**Multi-material 3D printed shape memory polymer with tunable melting and transition temperature activated by heat and light**

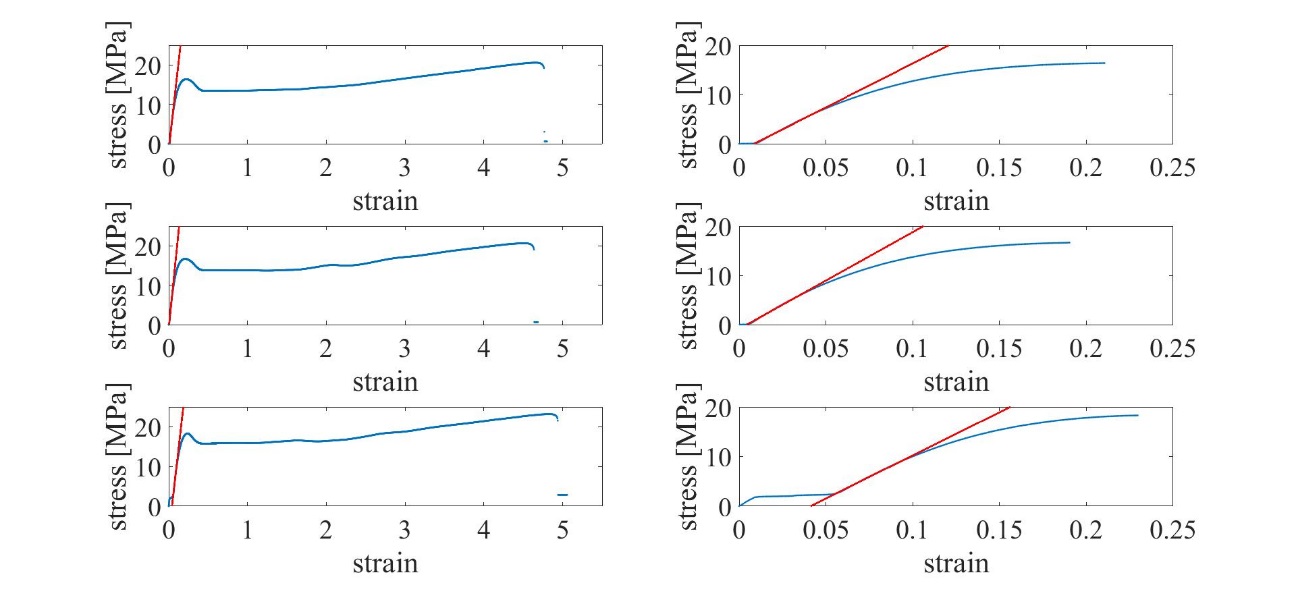
