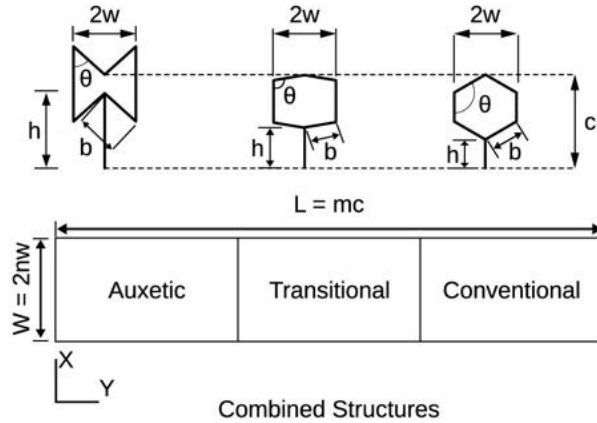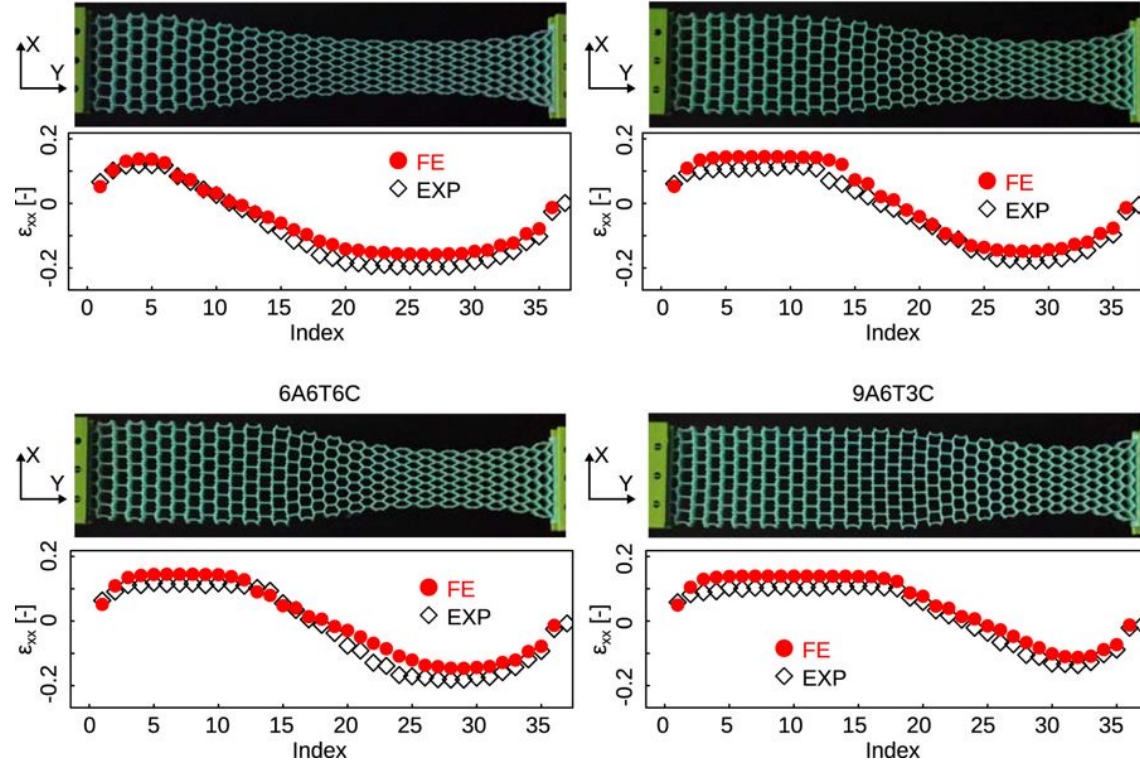# Designer materials with enhanced functional properties

