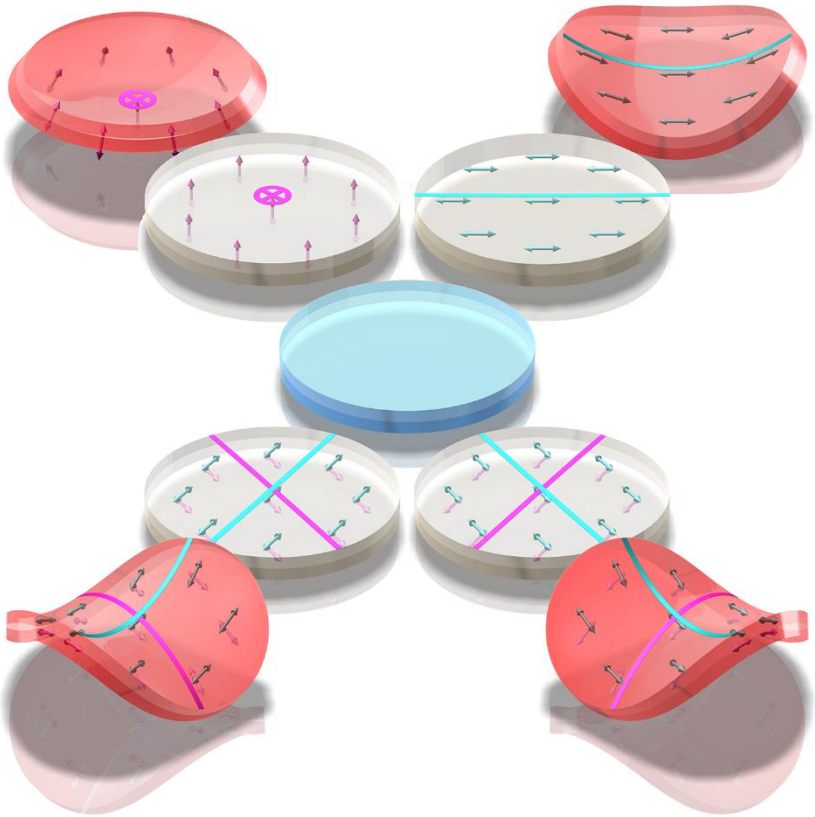
POLIMERNO-DISPERGIRANI TEKOČEKRISTALNI ELASTOMERI

mehki materiali s programabilnim oblikovnim spominom



polimerni kompoziti za uporabo v MEMS, NEMS, aditivnih tehnologijah, mikrofluidiki, senzorski in aktuatorski tehniki, ter umetnih mišicah

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Institut "Jožef Stefan"
F5-Odsek za fiziko trdne snovi

