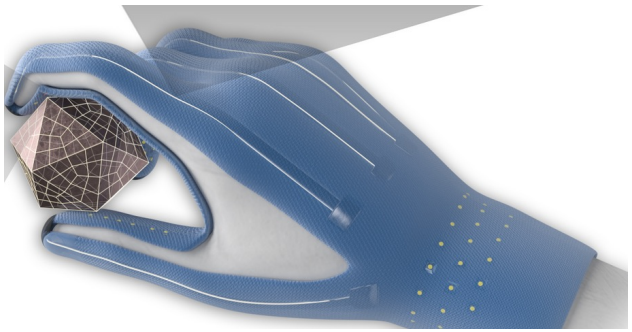
Strategic Focus Area
Advanced Manufacturing

SFA Annual Review Meeting 2022

18-03-2022

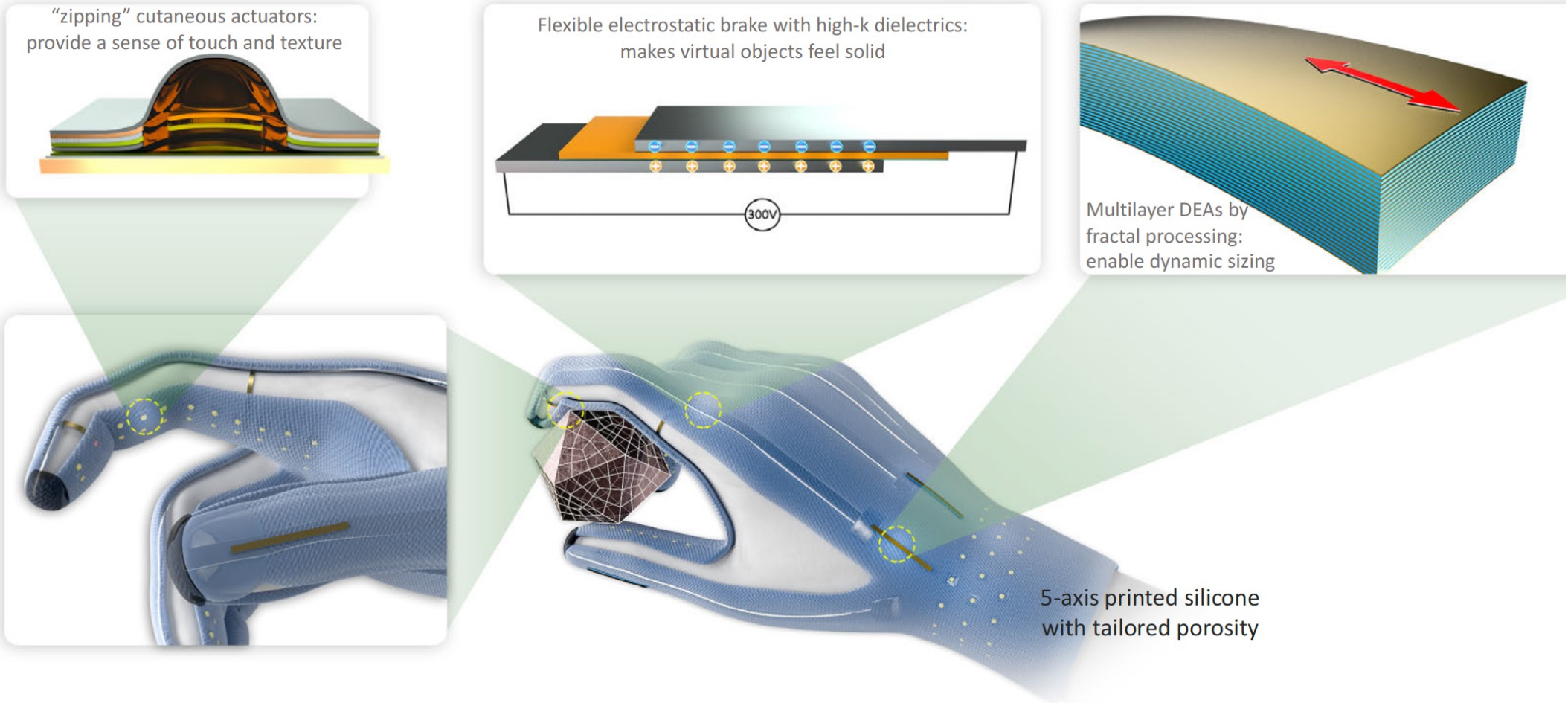
MANUFHAPTICS



ETH zürich EPFL Empa

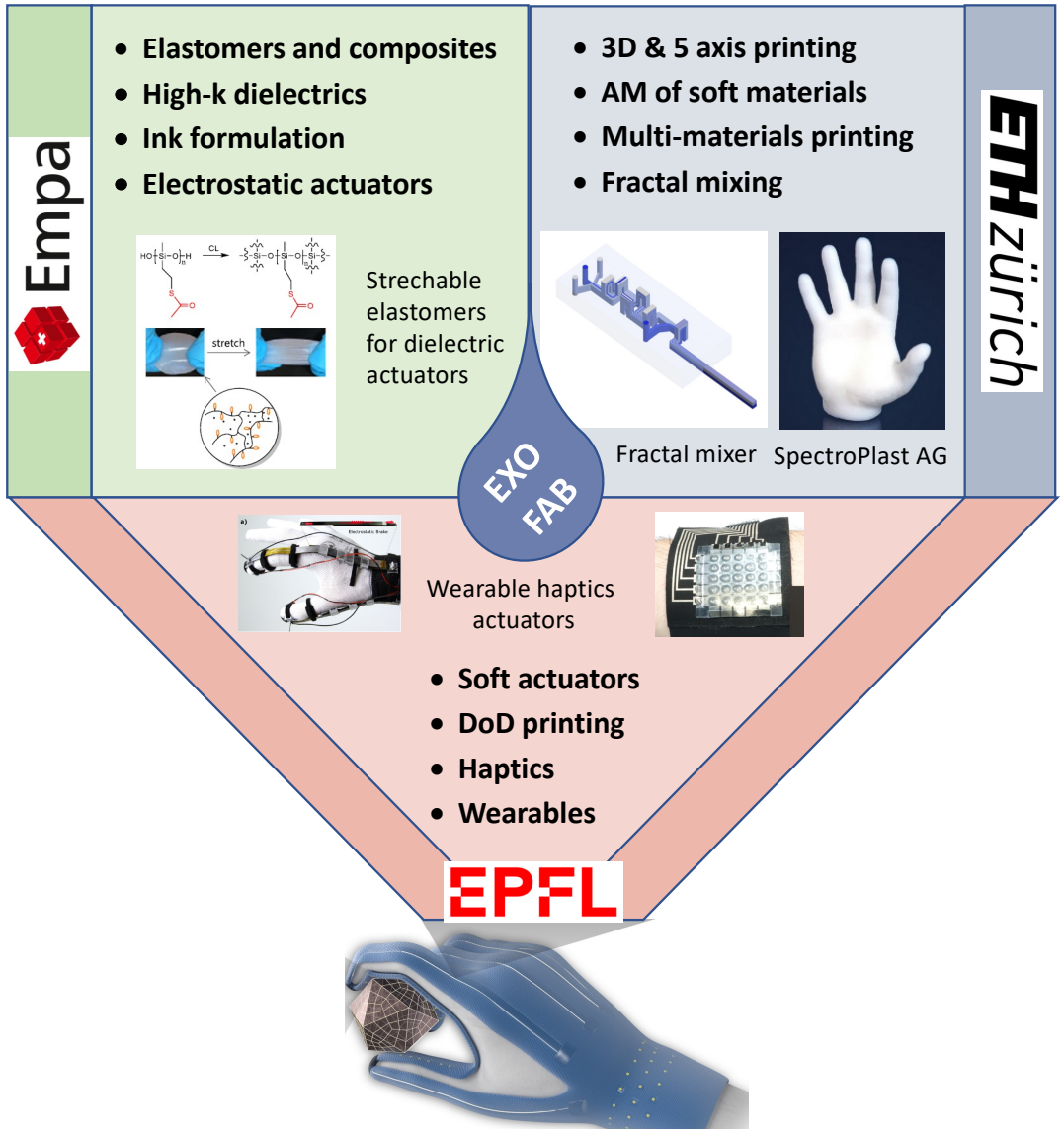
MANUFHAPTICS

We will develop AM techniques to build soft actuators in elastomer exoskeleton



Main Partners

- EPFL - Soft Transducers Lab (H. Shea)
- ETHZ - Complex Materials Lab(A. Studart)
- ETHZ - Soft Materials Lab (J. Vermant)
- Empa – Lab for Functional Polymers (D. Opris)


Empa
Elastomers and composites
High-k dielectrics
Ink formulation
Electrostatic actuators
stretch
Strechable elastomers for dielectric actuators
3D & 5 axis printing
AM of soft materials
Multi-materials printing
Fractal mixing
Fractal mixer
SpectroPlast AG
ETH zürich
EXO FAB
Wearable haptics actuators
Soft actuators
DoD printing
Haptics
Wearables
EPFL

