ADVANCED HEALTHCARE MATERIALS

Supporting Information

for *Adv. Healthcare Mater.*, DOI 10.1002/adhm.202300904

A Laser-Driven Microrobot for Thermal Stimulation of Single Cells

*Philipp Harder, Nergishan İyisan, Chen Wang, Fabian Kohler, Irina Neb, Harald Lahm, Martina Dreßen, Markus Krane, Hendrik Dietz and Berna Özkale**

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A Laser Driven Microrobot for Thermal Actuation of Single Cells

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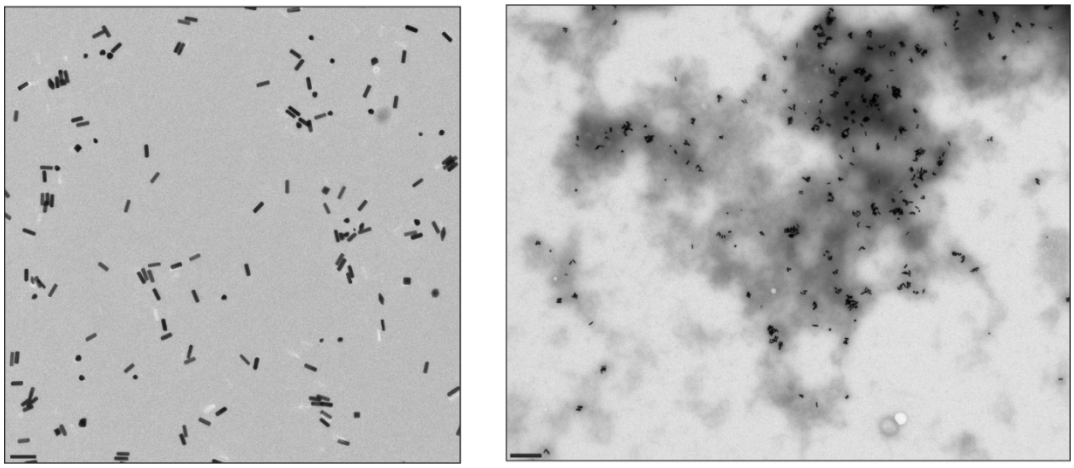

Figure S1. Transmission electron microscopy (TEM) overview images of GNRs without alginate encapsulation (left) and with alginate encapsulation (right). Scale Bar: 400 nm (left), Scale Bar: 2000 nm (right).

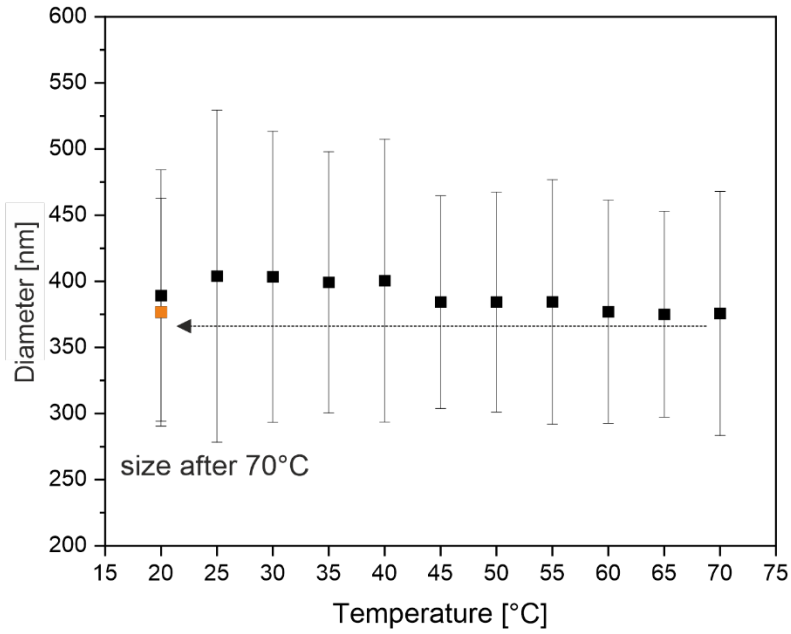

Figure S2. Size measurement using DLS, measured from 20°C to 70°C and back to 20°C (dotted line).