OvZ 2017
Gimnazija Novo mesto, 18. 10. 2017

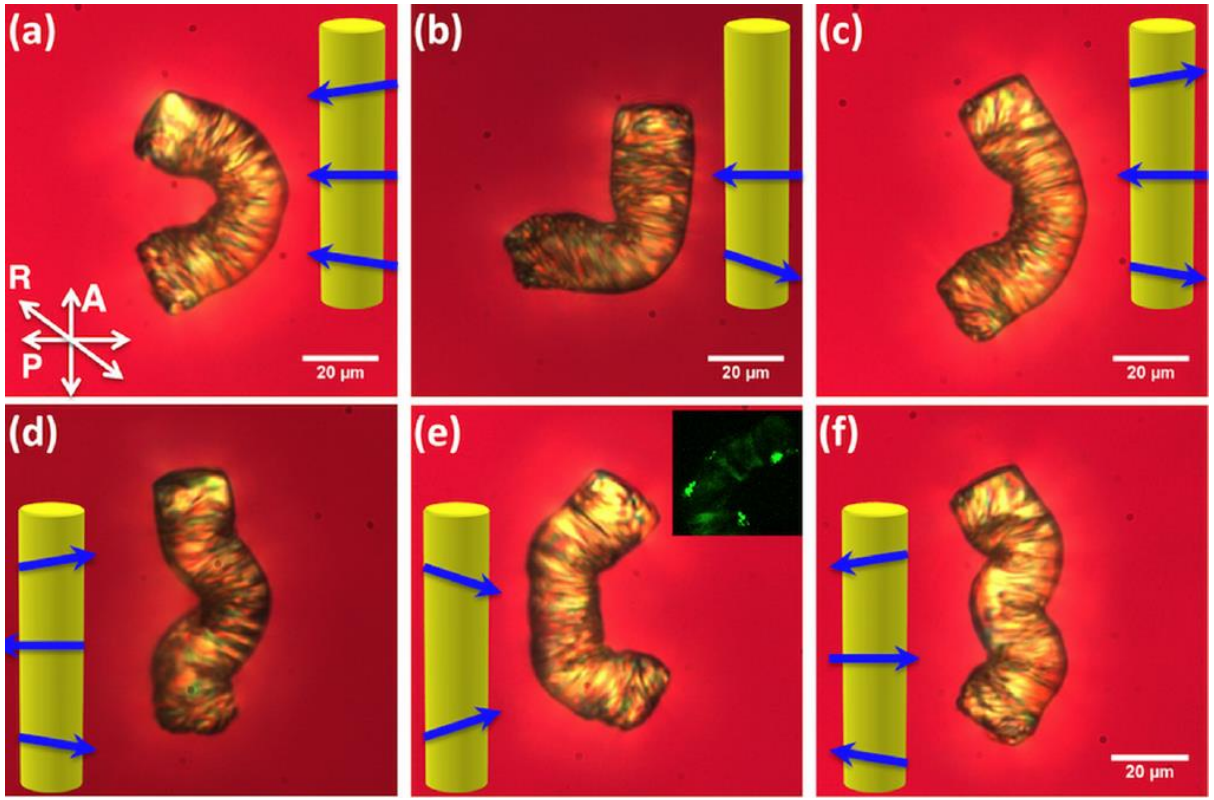
Preoblikovanje materialov

… v pop kulturi

Terminator 2: Judgment Day, Columbia TriStar Motion Picture Group, 1991

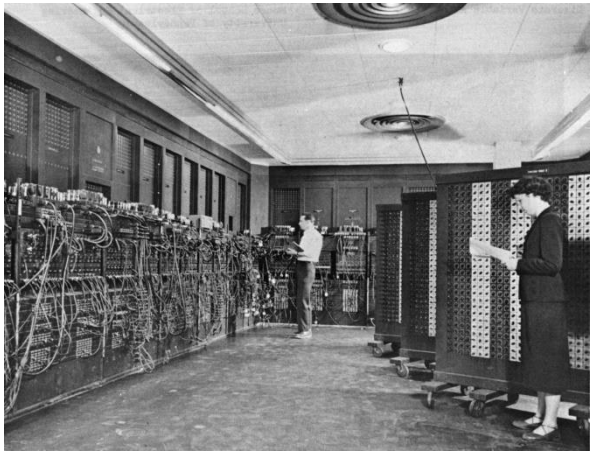
Preoblikovanje materialov

… in zares s tekočekristalnimi elastomeri



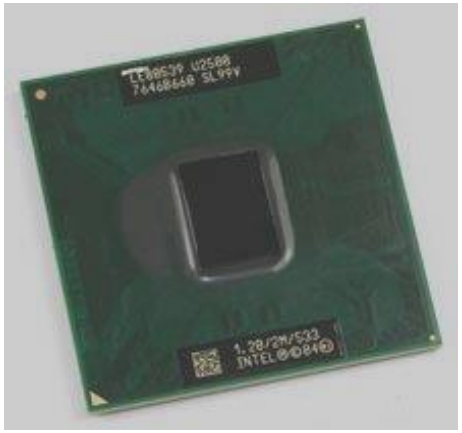
Sun et al, Applied Physics Letters, 2012

Miniaturizacija

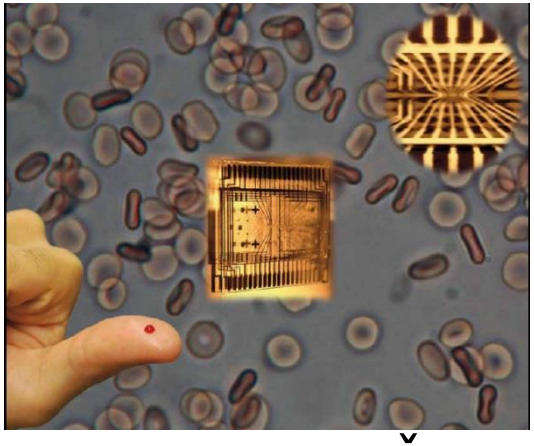


ENIAC 1947

BIOLABORATORIJ 201?