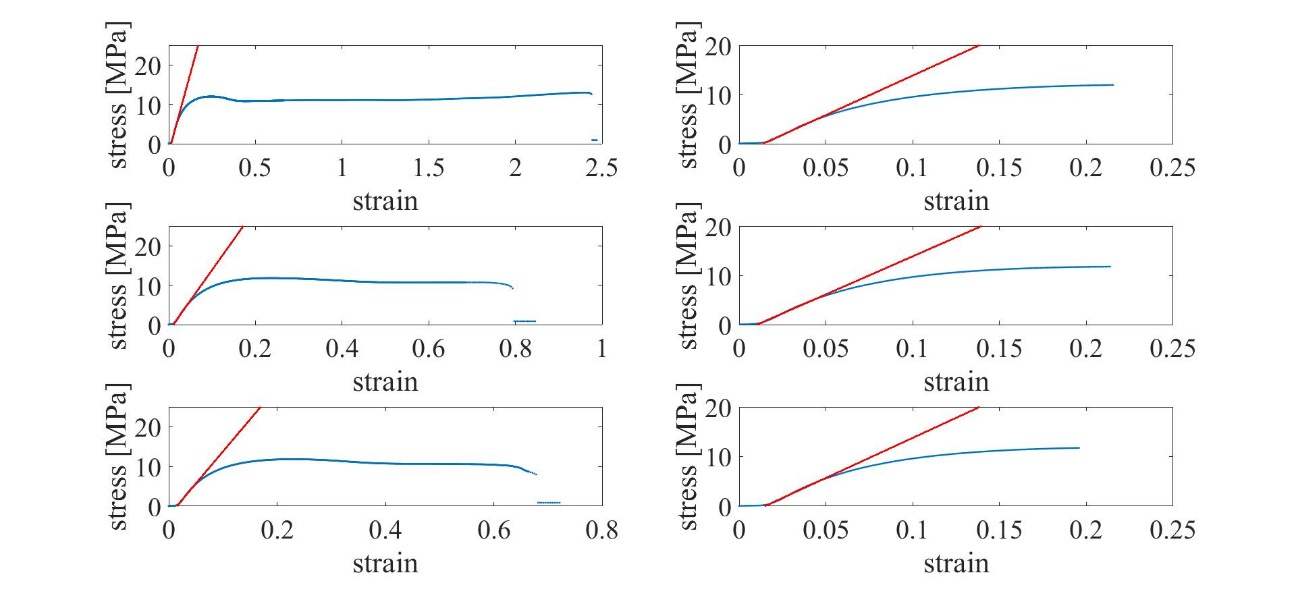
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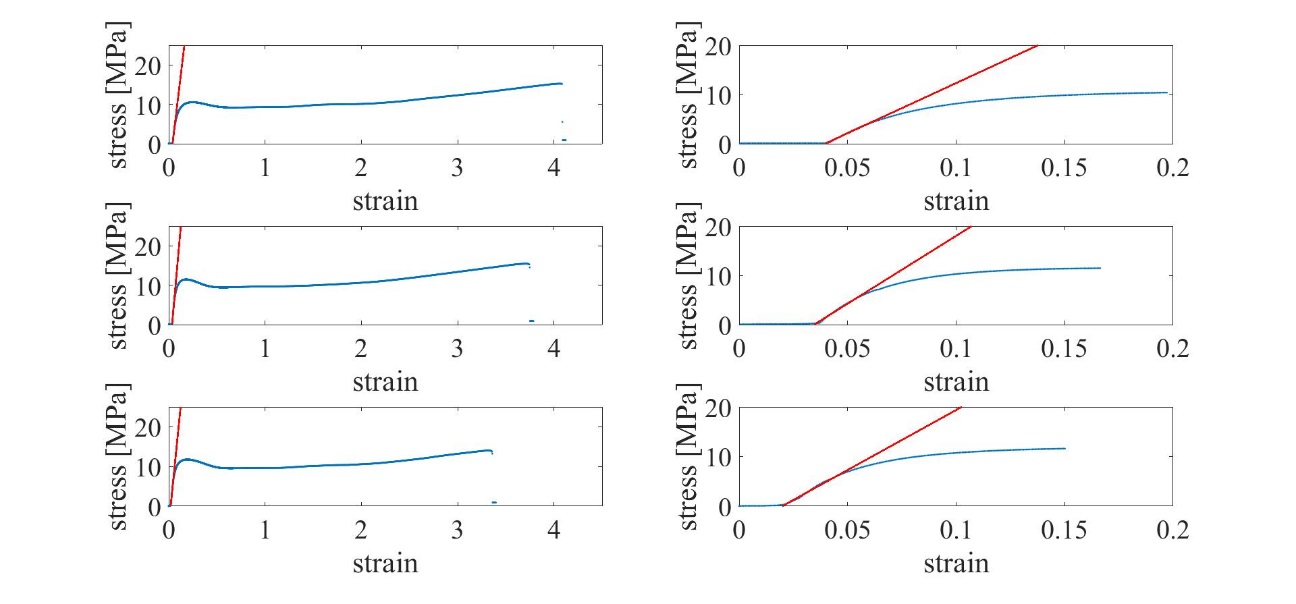
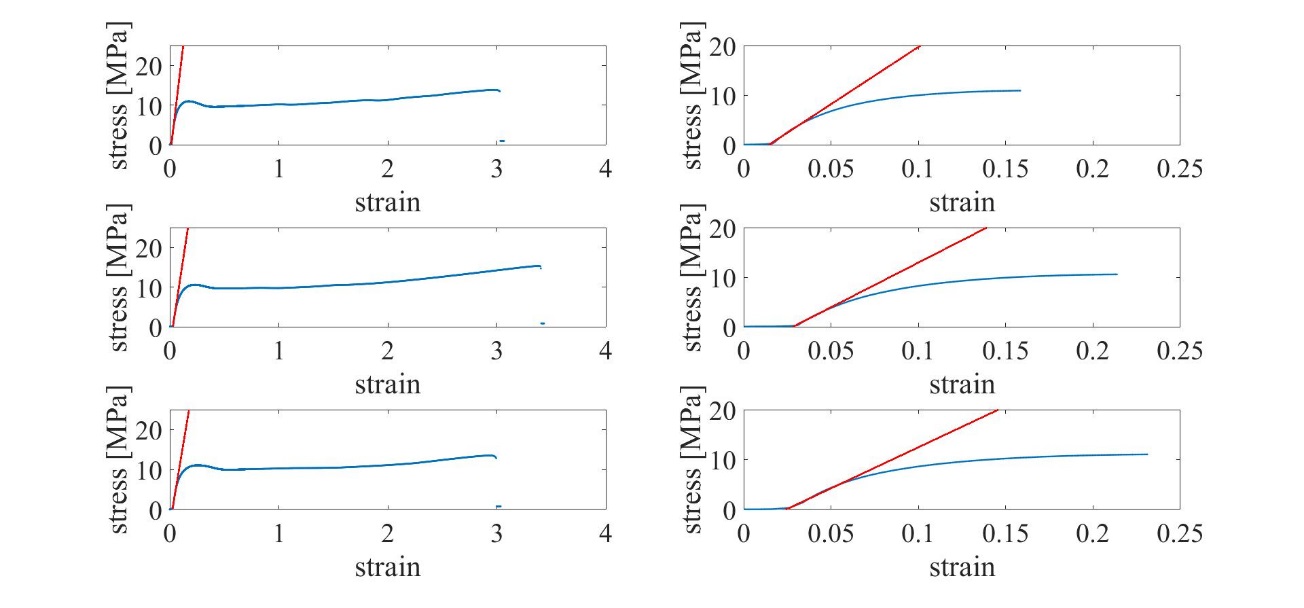
*\* Corresponding author.*