Mohammad J. Mirzaali

Department of Biomechanical Engineering
Faculty of Mechanical, Maritime, and Materials Engineering,
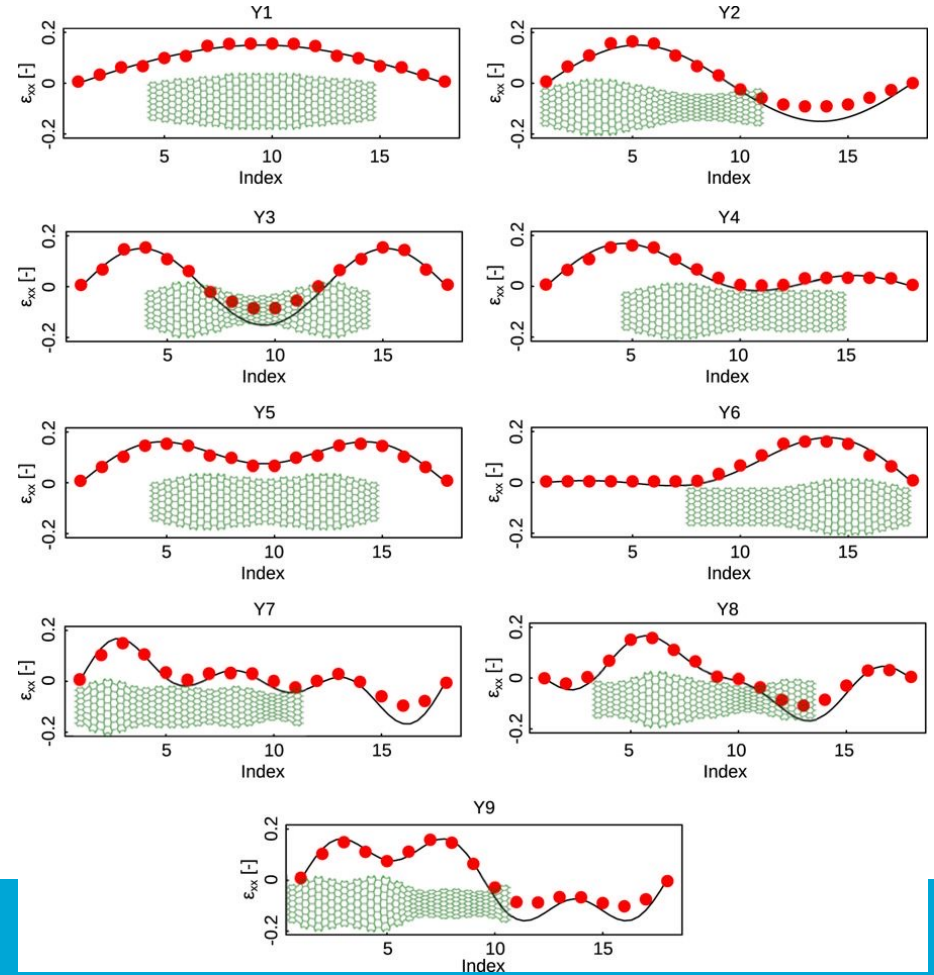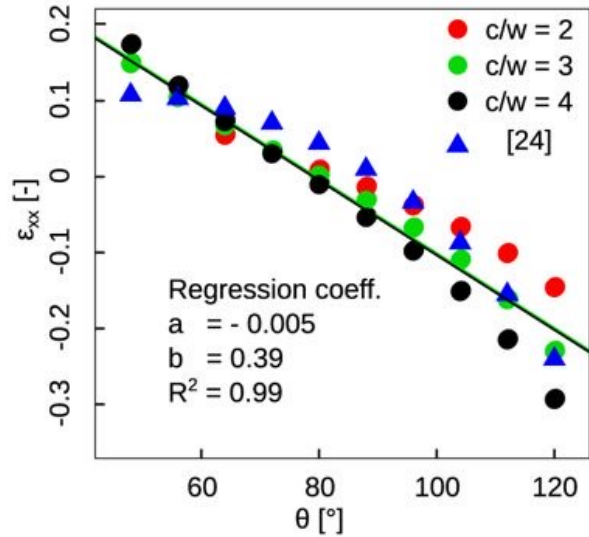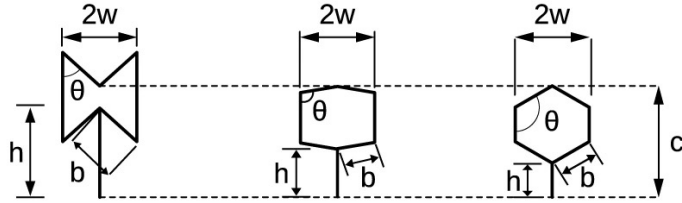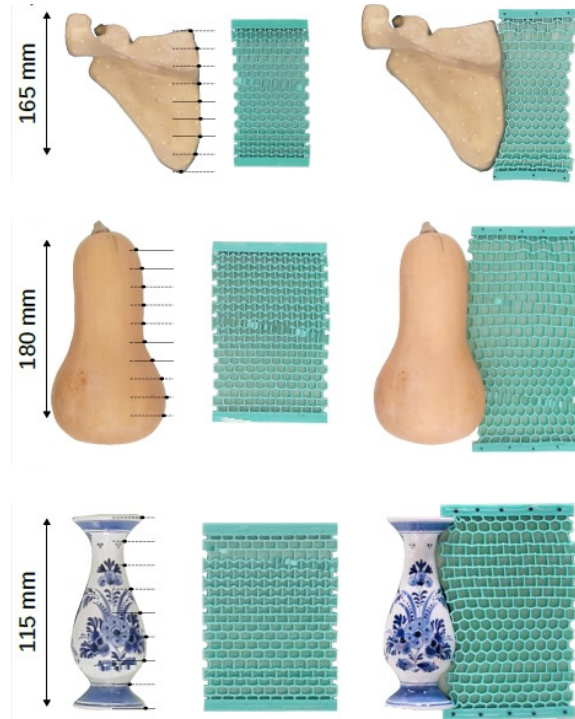Delft University of Technology (TU Delft)

