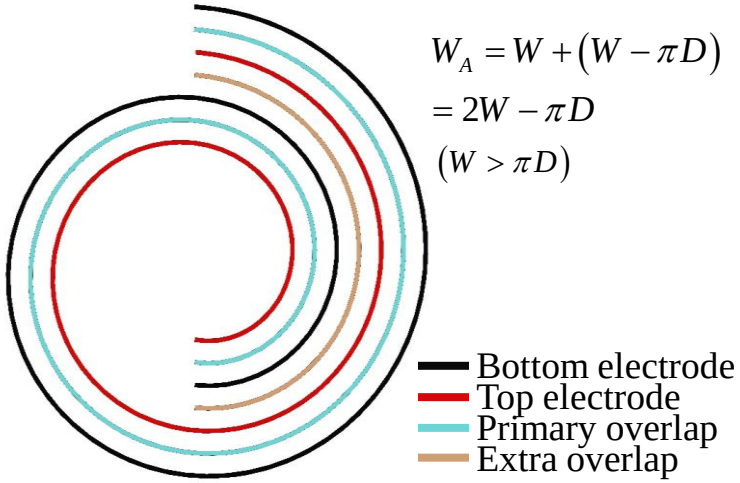
EATC Characterization

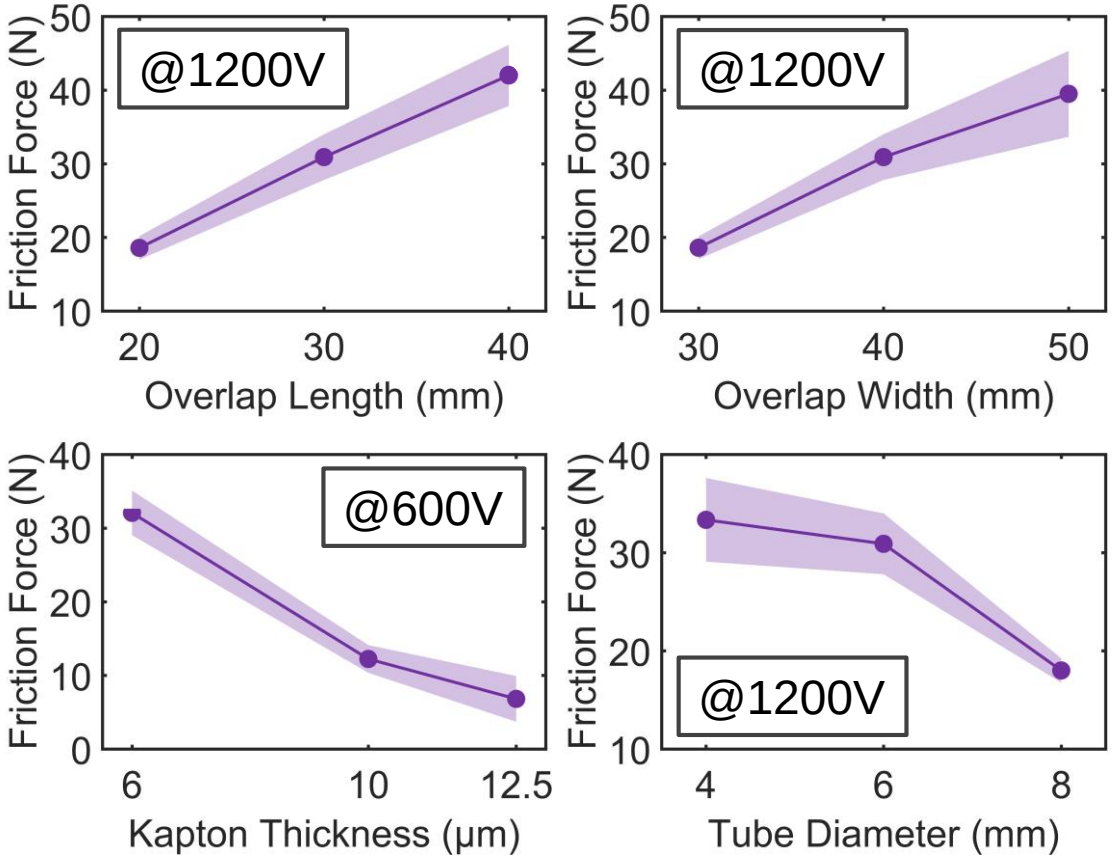
- Vary length and Kapton layer thickness.