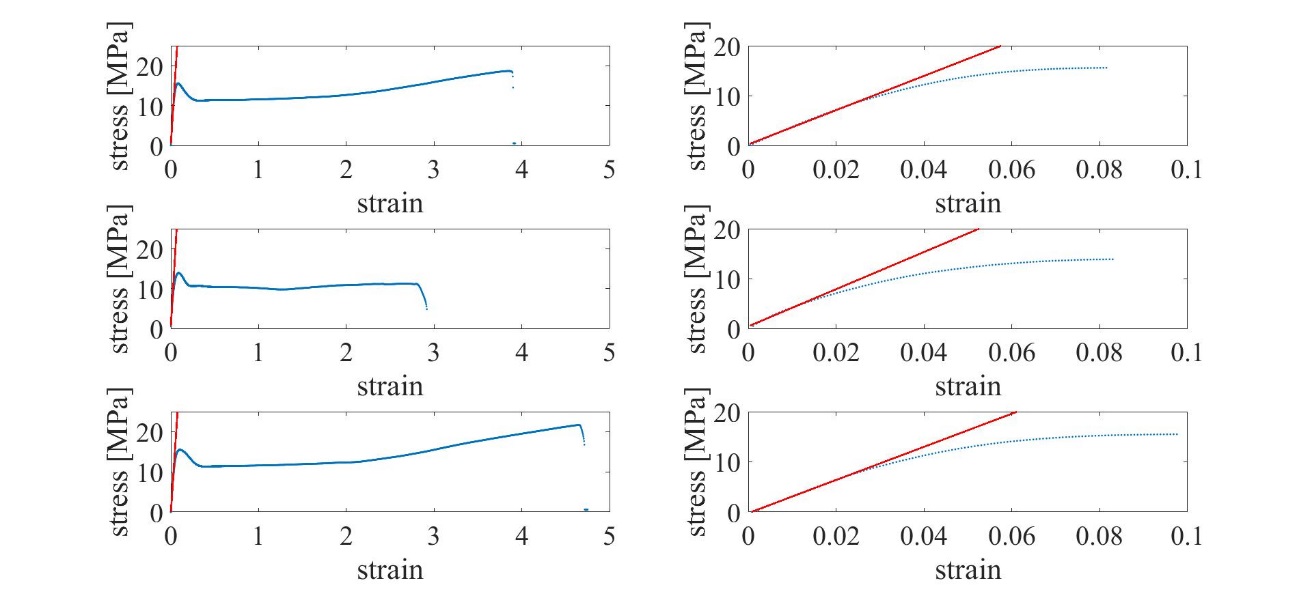
*Email addresses:* [*magdassi@mail.huji.ac.il*](mailto:magdassi@mail.huji.ac.il) *(S. Magdassi)*

**Supporting information**

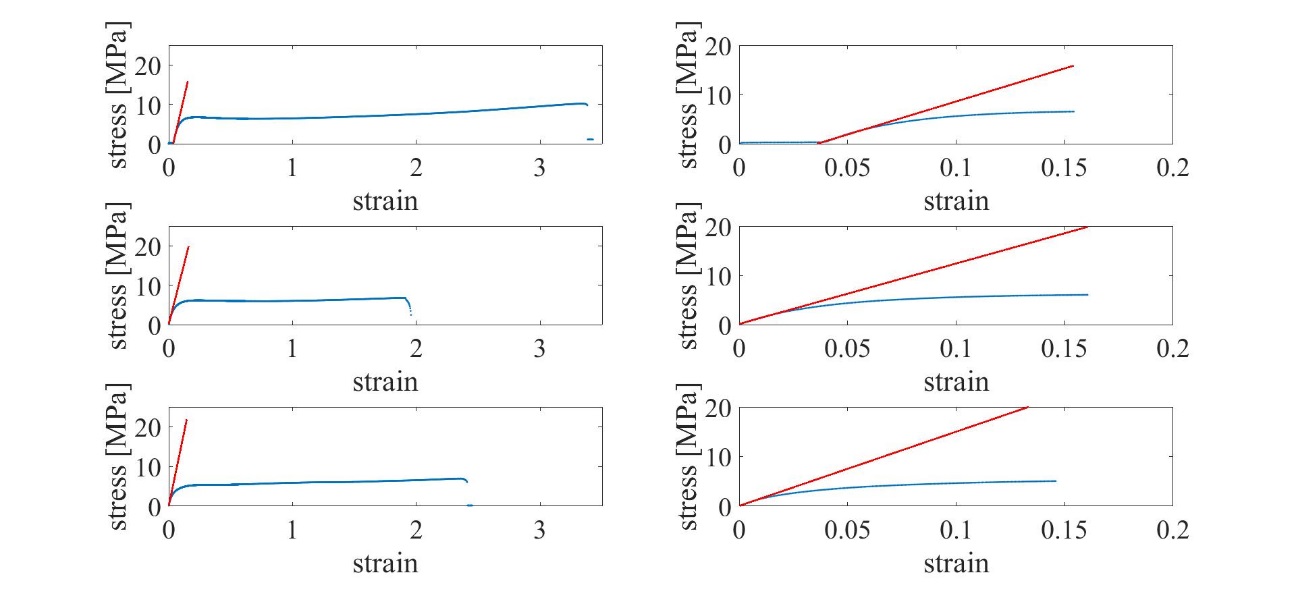
***Figure S1:*** *Young's modulus analysis for pure PCLMA polymer below transition temperature.*