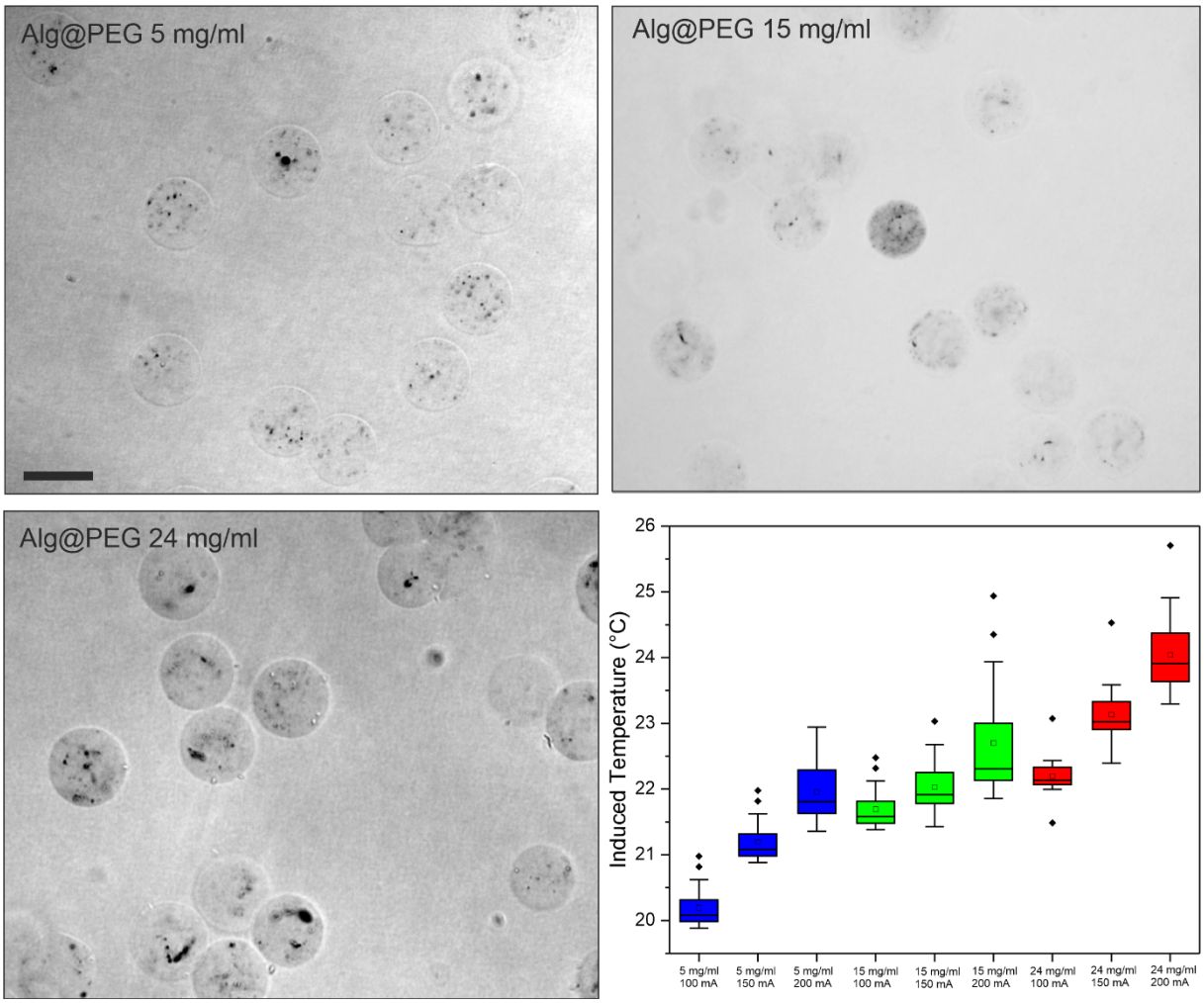

Figure S3. Brightfield images of TACSI microrobots fabricated with PEG-capped GNRs at three selected concentrations, and the corresponding photothermal performance graph (n=20). Laser conditions 100, 150, and 200 mA correspond to 2, 4, and 6 µW µm^{-2} laser power, respectively. Maximum observable induced temperature difference was limited to only 4 °C, at the highest initial GNR loading concentration (24 mg ml^{-1}). Scale Bar 30 µm.