$$F_f = \mu \times F_{EA} = \mu \cdot \frac{\varepsilon_0 \cdot \varepsilon_r \cdot A \cdot V^2}{2 \cdot d^2}$$

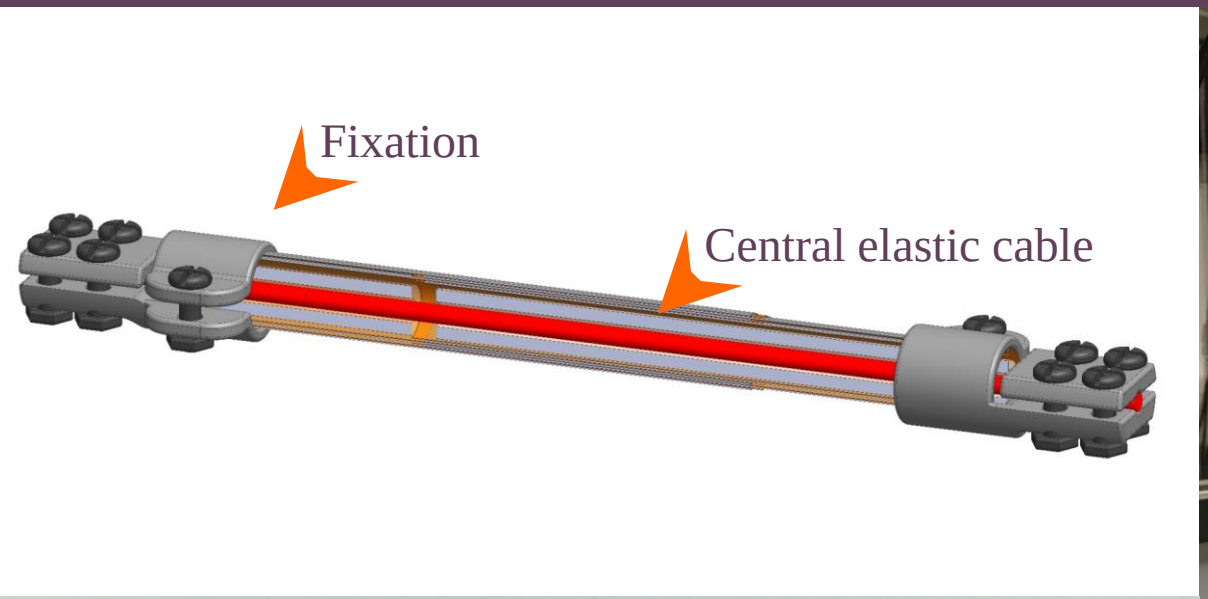