TUDelft

Mechanical metamaterials
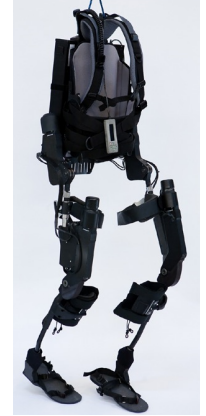
Shape matching mechanical metamaterials

Shape matching mechanical metamaterials

Exoskeleton (Designboom®)

Soft Robotics Inc.

Form fitting material
(Patent US20140109286)

165 mm

180 mm

115 mm
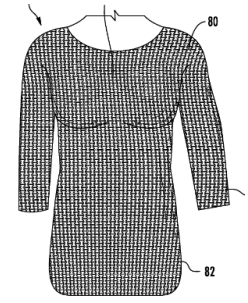
Scientific Reports, 2018
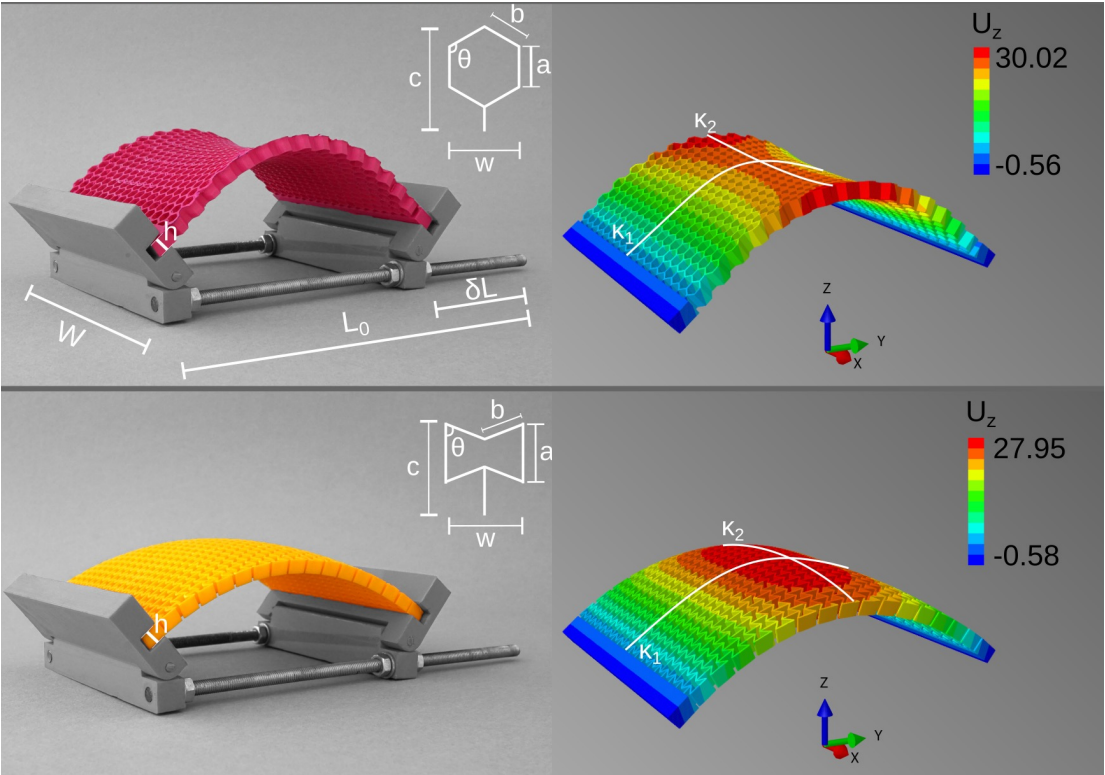
TUDelft