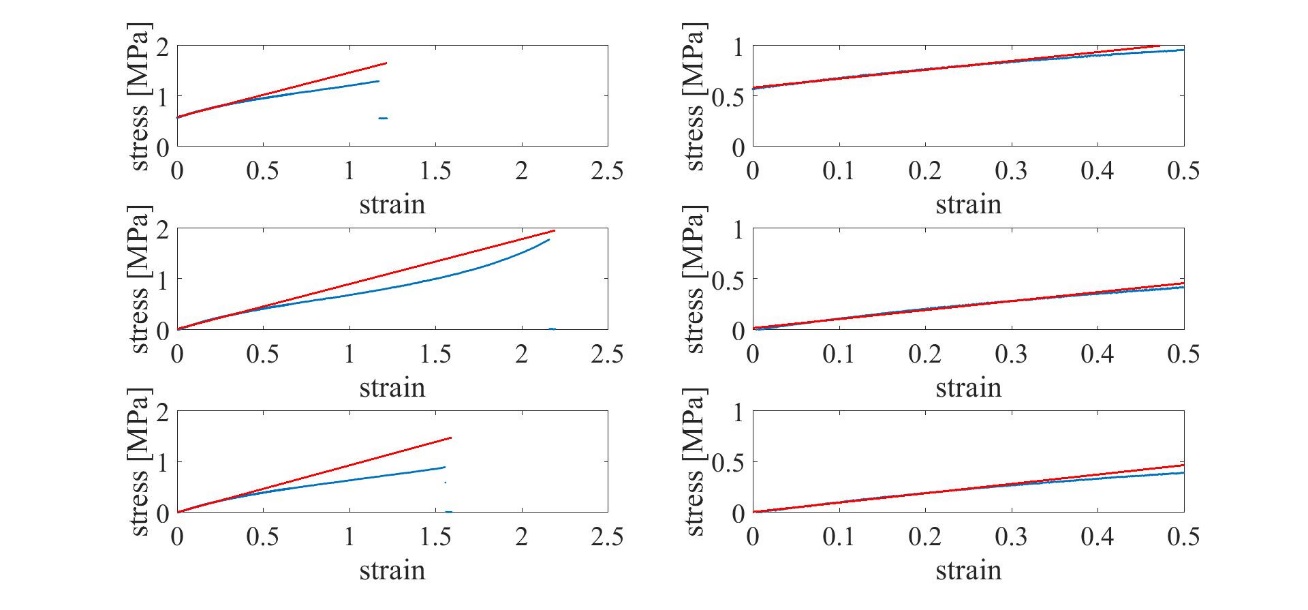
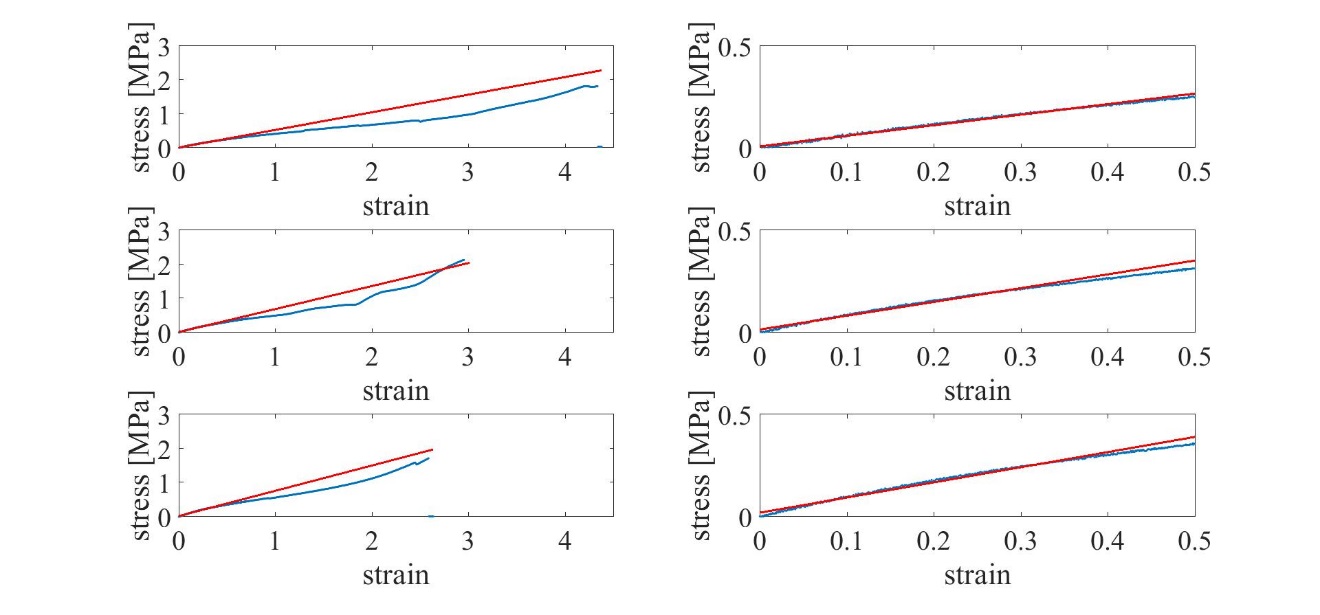
***Figure S2****: Young's modulus analysis for 10 wt% NCVL: PCLMA polymer composition below transition temperature.*