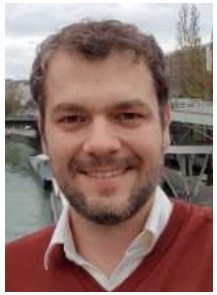
COMPLEX Materials

Relevant Expertise

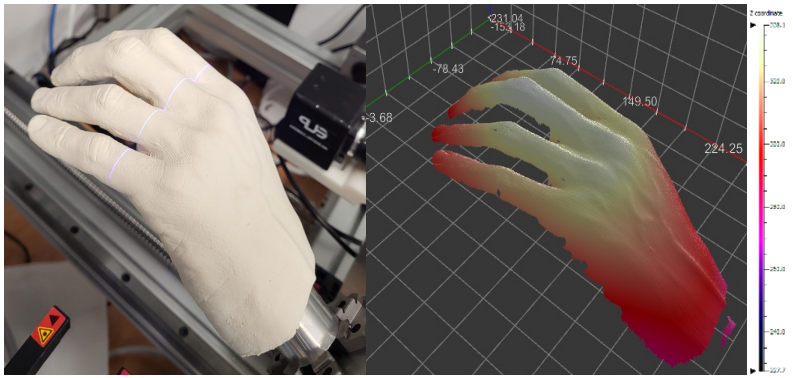
ETH zürich

Prof. André Studart

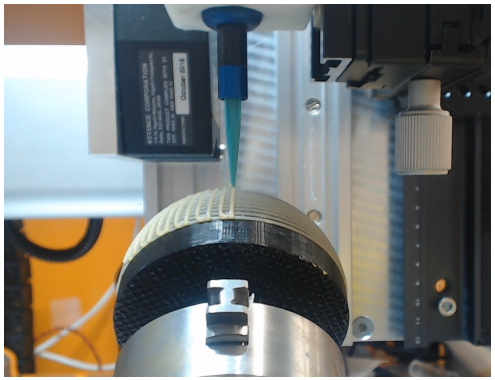
Fergal Coulter
Post-doc in 3D printing devices



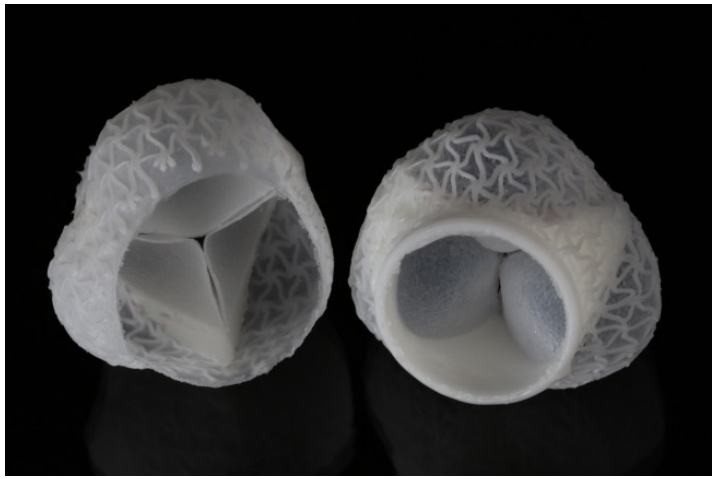
Rafael Libanori
Senior Scientist in active and adaptive materials



Scanning and Printing upon multi-curved surfaces



Multi Axis 3D Printer Design for Conformal Printing



Multi-Axis Additive manufacture of Soft Multi-material Implantable devices

3D Printed soft robotic actuators

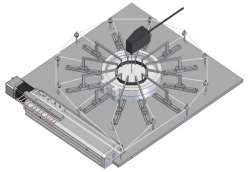
Coulter *et al.* (Matter 2019) doi: 10.1016/j.matt.2019.05.013

Schaffner *et al.* (Nat Comms 2018) doi 10.1038/s41467-018-03216-w

SOFTMAT

Relevant Expertise

ETH zürich



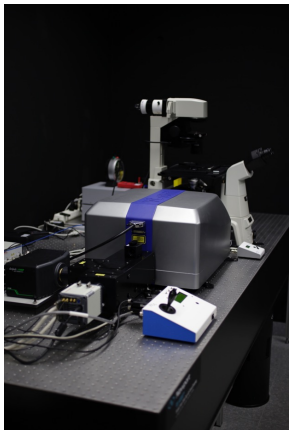
$$\boldsymbol{\sigma} = \sigma_{\alpha\beta}(\Gamma)\boldsymbol{I} + \boldsymbol{\sigma}_e$$

