ETH

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

ShanghAI Lectures HS 2012

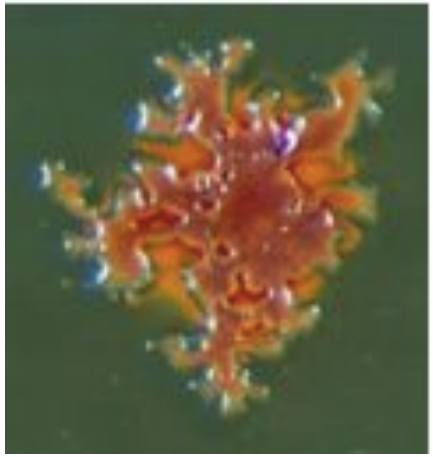
Soft Robotics Approach toward Artificial Ontogenetic Development

Fumiya Iida, Liyu Wang, Luzius Brodbeck

Bio-Inspired Robotics Lab,
Institute of Robotics and Intelligent Systems, ETH Zurich
Switzerland

FNSNF
Swiss National Science Foundation

BIRL
Bio-Inspired Robotics Lab

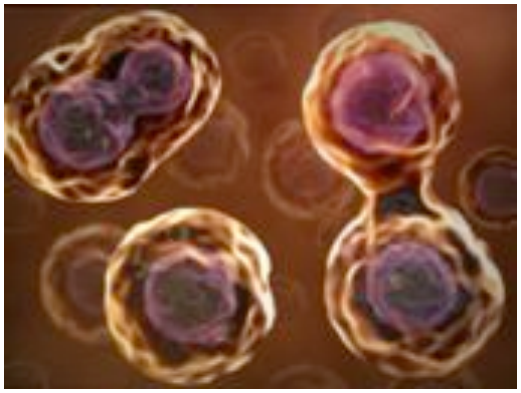


What is the origin of mophological intelligence?

Morphology and Developmental Processes

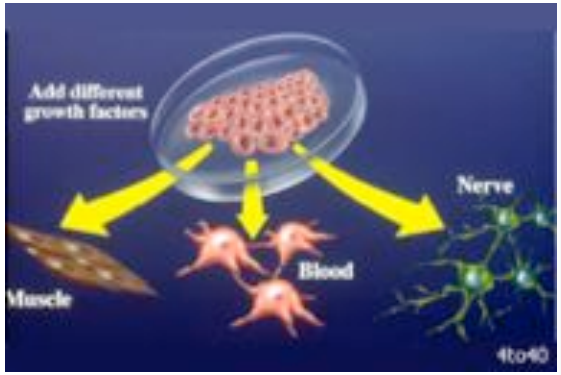
Developmental Processes

Growth



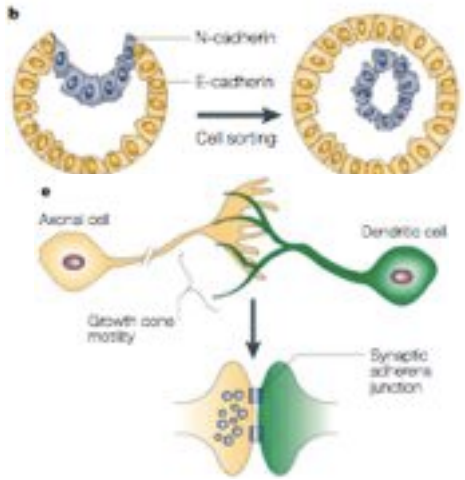
Multiplication
Metabolism
Size/volume increase

Differentiation



Changes of mechanical and chemical properties

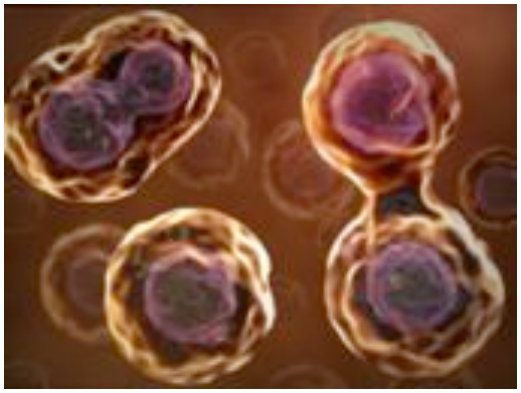
Morphogenesis



Changes of shapes and structures

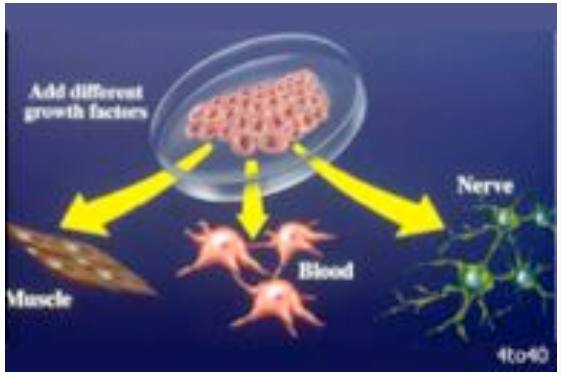
Developmental Processes

Growth



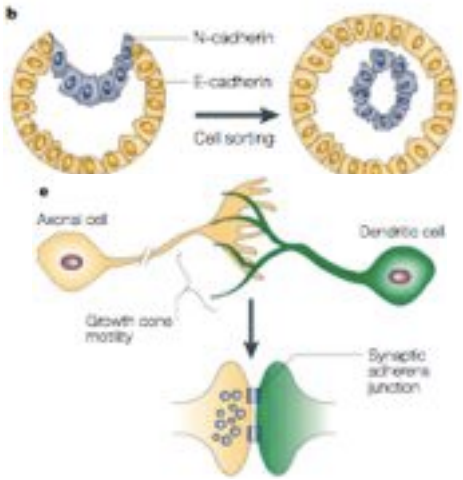
Multiplication
Metabolism
Size/volume increase