*********Figure S3****: Young's modulus analysis for 20 wt% NCVL: PCLMA polymer composition below transition temperature.*

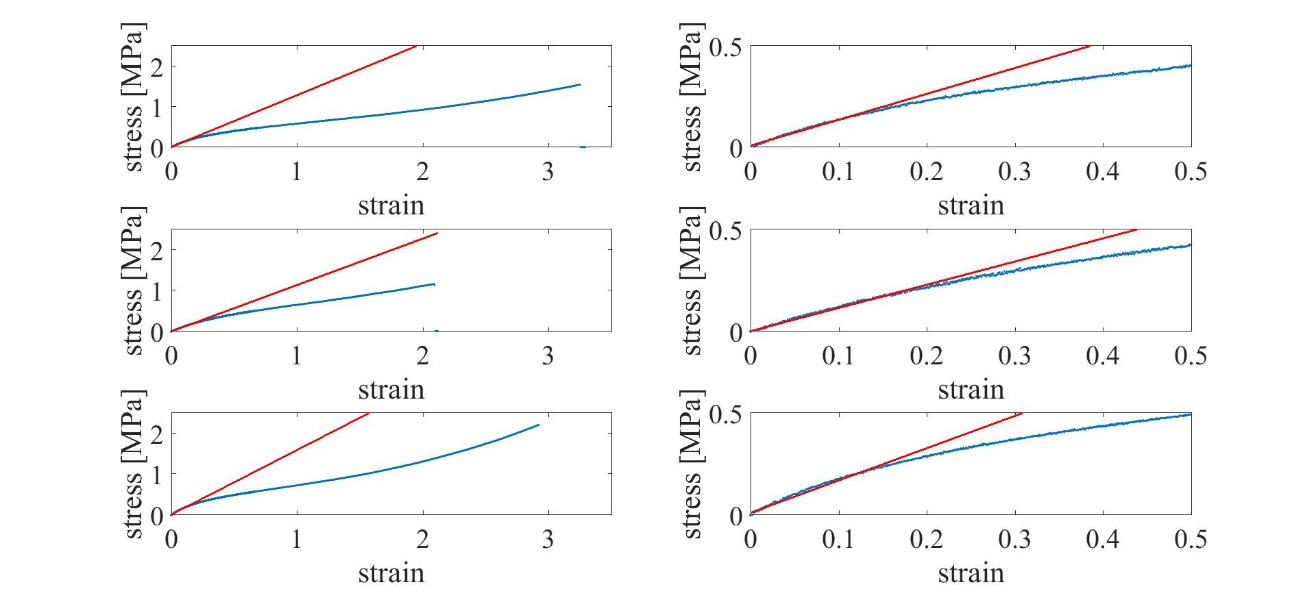
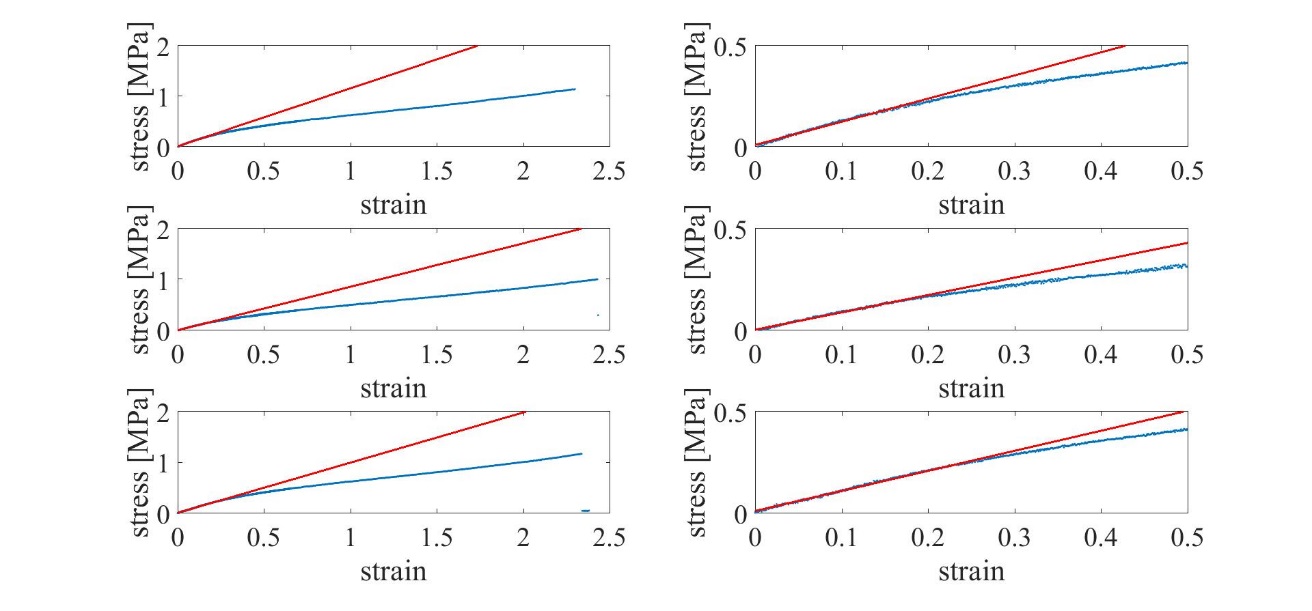
***Figure S4****: Young's modulus analysis for 30 wt% NCVL: PCLMA polymer composition below transition temperature.*