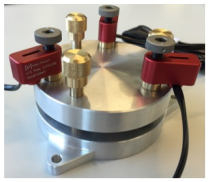
$$\boldsymbol{\sigma}_e^V = \left[(\kappa_s - \eta_s)\,\boldsymbol{\nabla}_s \cdot \boldsymbol{v}_s\right]\boldsymbol{I} + 2\eta_s \boldsymbol{D}_s$$

$$\boldsymbol{\sigma}_e^H = \frac{K}{J}\ln(J)\mathbf{I} + \frac{G}{J}\left(\tilde{\mathbf{B}}^s - \frac{1}{2}\mathrm{Tr}\left(\tilde{\mathbf{B}}^s\right)\mathbf{I}\right)$$

$$J = \sqrt{\det(\boldsymbol{F}^s)} \quad \tilde{\boldsymbol{B}}^s = \frac{1}{J}\boldsymbol{F}^s \cdot \boldsymbol{F}^{s,T}$$

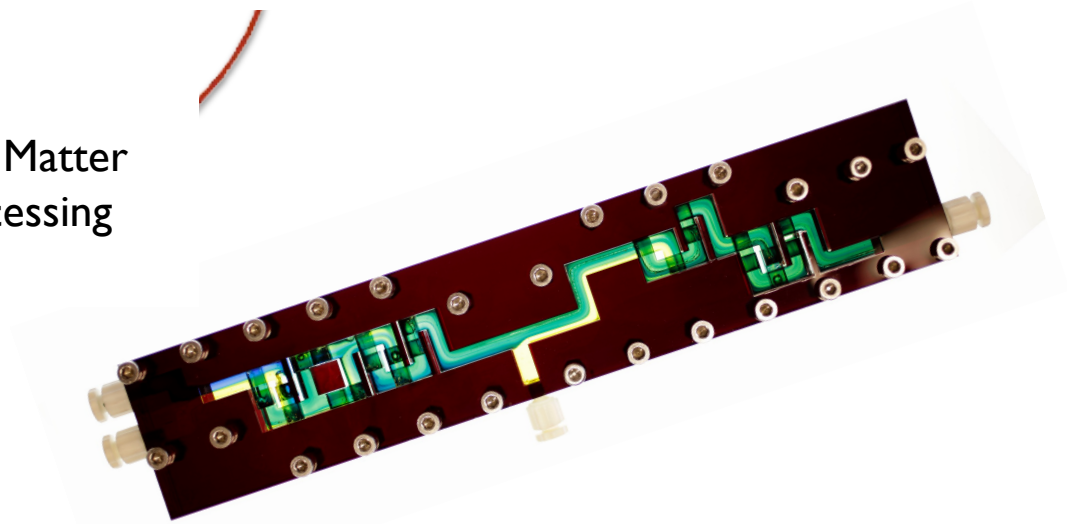
Complex Fluid-Fluid Interfaces:
rheology,
Structure and modeliing