Curvature analysis of meta-plates

TUDelft

Curvature analysis of meta-plates

0.2mm
Speed: 5x

Increasing Curvature

Mirror
Laser
Holder
Expanders
Photo's area
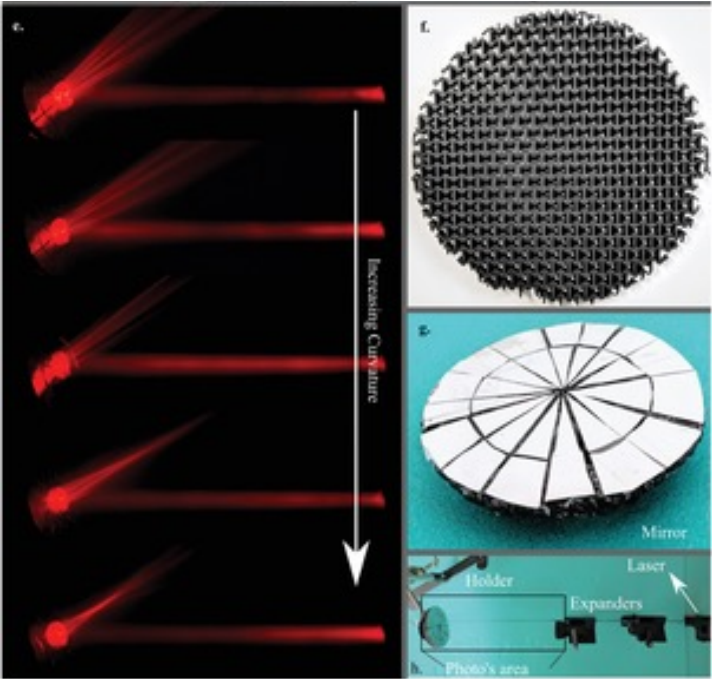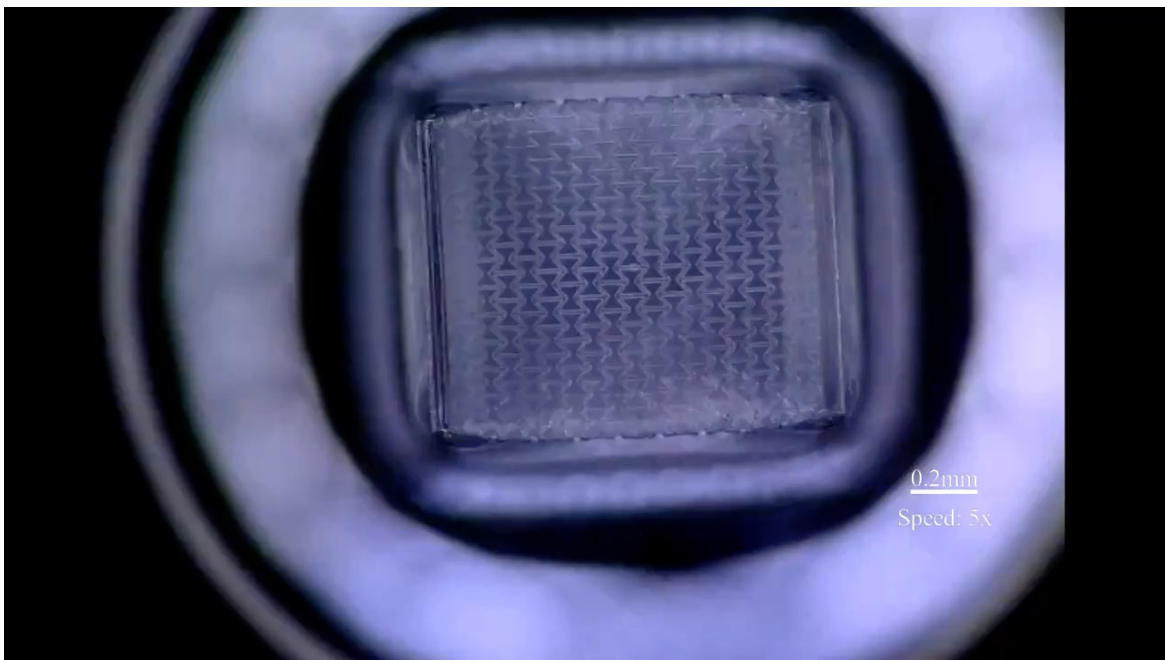
Disordered random network mechanical metamaterials
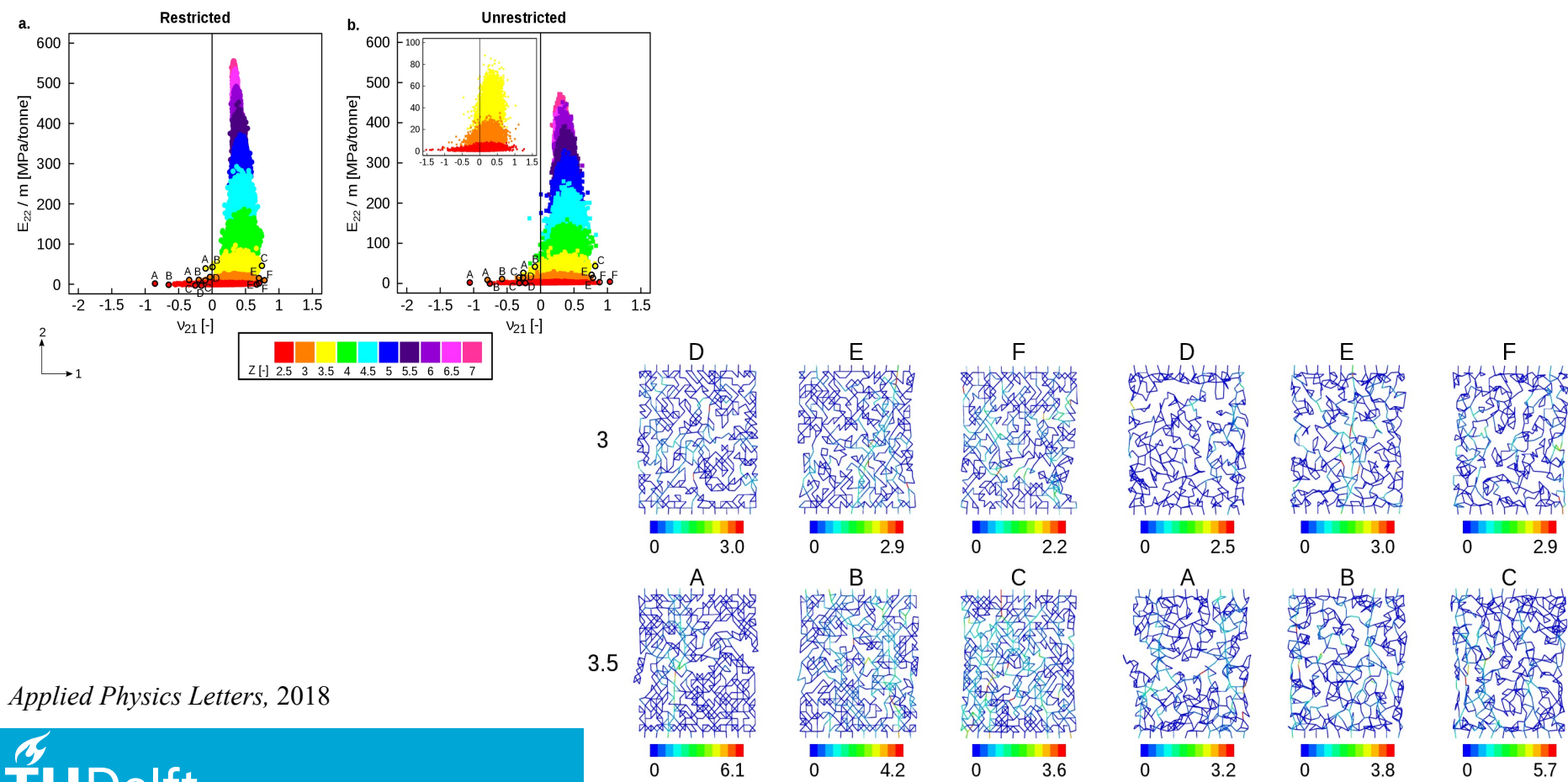
Applied Physics Letters, 2018