***Figure S5****: Young's modulus analysis for 40 wt% NCVL: PCLMA polymer composition below transition temperature.*

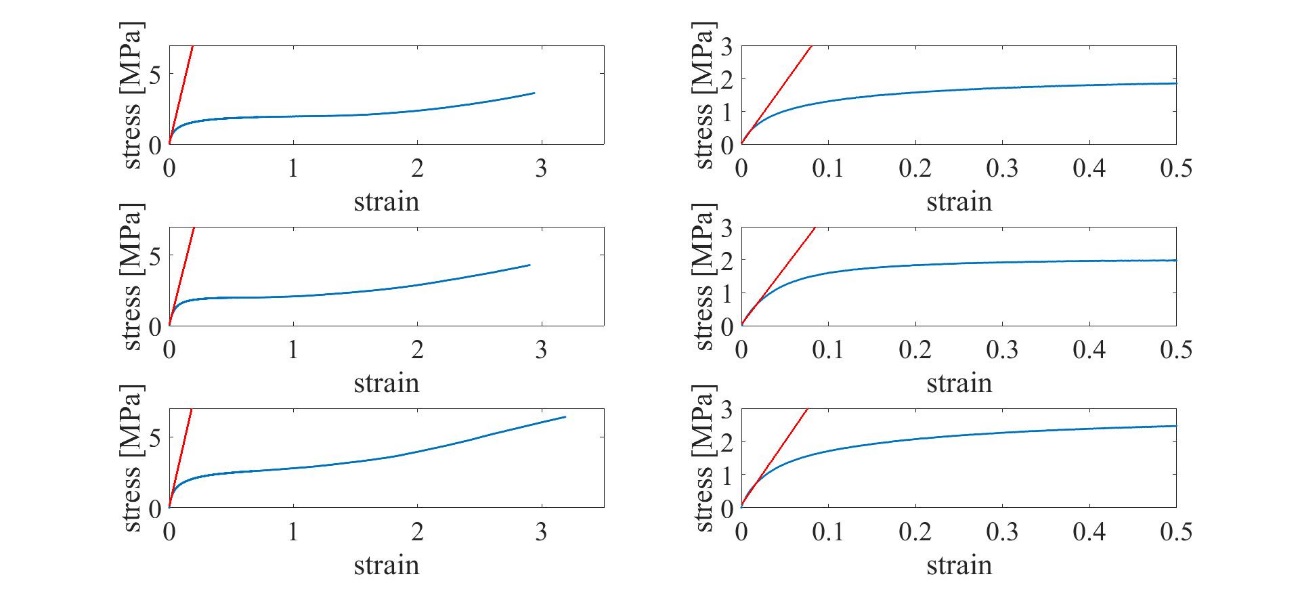
***Figure S6****: Young's modulus analysis for 50 wt% NCVL: PCLMA polymer composition below transition temperature.*