Differentiation



Changes of mechanical and chemical properties

Morphogenesis

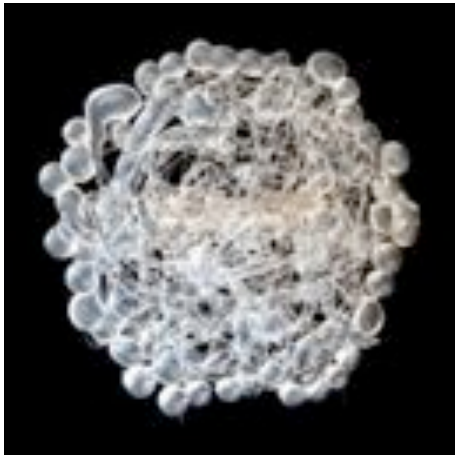


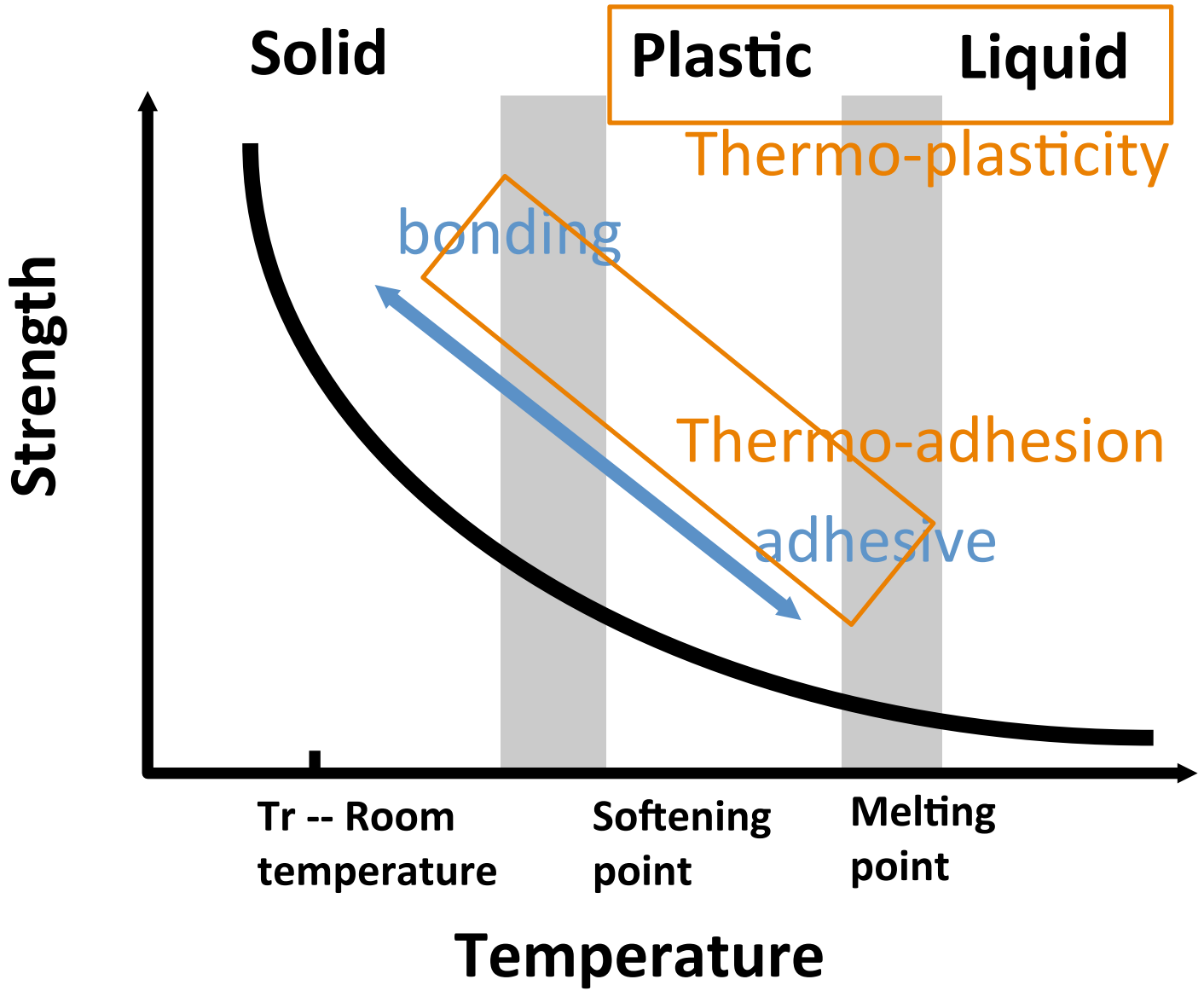
Changes of shapes and structures

Control of adhesion and plasticity
is important for ontogenetic development!

Thermo-Plastic Adhesives

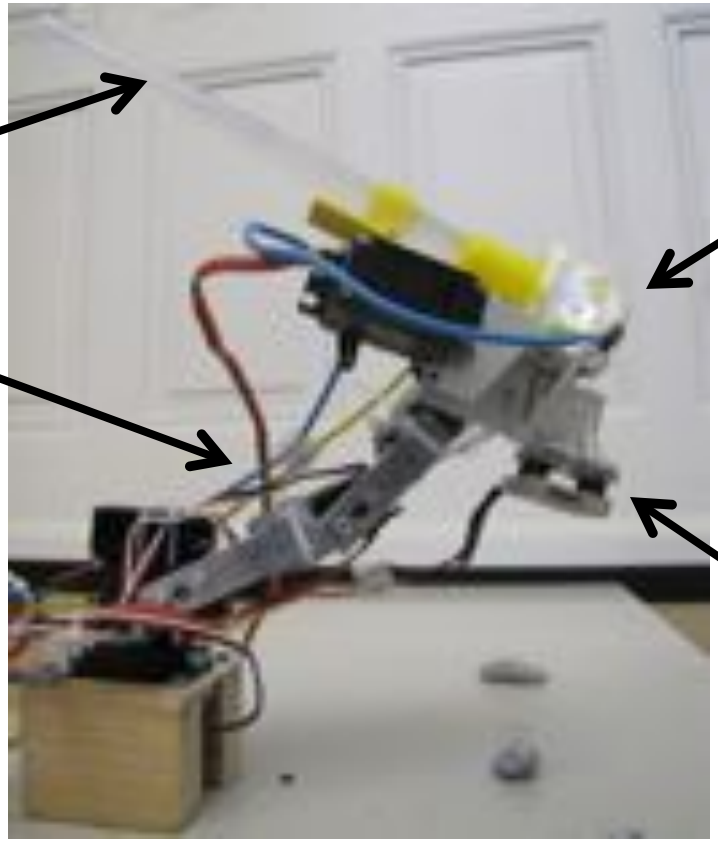
Thermo-Plastic Adhesives




Solid
Plastic
Liquid
Thermo-plasticity
bonding
Thermo-adhesion
adhesive
Strength
Tr -- Room temperature
Softening point
Melting point
Temperature