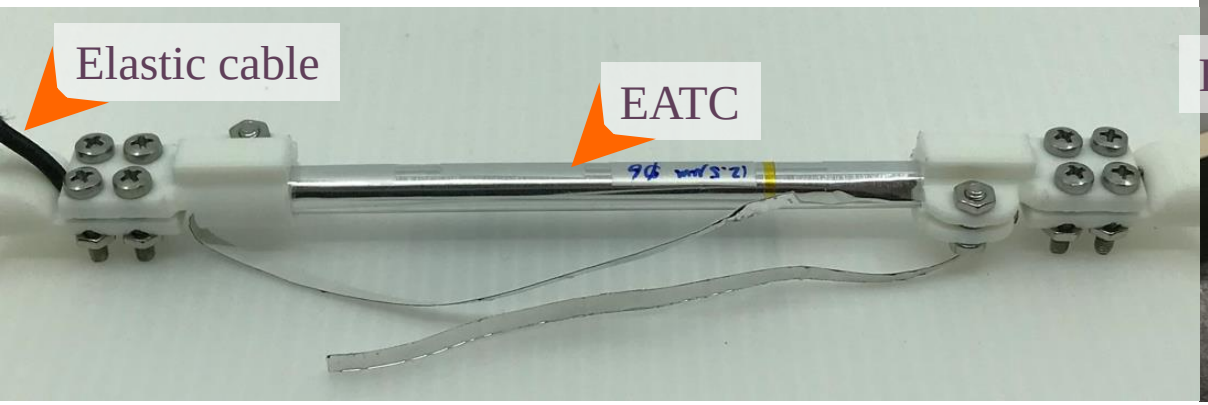






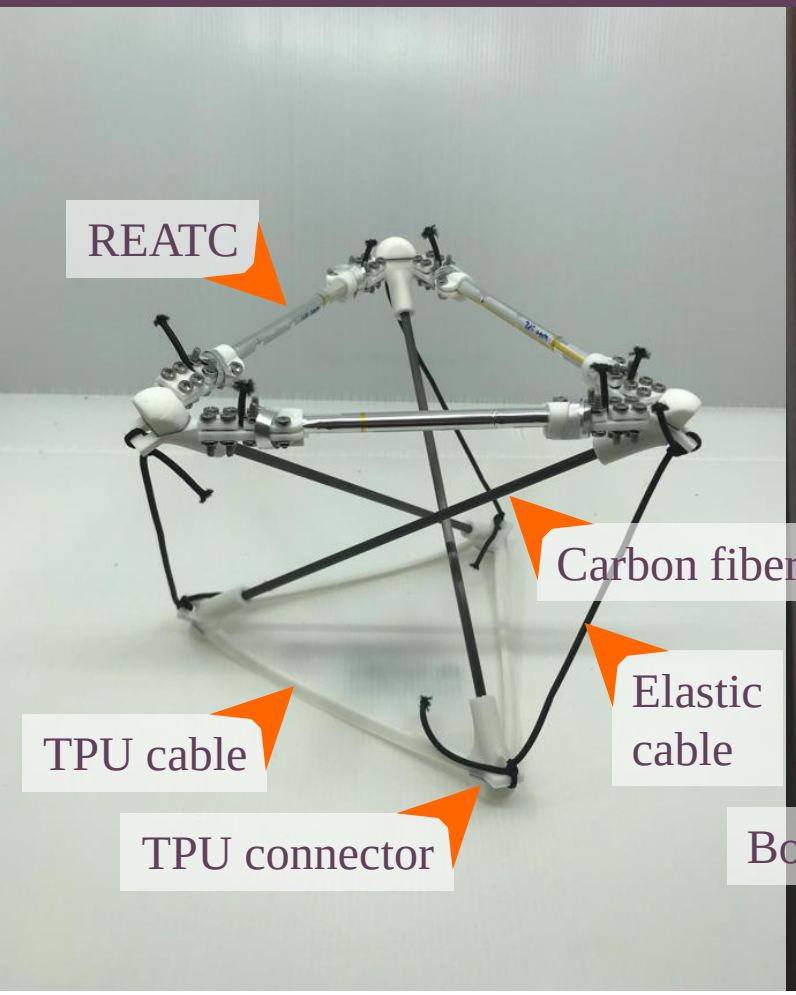
Retractable EATC (REATC)