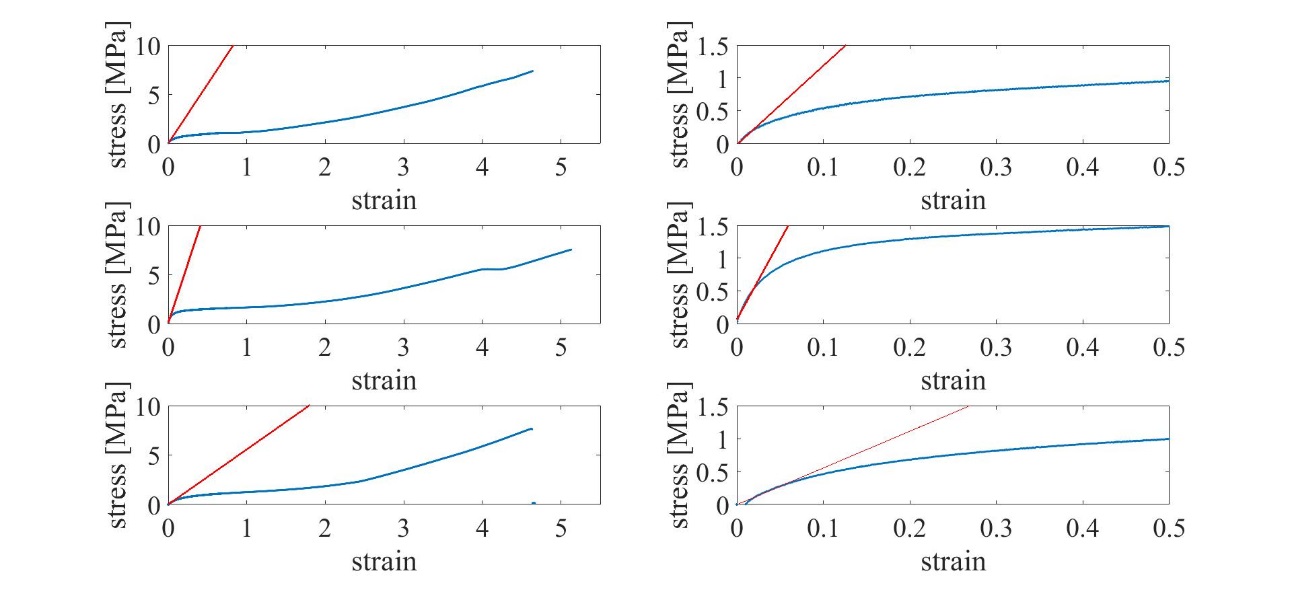
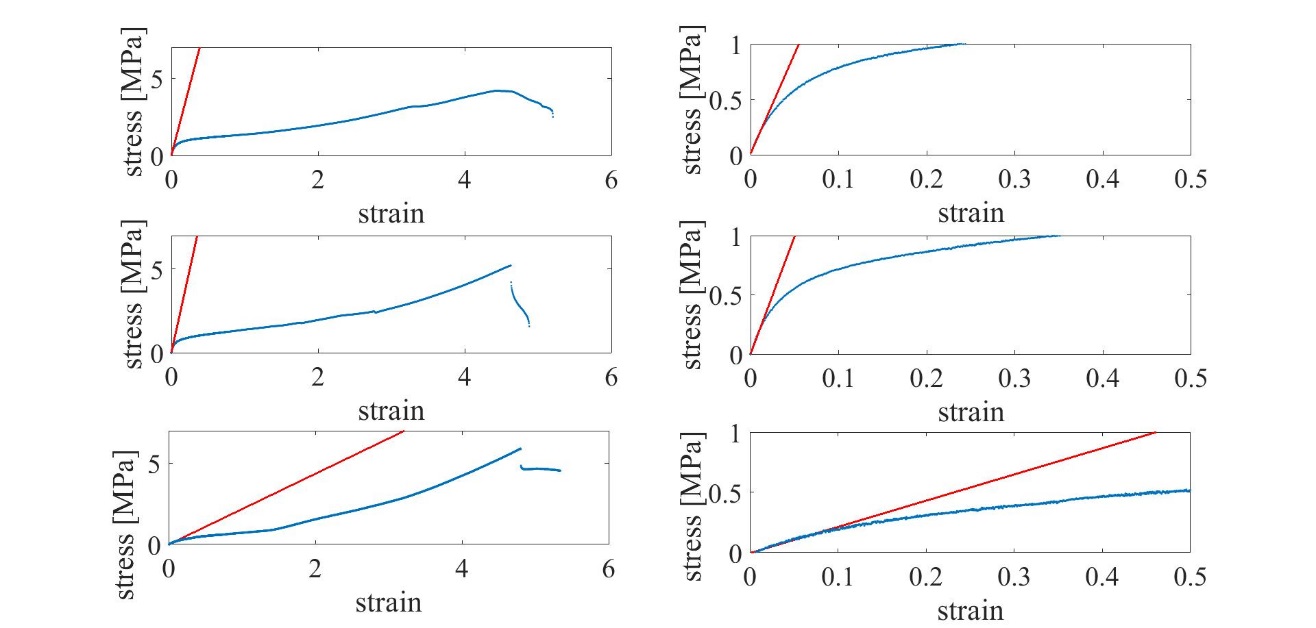
***********Figure S7****: Young's modulus analysis for pure PCLMA polymer above transition temperature.*