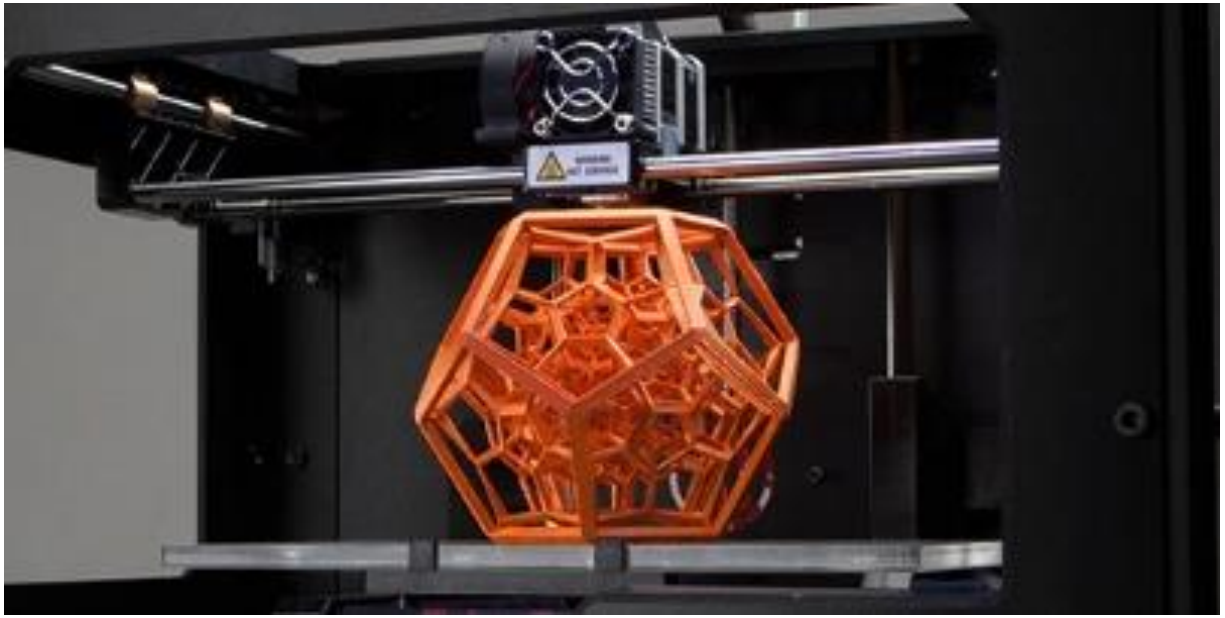


MIKROPROCESOR 2010



LABORATORIJ NA ČIPU 2???

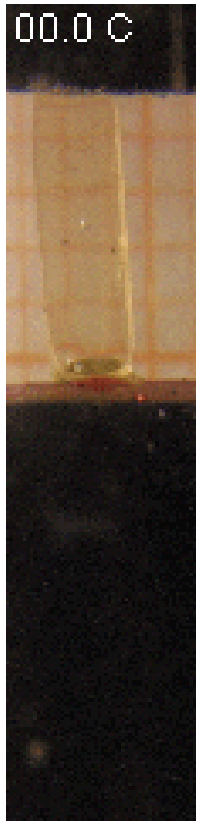
Tehnologije aditivnega nanašanja



Zankrat predvsem “FDM” 3D printanje izotropnih polimernih materialov

Orientacijski red molekul in mehanska deformacija v tekočekristalnih elastomerih (TKE)