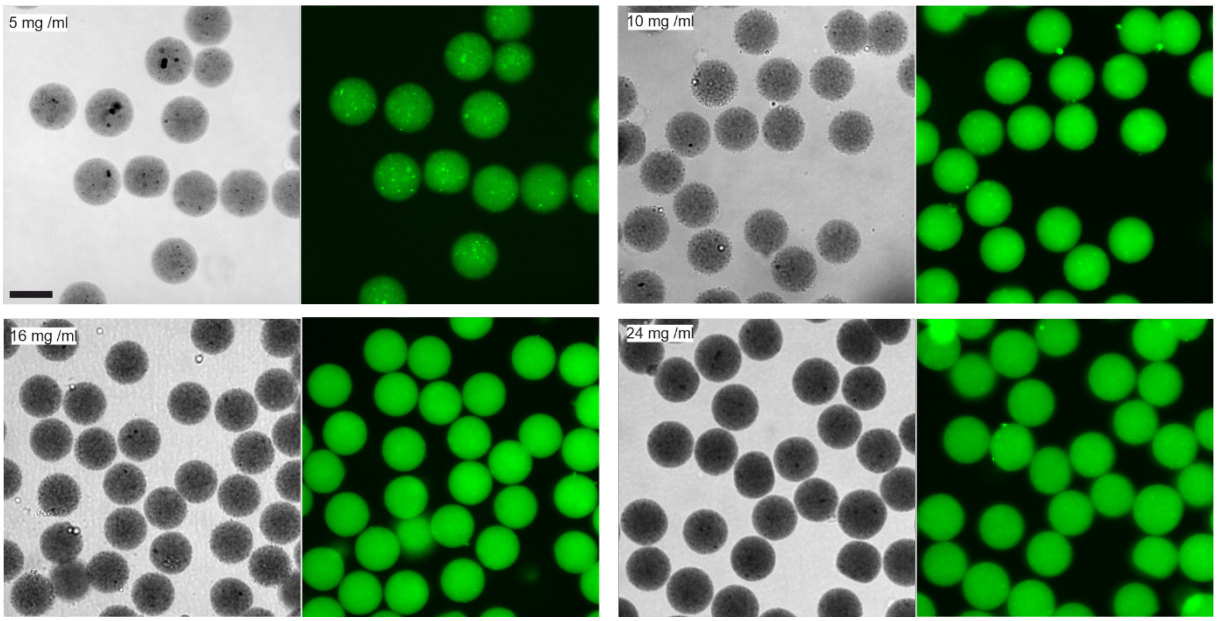

Figure S4. Overview images of TACSI microrobots fabricated at four different GNR loading concentrations. Brightfield images are accompanied by RhB channel images, both indicating homogeneous distribution of GNRs. Scale Bar: 30 µm.