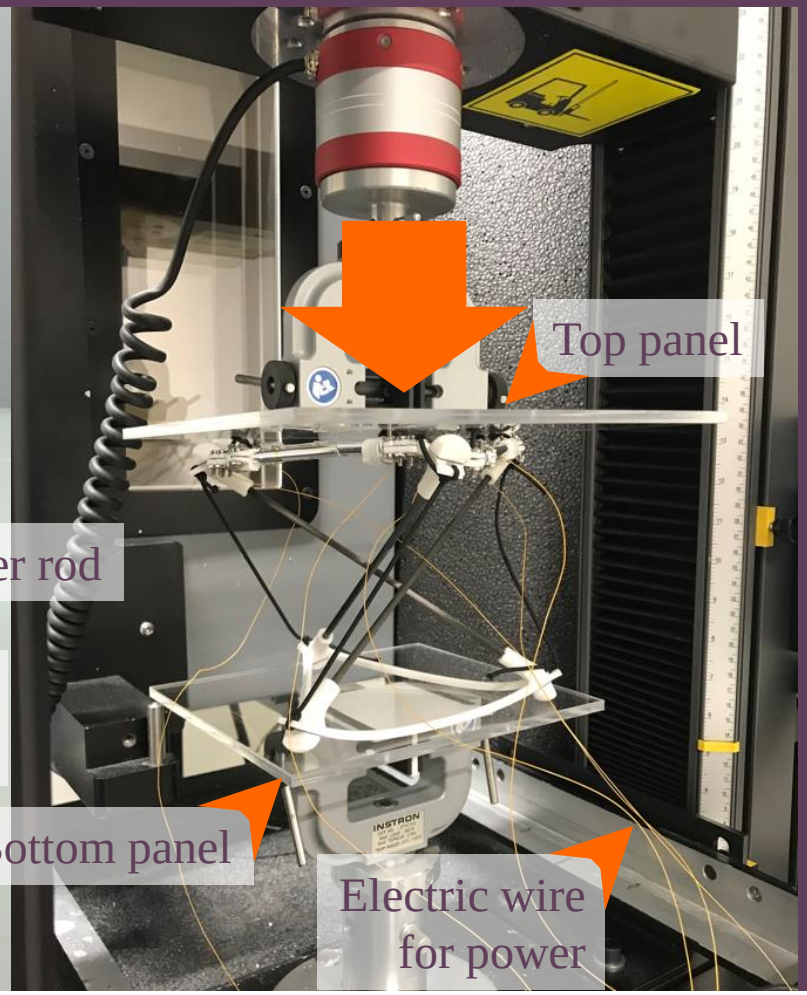




- Stiffness
  - 0.0119 N/mm @ 0V
  - 31 N/mm @ 1200V
  - Change factor – 260.1
- Load-bearing capacity
  - 3.58 N @ 0V
  - 31.77 N @ 1200V
  - Change factor – 8,88