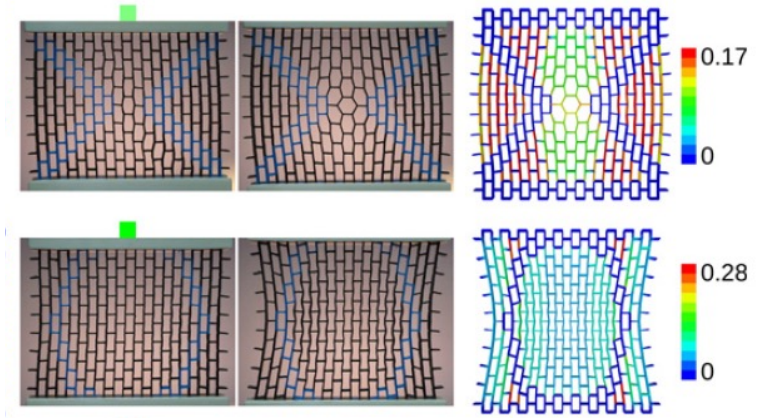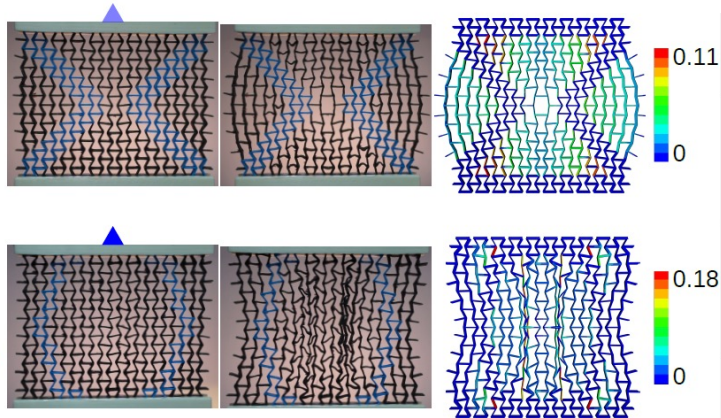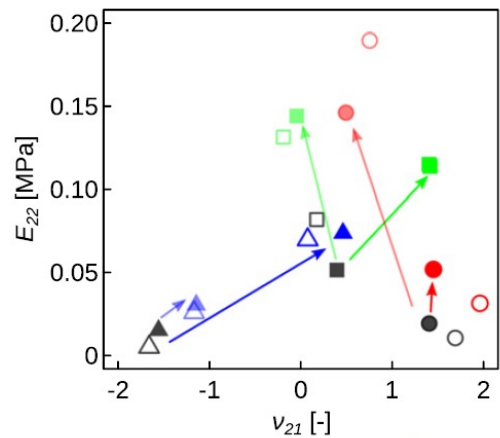# Disordered random network mechanical metamaterials