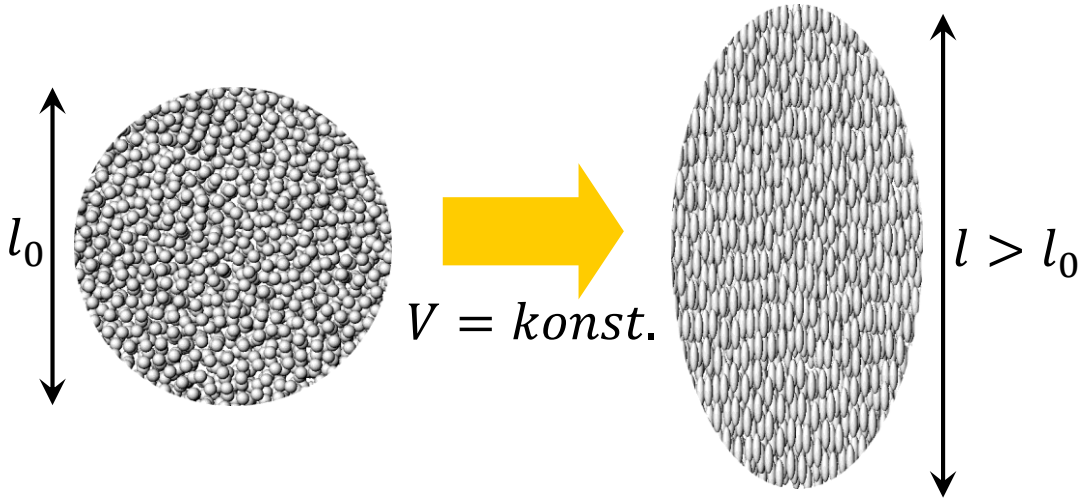
"side chain"



"main chain"

ε – makroskopska mehanska deformacija

S – orientacijska urejenost molekul



$l(T \to \infty) = l_0$

$S = 0$

$l(T)$

$S > 0$

OBRNLJIV TERMOMEHANSKI ODZIV

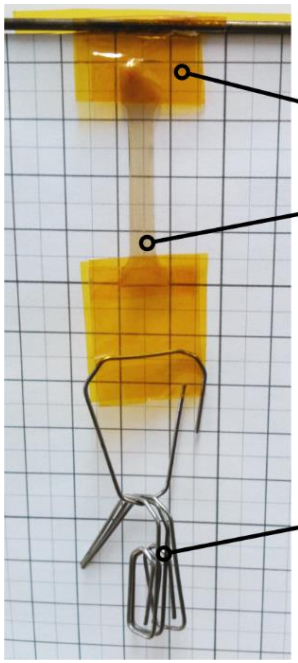
$$S(T) \propto \varepsilon(T) = \frac{\Delta l}{l_0} = \frac{l(T)}{l_0} - 1$$