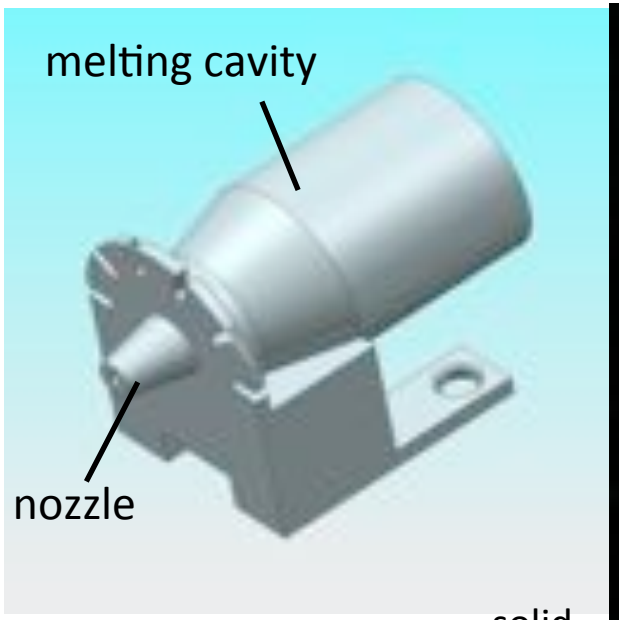
Video 1

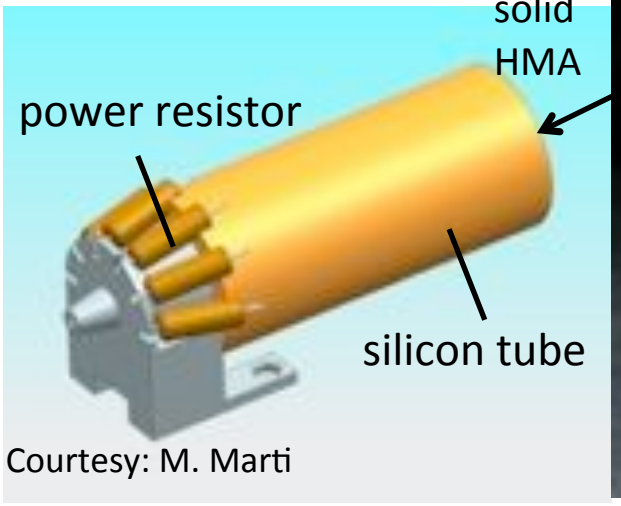
Robotizing Glue Gun



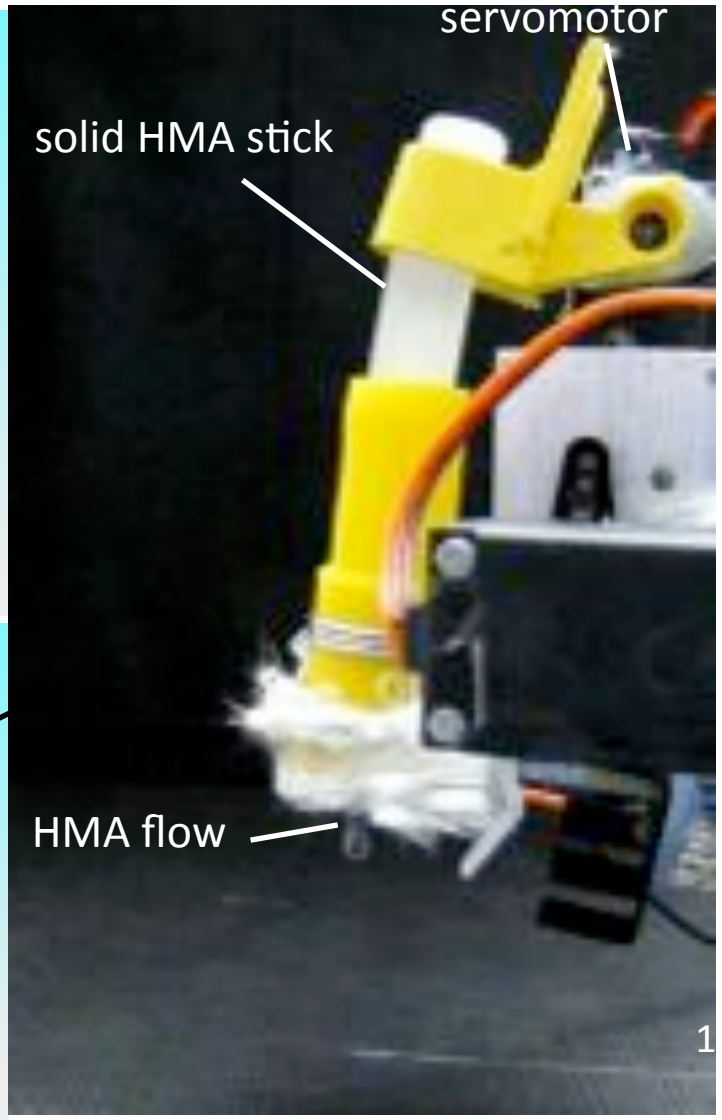
Brodbeck, L., Wang, L. and Iida, F. (under review).