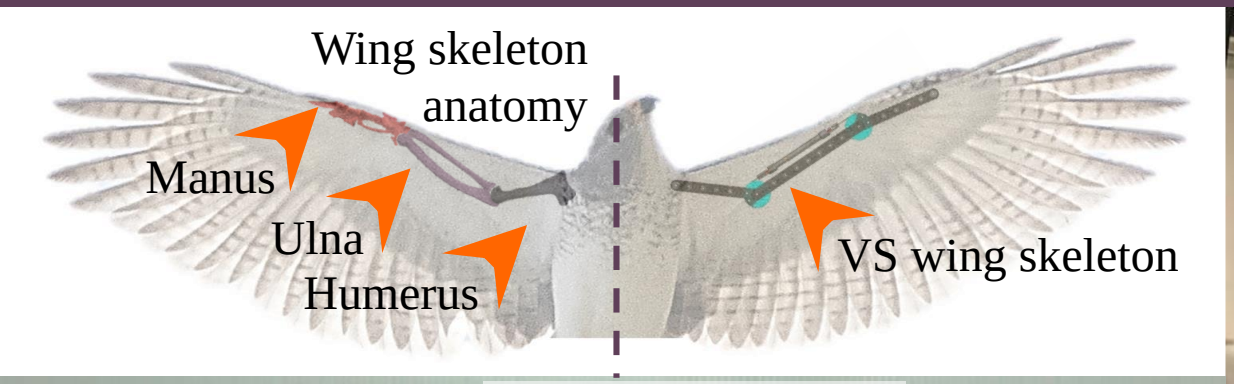
Variable Stiffness (VS) Tensegrity

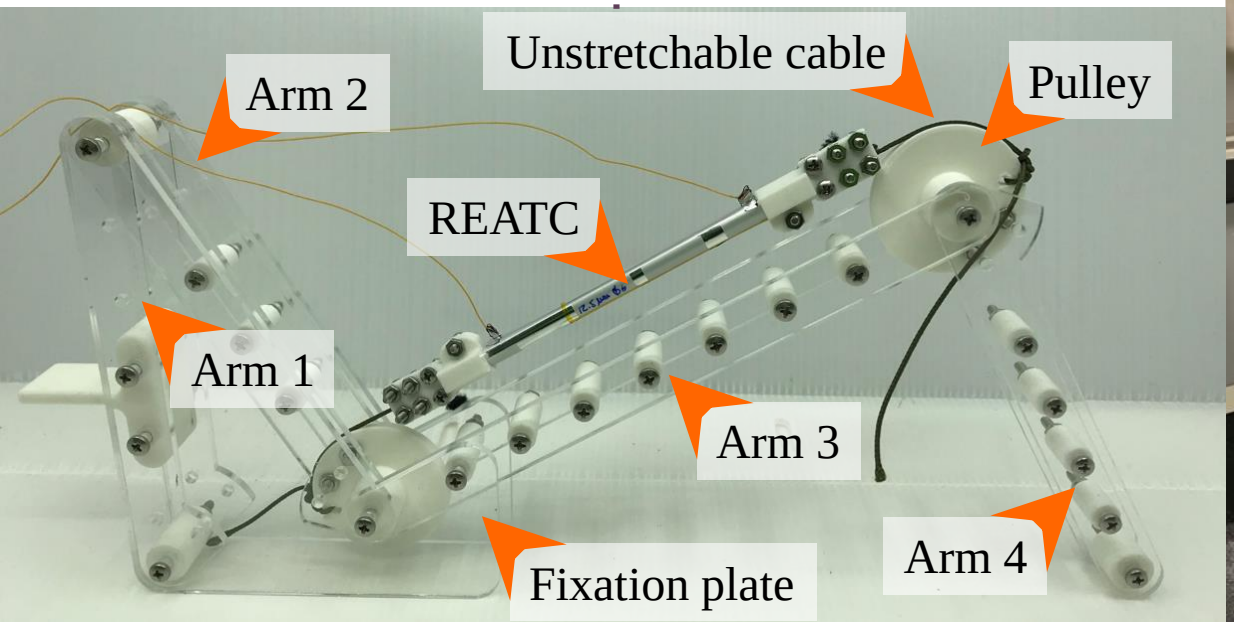


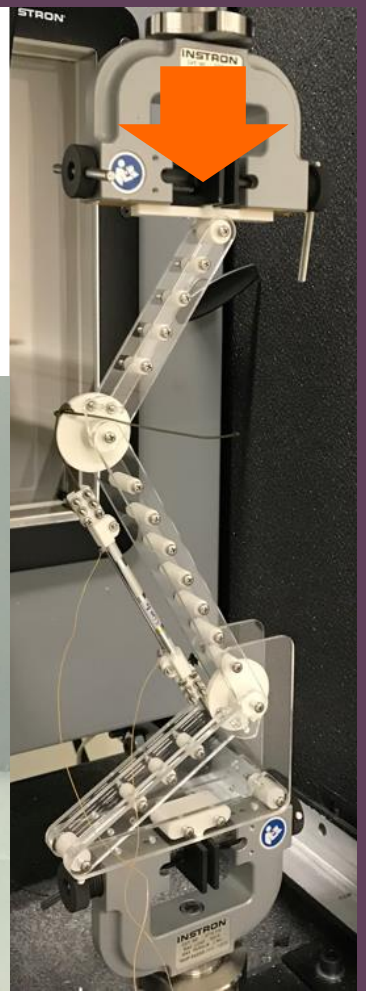


- Stiffness
  - 1,12 N/mm @ 0V
  - 14,8 N/mm @ 1200V
  - Change factor – 13,21
- Load-bearing capacity
  - 17,62 N @ 0V
  - 147,29 N @ 1200V
  - Change factor – 8,36