Priprava konvencionalnih TKE

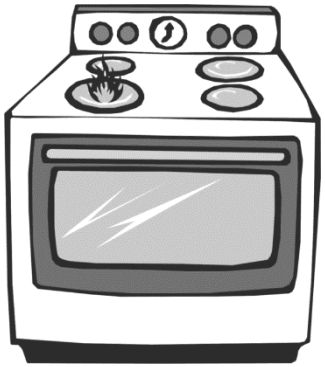
mešanje kemikalij

centrifugiranje

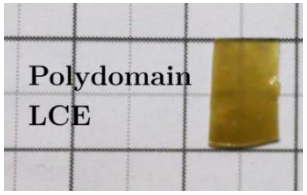
delno zamreženi TKE

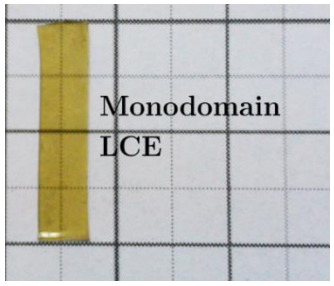


mehansko natezanje

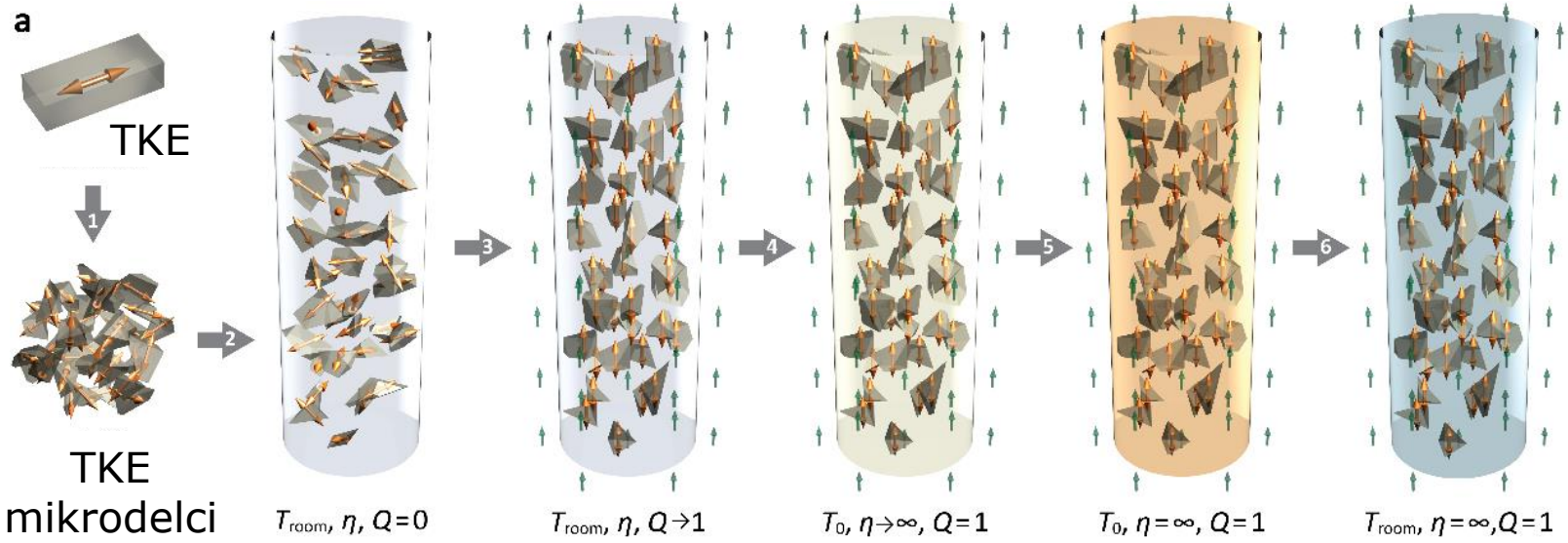


polimerizacija



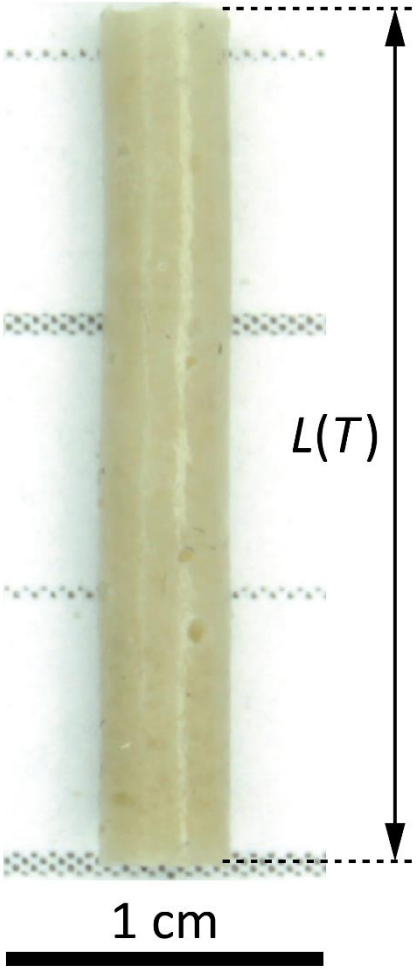