HMA Supplier

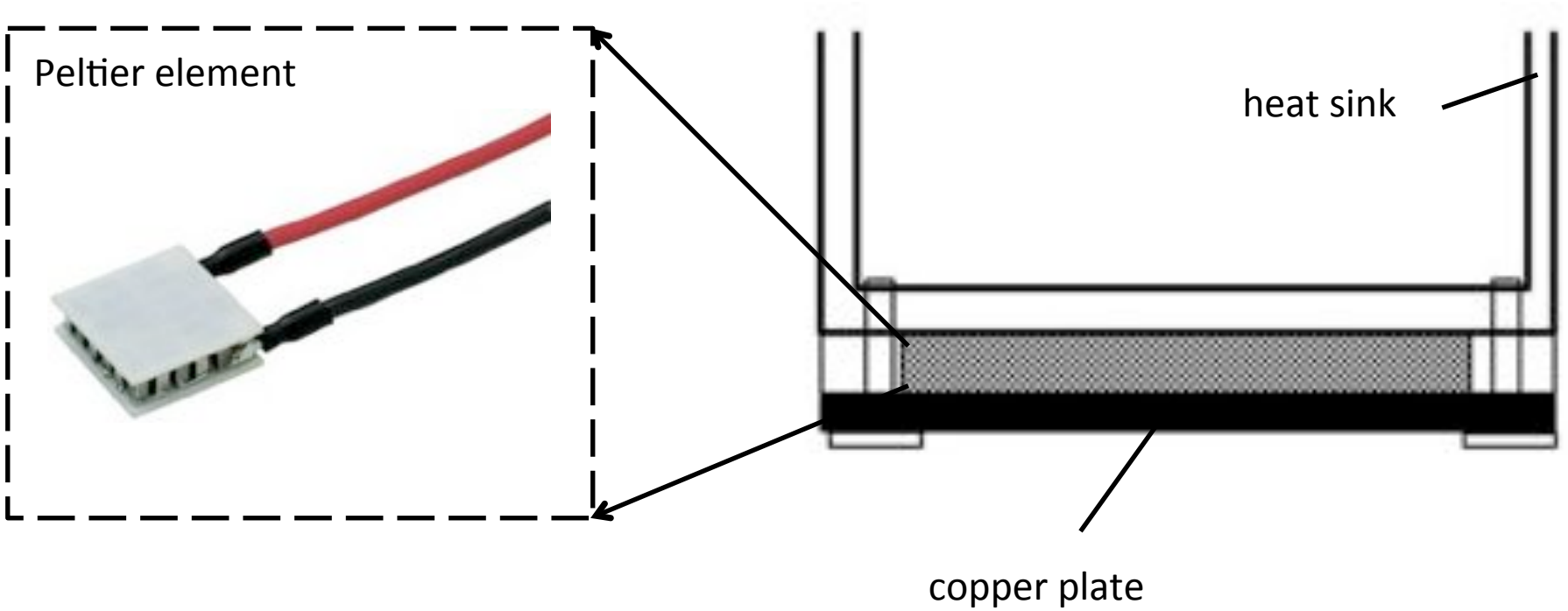




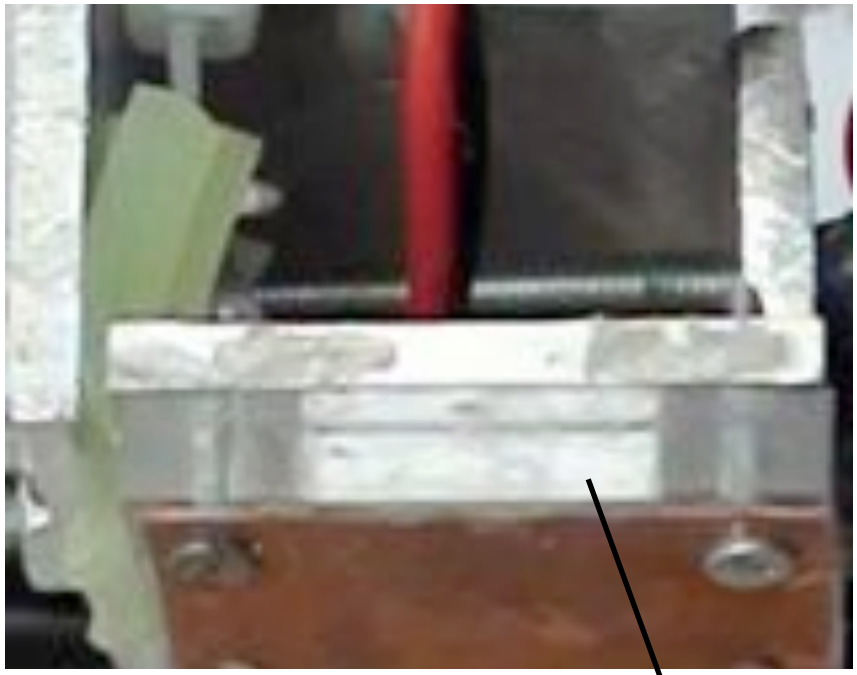
Courtesy: M. Marti

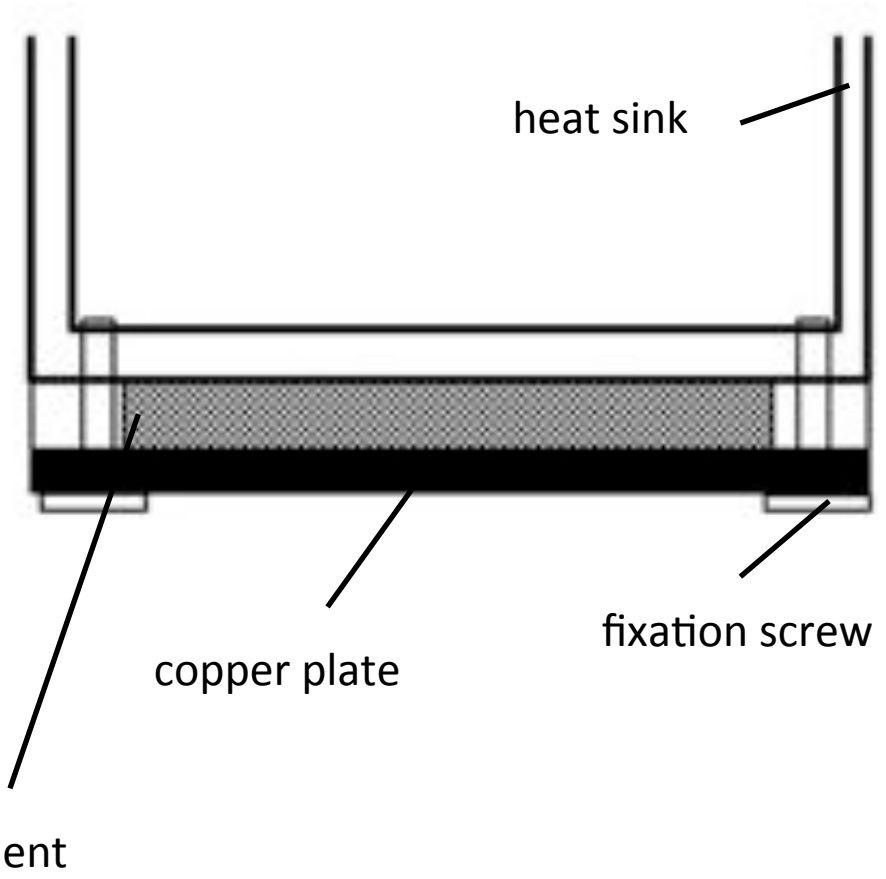


Active HMA Connector

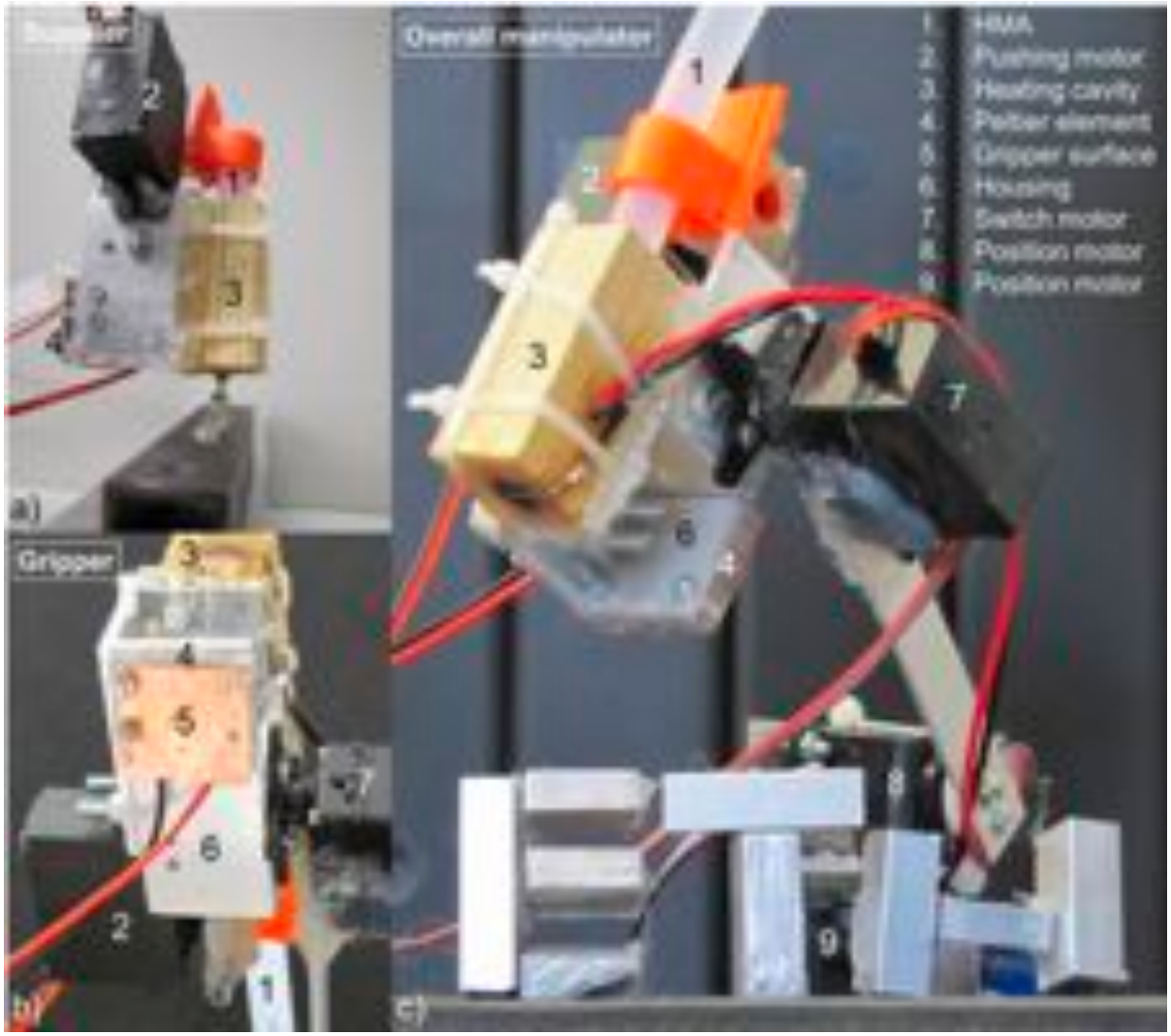