Pi Lab: Adaptable Auxetics

4TU.HTM Funding for CROSS-LAB materials
science activities between TUEindhoven (Dr. W.G.
Ellenbroek, Prof. C. Storm) and TUDelft (Prof. A.
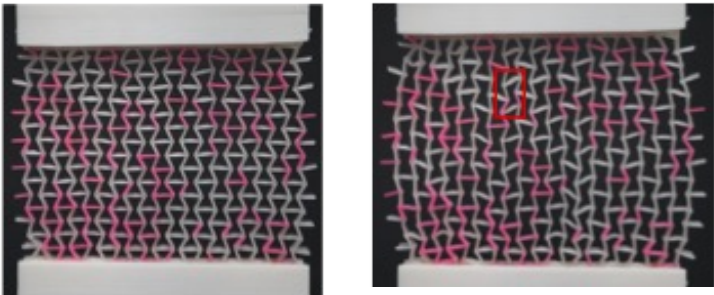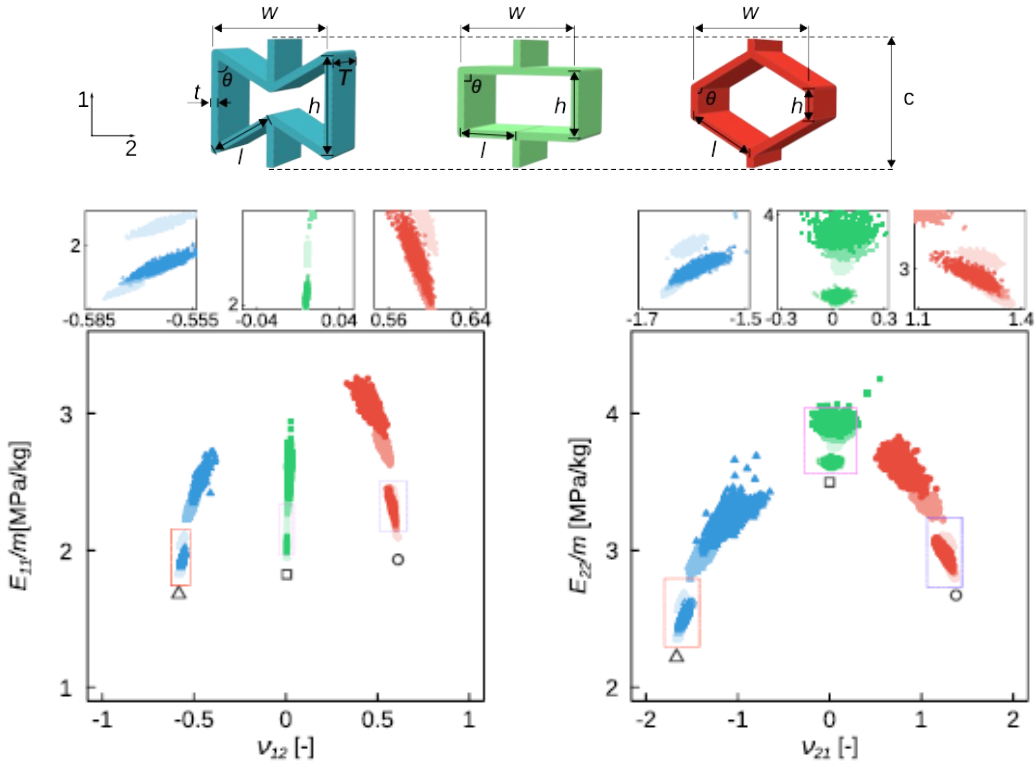Zadpoor)