Priprava polimerno dispergiranih TKE z urejanje mikrodelcev v zunanjem polju

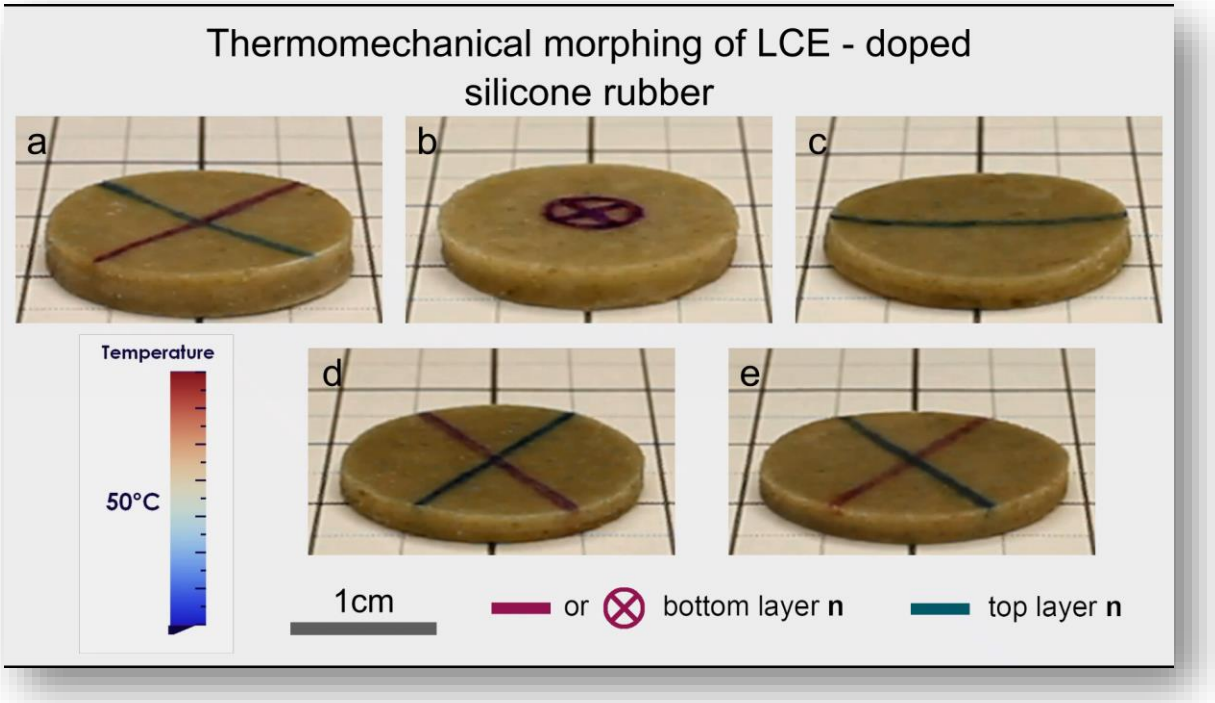


1. priprava TKE mikrodelcev
2. mešanje mikrodelcev v polimerno matriko
3. urejanje mikrodelcev z magnetnim poljem
4. segrevanje kompozitne smole do temperature zamreževanja
5. zamreževanje polimerne matrike
6. ohlajanje materiala do sobne temperature