Active HMA Connector





Case Study 1
Autonomous Construction



Developed by Liyu Wang

Video 2

Modelling of thermoplasticity I

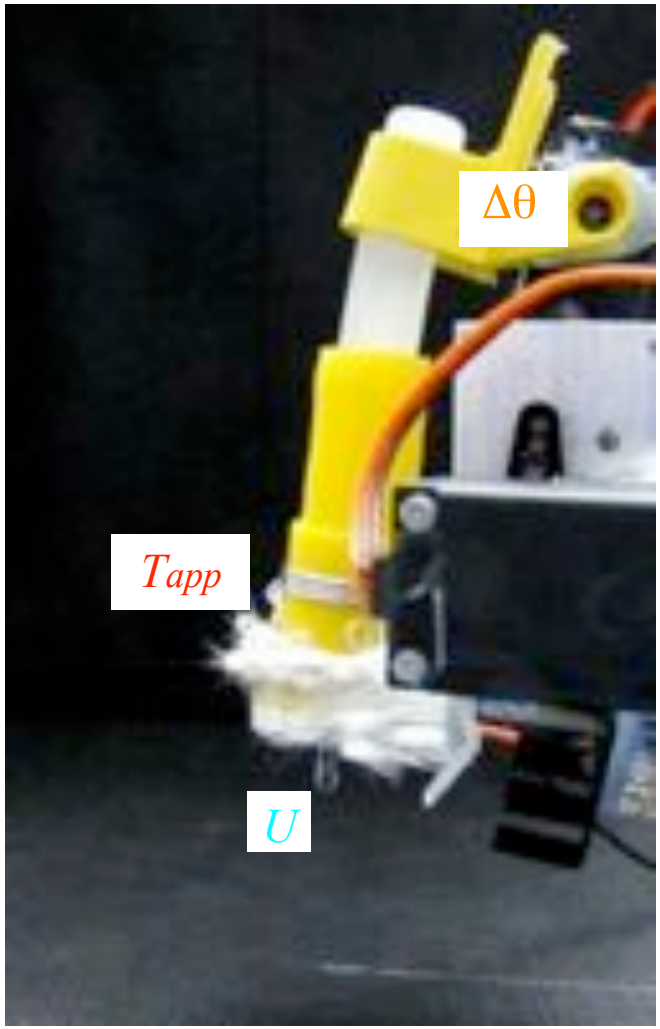
HMA flow model

Flow volume U in time t:

$$U = K_1 \frac{F_{motor}}{\mu_{(viscosity)}} t$$

where $F_{motor} = f_1(\Delta\theta)$

$$\mu = f_2(T_{app})$$

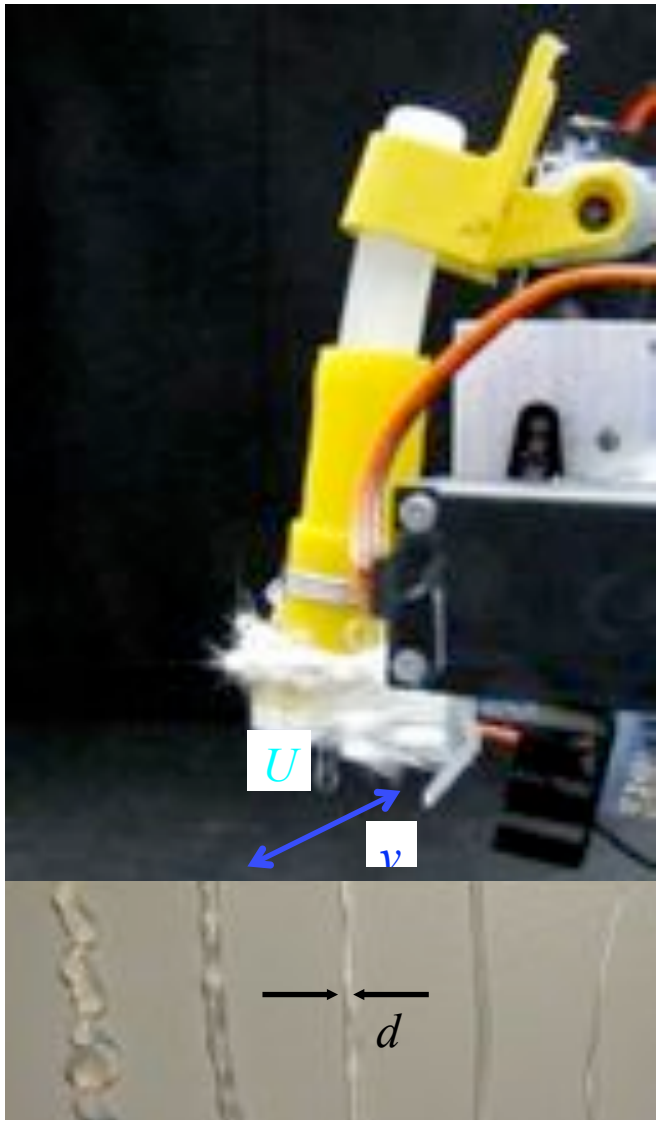


Modelling of thermoplasticity II

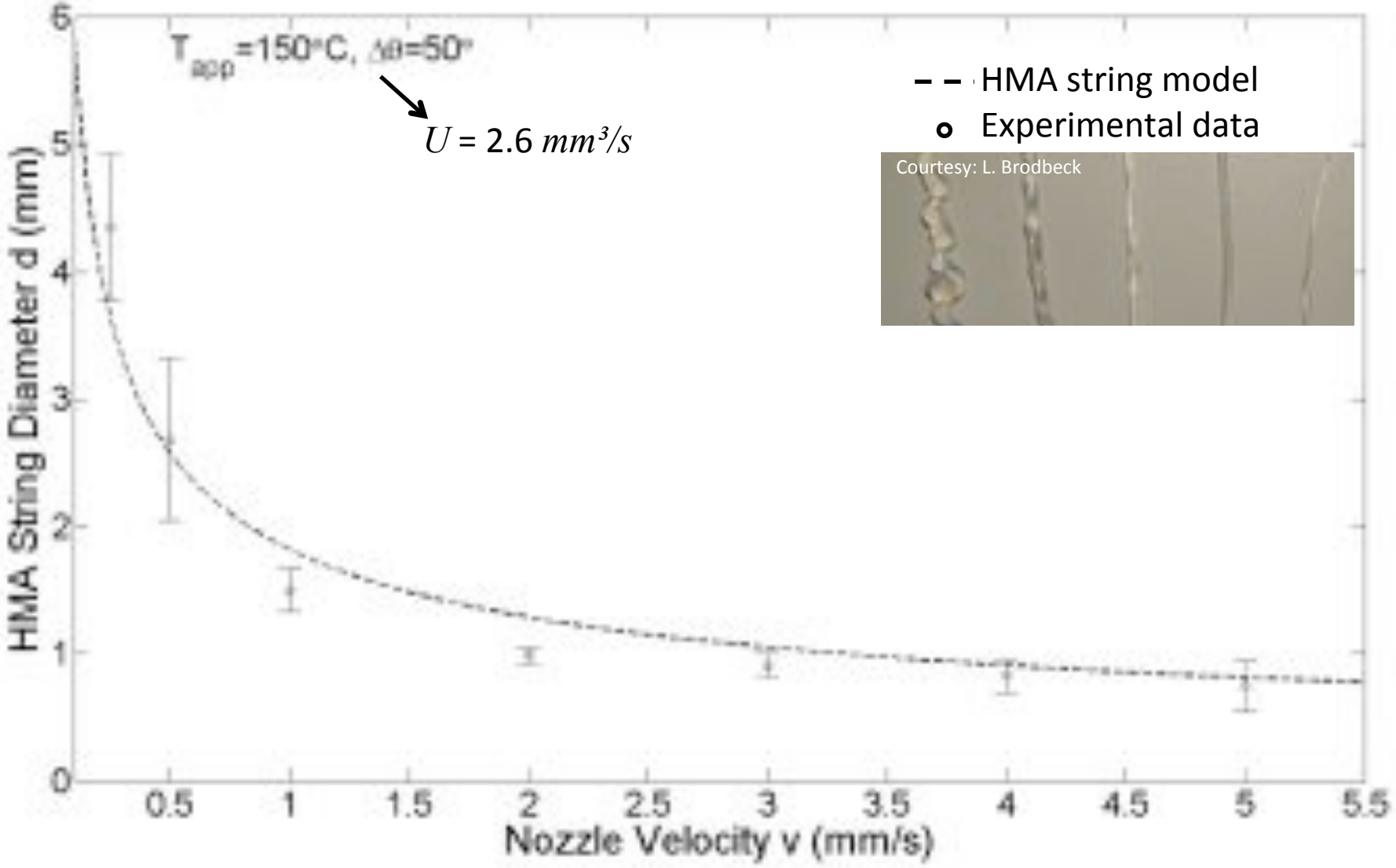
HMA string model

For given U in time t, string diameter d:

$$d = K_2 \sqrt{\frac{U / t}{v}}$$



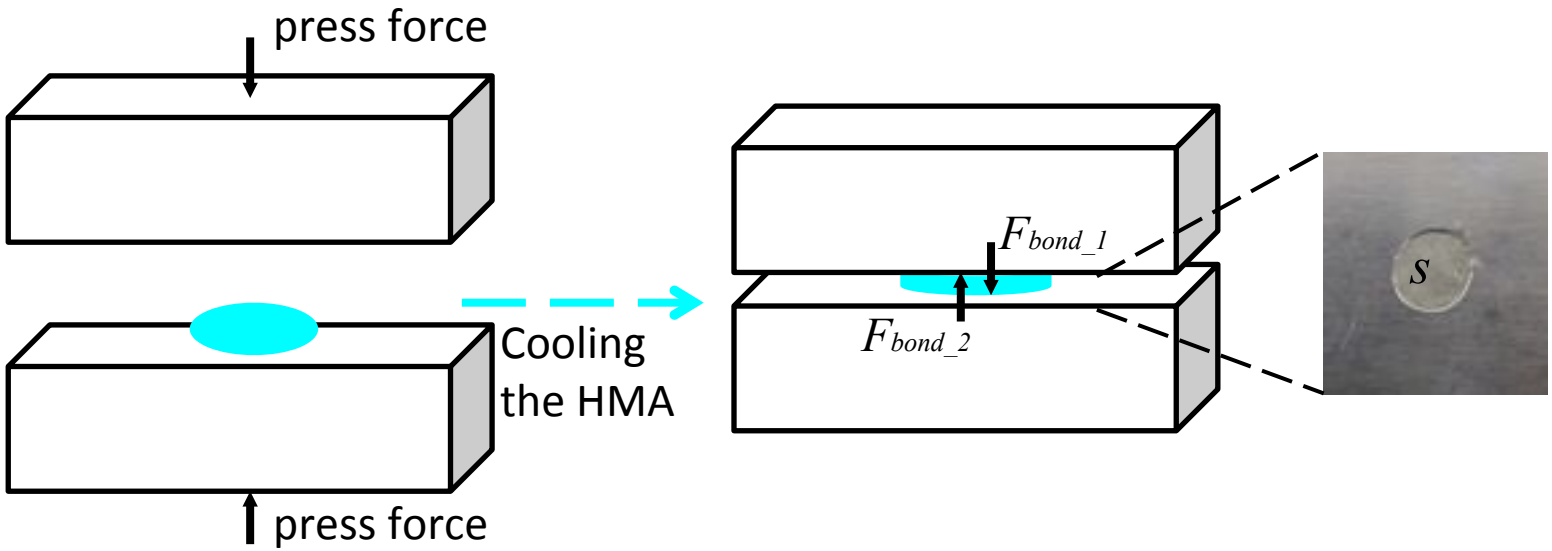
Modelling of thermoplasticity II



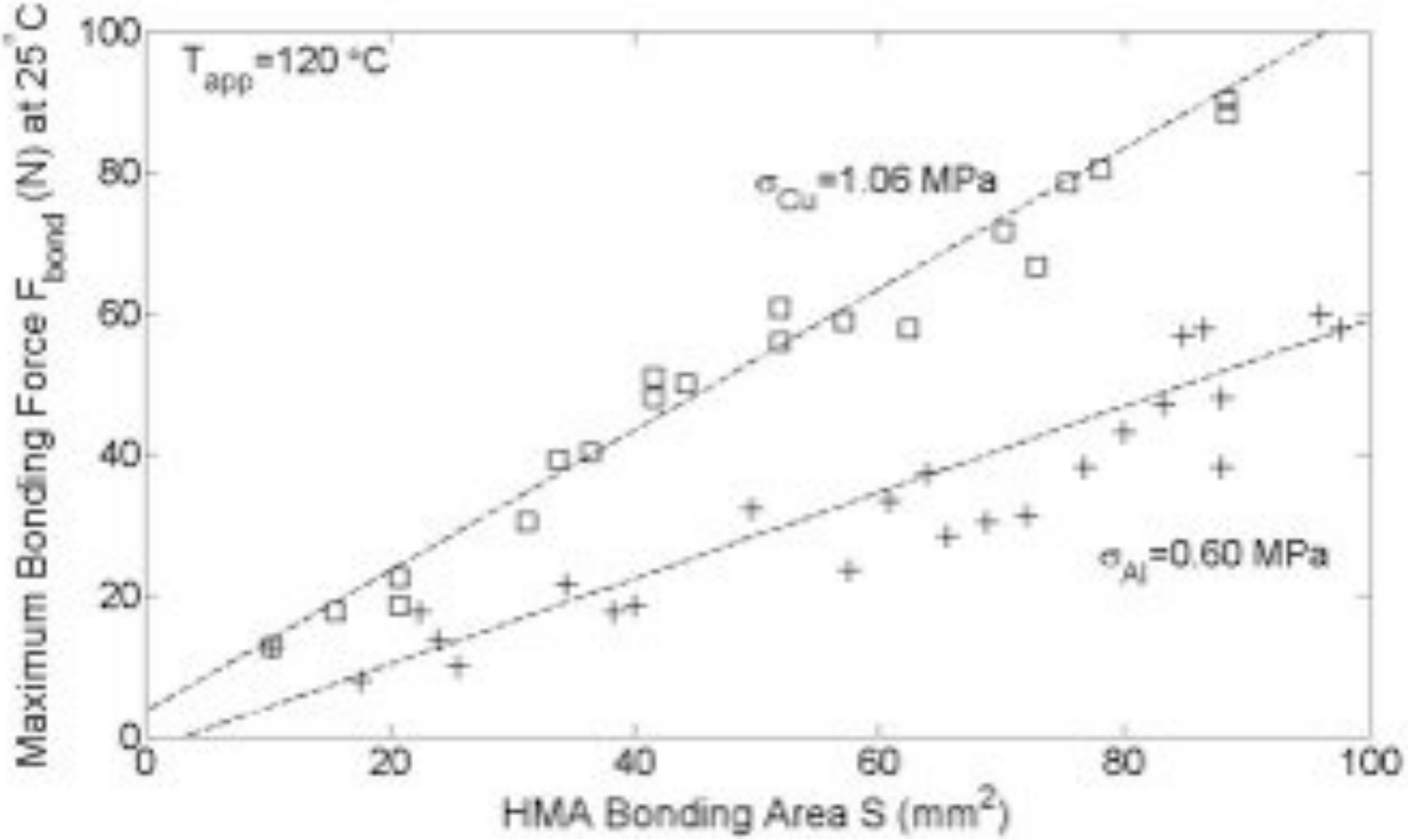
Modelling of thermo-adhesion

The maximum bonding force F_{bond}:

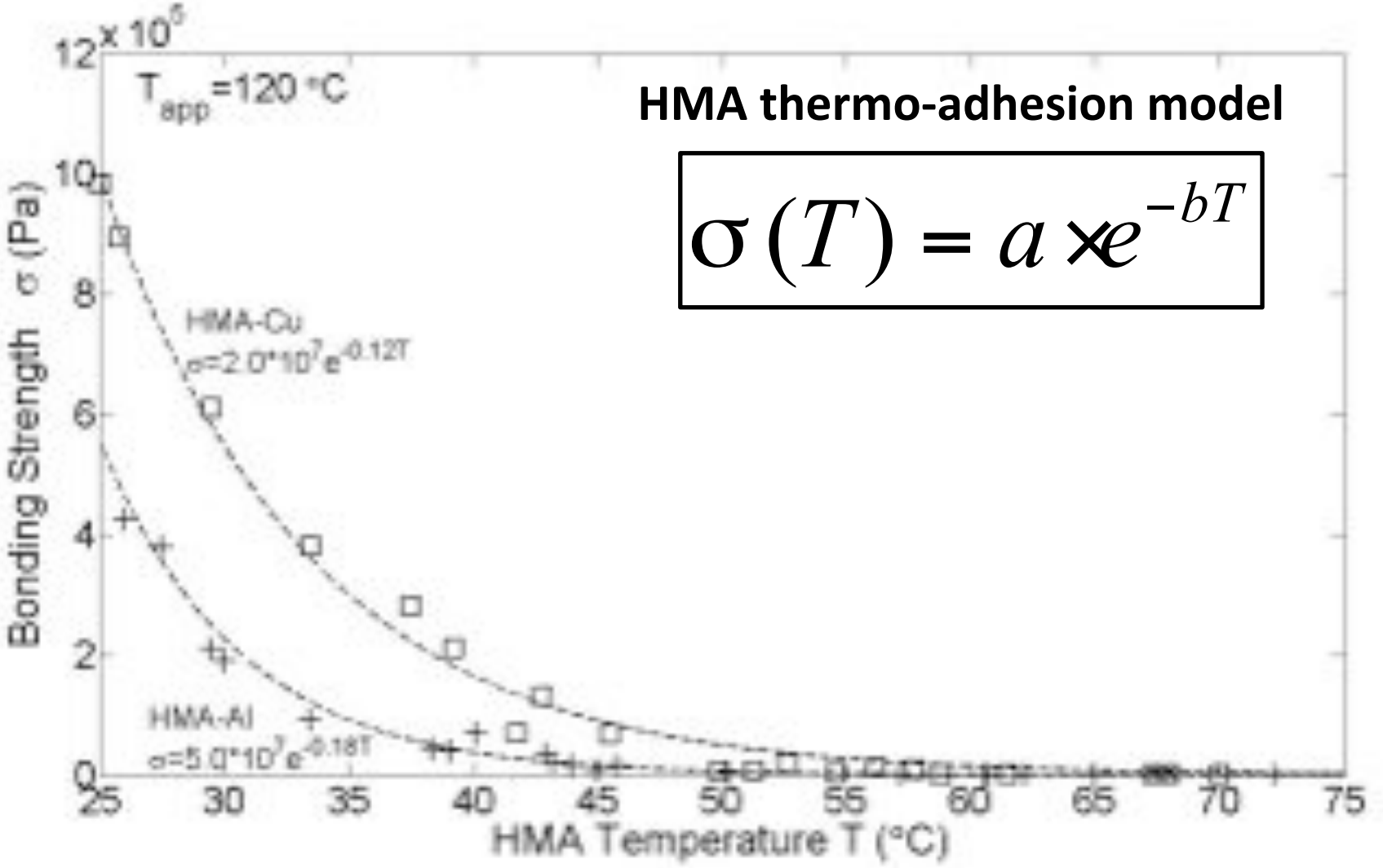
$$F_{bond} = \sigma(T) \times S$$



Modelling of thermo-adhesion



Modelling of thermo-adhesion

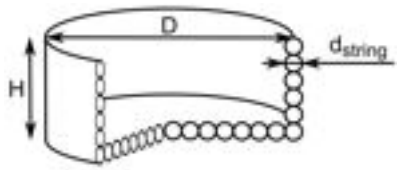


HMA thermo-adhesion model

$$\sigma(T) = a \times e^{-bT}$$

Case Study 2
Autonomous Body Extension

Autonomous Design



Autonomous Construction

Autonomous Assembly

Autonomous Operation

Plasticity and Adhesion

Connection and Disconnection

Large Breaking Strength

Developed by Luzius Brodbeck and Liyu Wang

Video 3

Courtesy: L. Brodbeck
Photo: L. Wang

Case Study 3: Climbing

Video 4

Conclusions

- Morphology control is one of the most important challenges in embodied intelligence research
- We have many technological challenges in robotic developmental processes
- Soft robotics (e.g. control of adhesion and plasticity) opens a door for artificial ontogenetic development

Collaborators & Acknowledgement

Bio-Inspired Robotics Laboratory
ETH Zurich, Switzerland

Liyu Wang
Nandan Maheshwari
Keith Gunura
Murat Reis
Derek Leach
Hugo Marques
Luzius Brodbeck
Xiaoxian Yu
Marc Osswald
Fabian Guenther
Cristian Montillo

Sponsors:

FNSNF
Swiss National Science Foundation

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

robotics
Swiss National Centre of Competence in Research

Thank you!

For publications, video, pictures:

Fumiya Iida
Bio-Inspired Robotics Lab
Institute of Robotics and Intelligent Systems
ETH Zurich

Email: iidaf@ethz.ch
URL: http://www.birl.ethz.ch