VS Wing skeleton

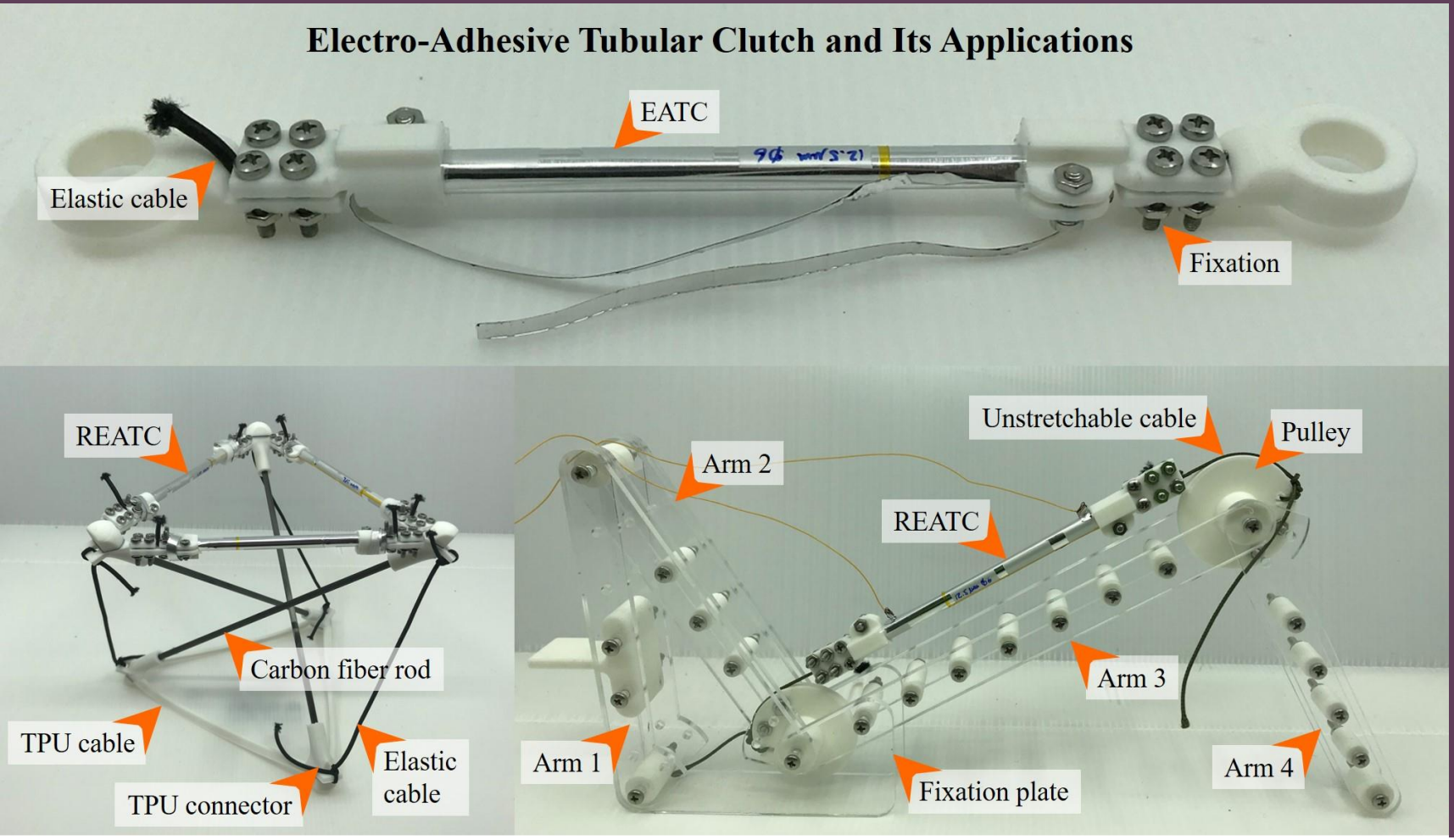




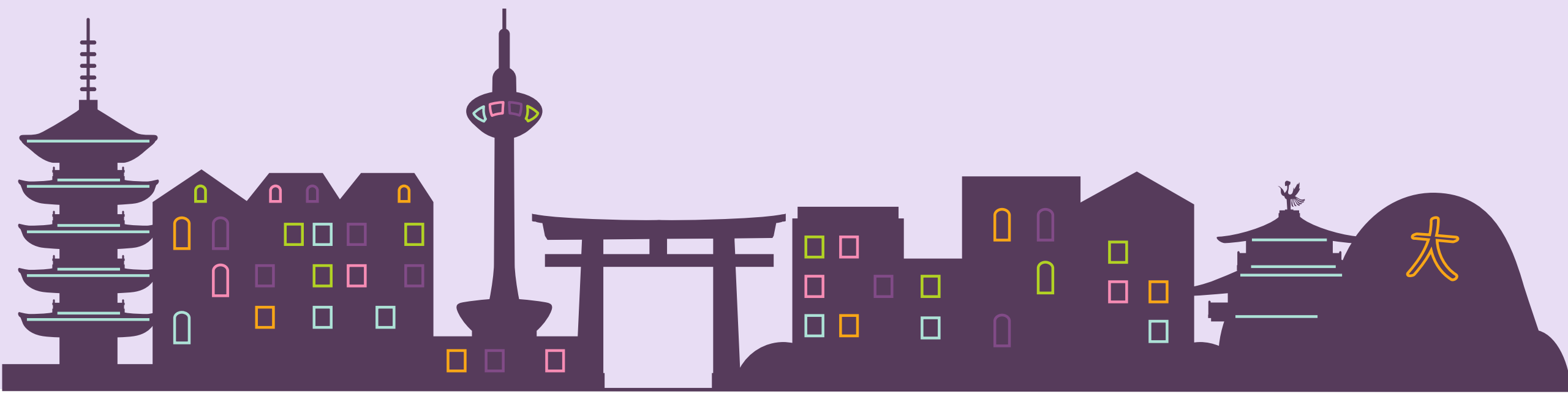


- Stiffness
  - 0.0127 N/mm @ 0V
  - 0,383 N/mm @ 1200V
  - Change factor – 30,16
- Load-bearing capacity
  - 0,789 N @ 0V
  - 10,96 N @ 1200V
  - Change factor – 13,89

Conclusion



- Compact ($3.2cm^3$) and lightweight (10g)
- Scalable in size and brake force
- Suitable for force transmission via tensioned cables
- Targeted on lightweight and compact systems for variable stiffness functions



End of Presentation
Thank you very much
Q&A

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