Termomehanski odziv PDTKE kompozita



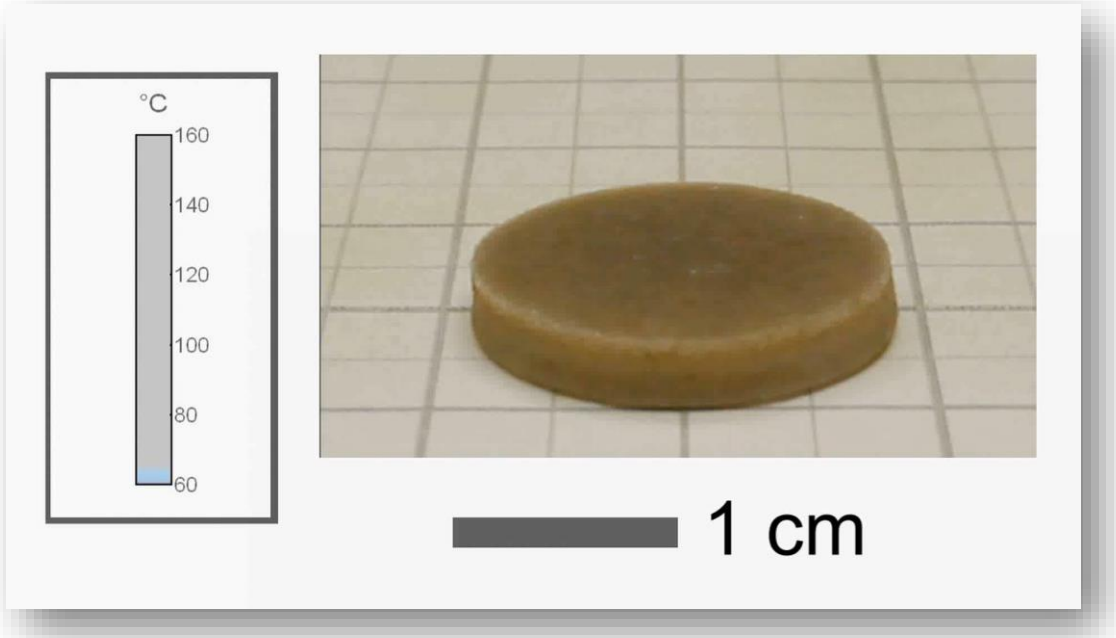
Programabilni oblikovni spomin



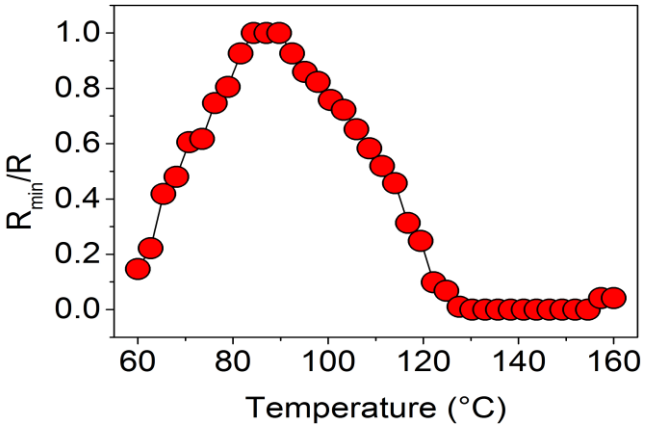
a) sedlo b) leča c)zavitek d) desni vijak e) levi vijak

- objekti enake oblike, z različnimi vprogramiranimi načini termomehanske deformacije
- že z enostavnim dvoplastnim urejanjem TKE mikrodelcev je mogoče doseči katerikoli osnovni način deformacije
- potencialna uporaba v tehnoligijah 3D tiskanja: **vokseli**ranje materiala s kontrolo zunanjega polja (magnetno, električno) med zamreževanjem

Netrivialni termični odziv



- utripanje materiala pri spreminjanju temperature
- dvoplastna struktura urejnih TKE mikrodelcev z različnimi temperaturami termomehanskega predhoda



Zaključki

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Polymer-dispersed liquid crystal elastomers

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thermomechanical deformation modes. The future looks bendy. *BV*

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research highlights

ELASTOMERS

Morph on demand

Nat. Commun. **7,** 13140 (2016)

Wouldn't it be nice to have an elastomer that could change into any given shape? Most definitely — if only for applications like microfluidic valves, Braille readers or artificial muscles.

Andraž Rešetič and colleagues have made an important step towards the manufacture of such functional rubbers. They took low-viscosity polydimethylsiloxane, a conventional elastomer, and added elastomeric liquid-crystal microparticles exhibiting shape memory — the ability to return from a deformed state into the undeformed state through heating. Under the application of an external magnetic field, the particles collectively align, and the shape-memory effect is carried over to the macroscopic structure. Subsequent hardening via thermal treatment results in a material that will deform when heated. The composite's shape-memory behaviour depends on the concentration and distribution of the fillers — enabling control of its thermoelastic response.

The authors further showed that macroscopic bilayers of these elastomeric composites with different deformational directions can result in any of five basic thermomechanical deformation modes. The future looks bendy. *BV*