***Figure S8****: Young's modulus analysis for 10 wt% NCVL: PCLMA polymer composition above transition temperature.*

**********Figure S9**: Young's modulus analysis for 20 wt% NCVL:PCLMA polymer composition above transition temperature.

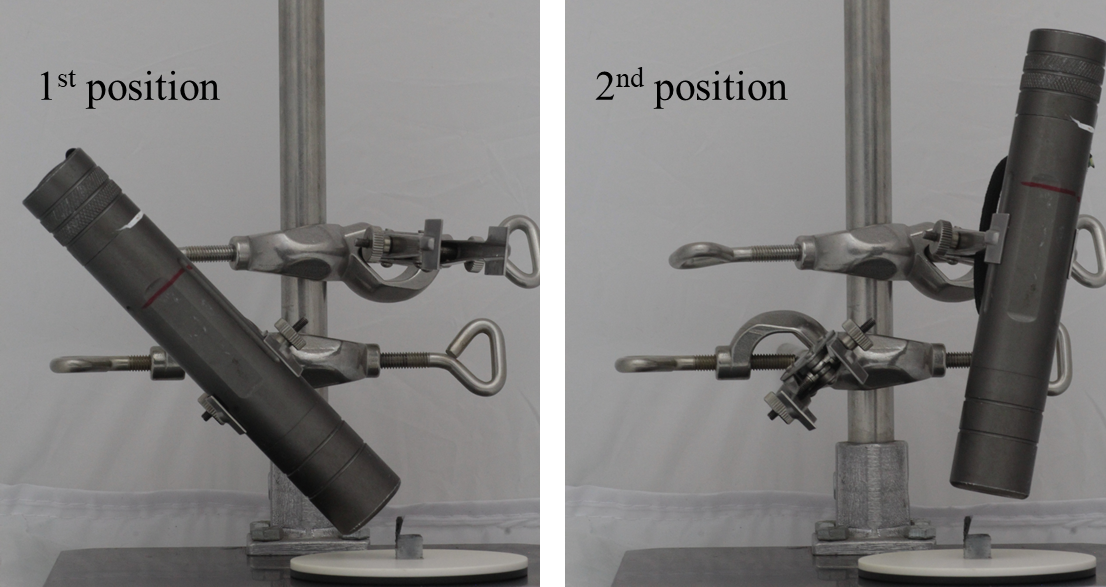
**Figure S10**: Young's modulus analysis for 30 wt% NCVL:PCLMA polymer composition above transition temperature.

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**Figure S11**: Young's modulus analysis for 40 wt% NCVL:PCLMA polymer composition above transition temperature

**Figure S12**: Young's modulus analysis for 50 wt% NCVL:PCLMA polymer composition above transition temperature

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***Figure S13:*** *Experimental setup for the cube's light activation.*

***Table 1****: Constitutive model parameters adopted for modeling the pure ink (i.e., pure PCLMA) in the finite element analysis.*

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Symbol** | **Value** | **Unit** |
| Young’s modulus of the glassy phase | Eg | 185 | MPa |
| Young’s modulus of the rubbery phase | Er | 0.25 | MPa |
| Poisson’s ratio of the glassy phase | νg | 0.29 | - |
| Poisson’s ratio of the rubbery phase | νr | 0.49 | - |
| Transformation temperature | θt | 56.5 | °C |
| Half-width of the temperature range | Δθ | 3 | °C |
| Transformation coefficient | w | 3.8 | 1/°C |
| Plastic hardening coefficient | h | 10 | MPa |
| Stress limit for plastic yielding of the glassy phase | Rpg | 15 | MPa |
| Imperfect shape-fixing coefficient | c | 1 | - |
| Incomplete shape-recovery coefficient | cp | 0 | - |

***Table 2****: Constitutive model parameters adopted for modelling the mixed ink (i.e., ink composed of 40 wt% NVCL) in the finite element analysis.*

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Symbol** | **Value** | **Unit** |
| Young’s modulus of the glassy phase | Eg | 245 | MPa |
| Young’s modulus of the rubbery phase | Er | 17 | MPa |
| Poisson’s ratio of the glassy phase | νg | 0.29 | - |
| Poisson’s ratio of the rubbery phase | νr | 0.49 | - |
| Transformation temperature | θt | 51 | °C |
| Half-width of the temperature range | Δθ | 3 | °C |
| Transformation coefficient | w | 3.8 | 1/°C |
| Plastic hardening coefficient | h | 10 | MPa |
| Stress limit for plastic yielding of the glassy phase | Rpg | 10 | MPa |
| Imperfect shape-fixing coefficient | c | 1 | - |
| Incomplete shape-recovery coefficient | cp | 0 | - |

***Movie S1:*** *A 3D printed two-lid-box with two transition temperatures activated by direct heating*.

***Movie S2:*** *A 3D printed carbon nanotubes (CNTs) coated two-lid-box with two transition temperatures activated by light*.