Advanced bulk material rheomtery

Soft Matter processing

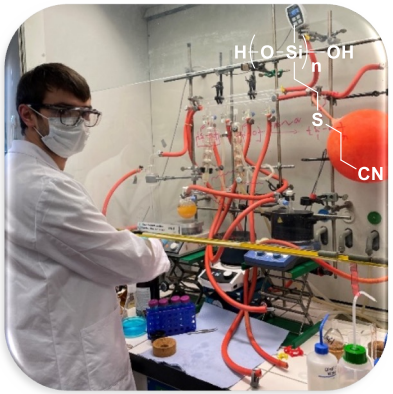


Laboratory for Functional Polymers

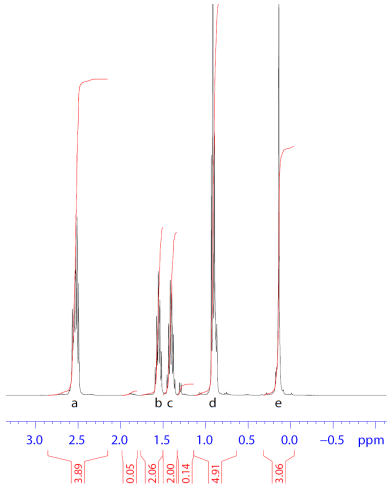
Relevant Expertise

Empa
Materials Science and Technology

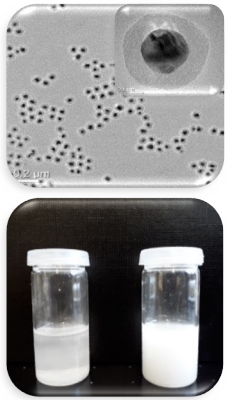
Molecular design, polymer synthesis



Structural proof

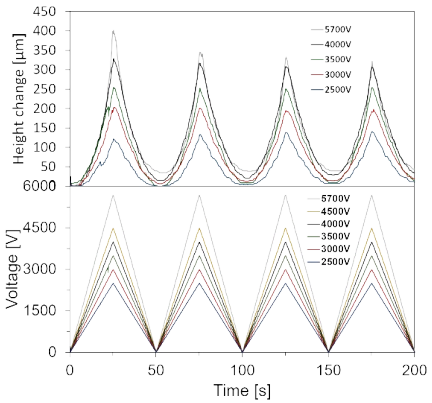


Nanoparticles and surface treatment



Composites, thin films, characterization

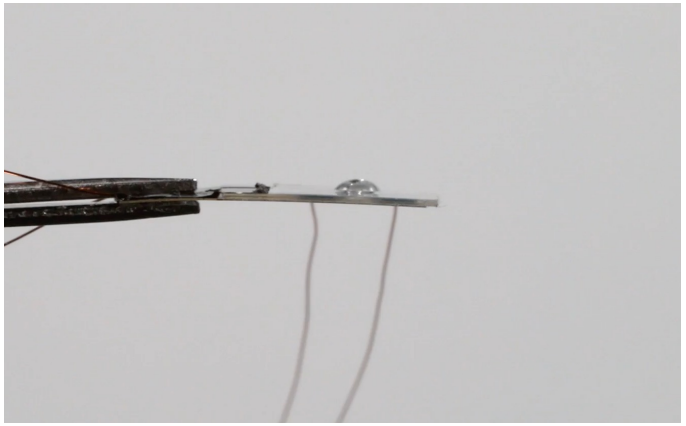
Prototype devices and characterization



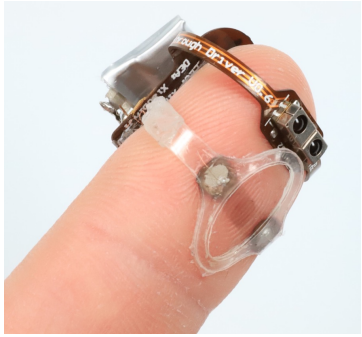
Relevant Expertise

Soft actuators for wearable haptics

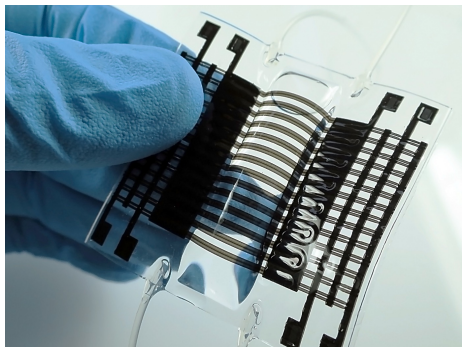
Hinchet, Adv Mat Tech 2019



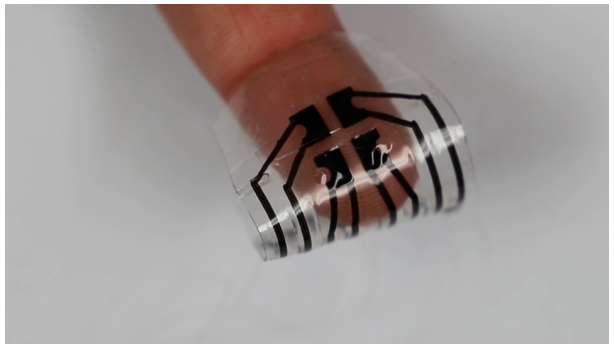
Leroy, Adv Mat 2020



X Ji, Adv Func Mat 2021



S. Schlatter, Adv Intell Sys 2020



G. Grasso, in prep 2022

Manufhaptics Objectives and deliverables

- Develop scalable AM processes for 3D integrated multi-functional layers, enabling soft systems with embedded electrically driven actuation.

- we:
  - develop **multi-materials printing over multiple size scales**, including µm-thick stacked layers made using a fractal extrusion process, µm-thick inkjet printed films, mm-thick DIW structures with graded-stiffness and graded-porosity silicones.
  - develop **high performance dielectric materials required for high energy density actuators**, inks enabling sacrificial layers, compatible with different printing tools.
  - embed three types of **high-force flexible electrostatic actuators** enabling force feedback
  - **validate integration of the different AM technologies in a glove**

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