Dutch design week

TUDelft

Multi-material metamaterials with tailored elastic properties

Multimaterial mechanical metamaterials

TUDelft

Non-affinity in multi-materials mechanical metamaterials
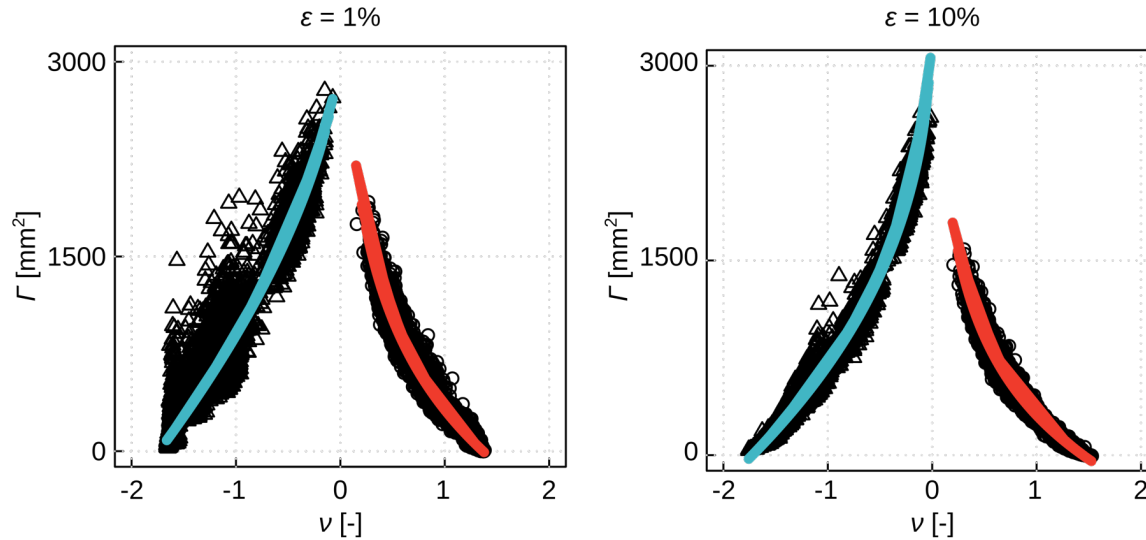
θ	a	b	c	a	b	c
60°	-2324.12	0.59	3215.42	-2991.73	0.38	3682.80
120°	-44134.83	0.02	44453.14	10080.00	-0.08	-9772.00

$$\Gamma = \frac{1}{{\varepsilon_{22}}^2 N} \sum_{i=1}^{N} \left(u_i^{non-affine} - u_i^{affine} \right)^2$$

Deep learning multi-materials mechanical metamaterials

Single unit cell model

a.

Generate training set (n_1=16,500,000)

Deep Neural Network

n_I=151
n_H=256
n_H=128
n_H=128
n_H=64
n_H=32
n_O=4

Finite Element Code

Prediction ($n_{Prediction}$=1,500,000,000)

FEM   DIC

FEM   DIC

TUDelft

Deep learning multi-materials mechanical metamaterials

TUDelft