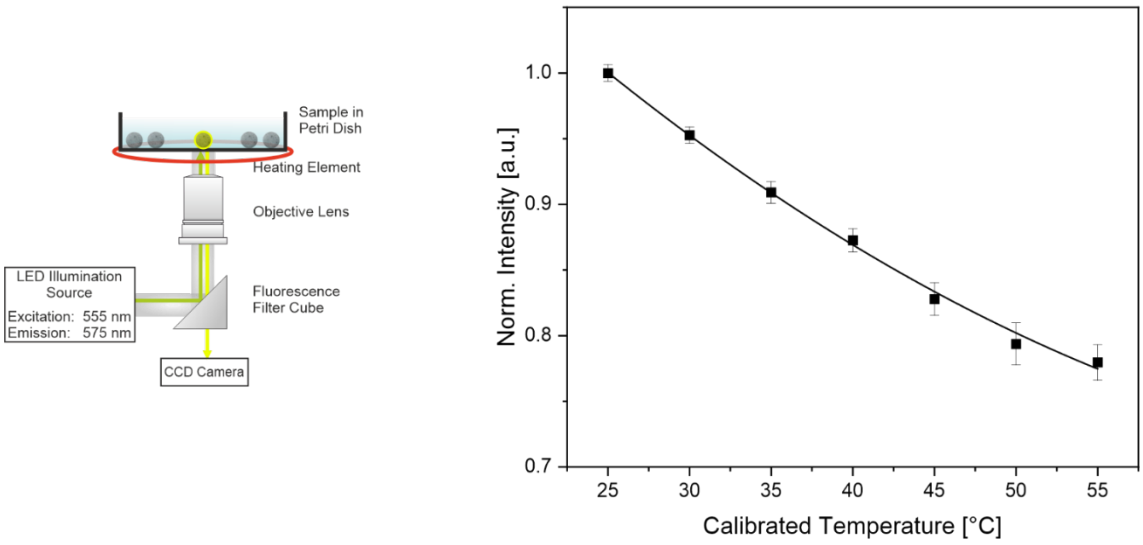

Figure S5. Schematic set up for calibrating fluorescent intensity changes at different temperature (left). Measured calibration curve using a heating element (right), measured at 40x (n = 100).

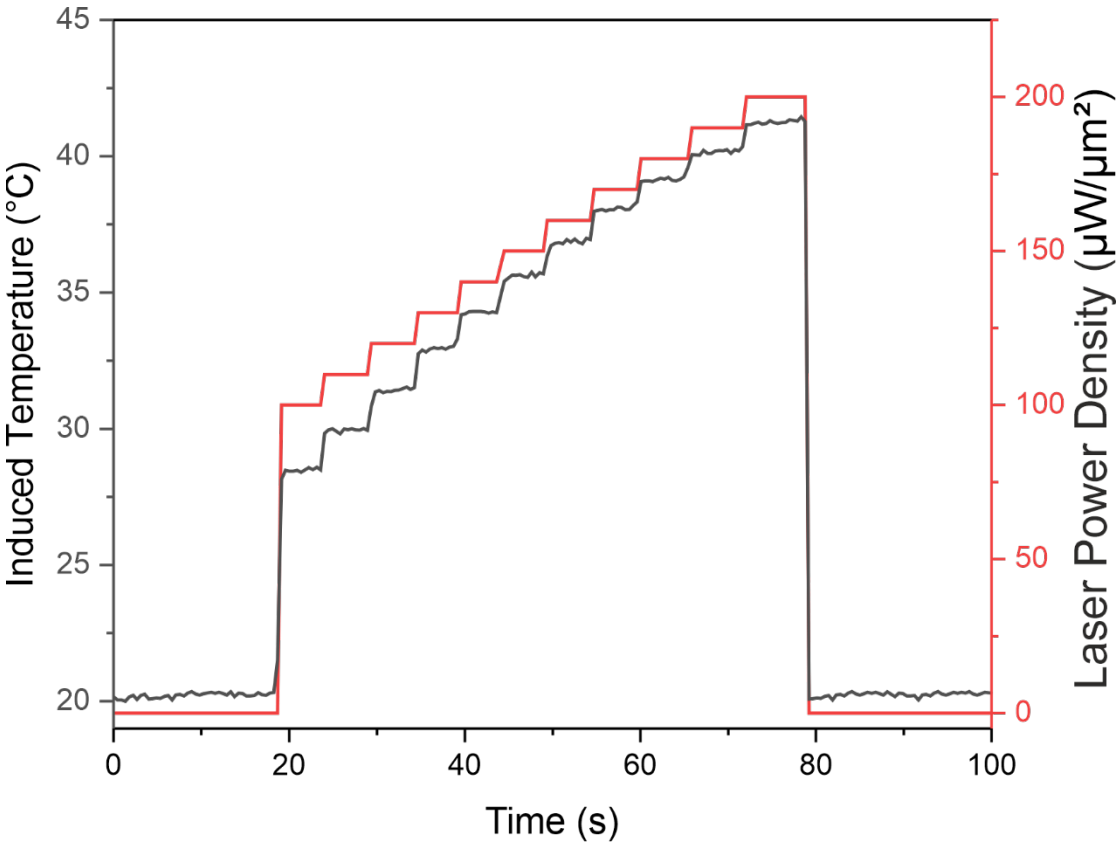

Figure S6. Photothermal heating of a single TACSI microrobot fabricated at 10 mg ml^{-1} initial GNR loading concentration. Laser power was increased step wise by increments of 10 µW $µm^{-2}$ for 5 seconds. Induced microrobot temperature closely followed applied laser power.

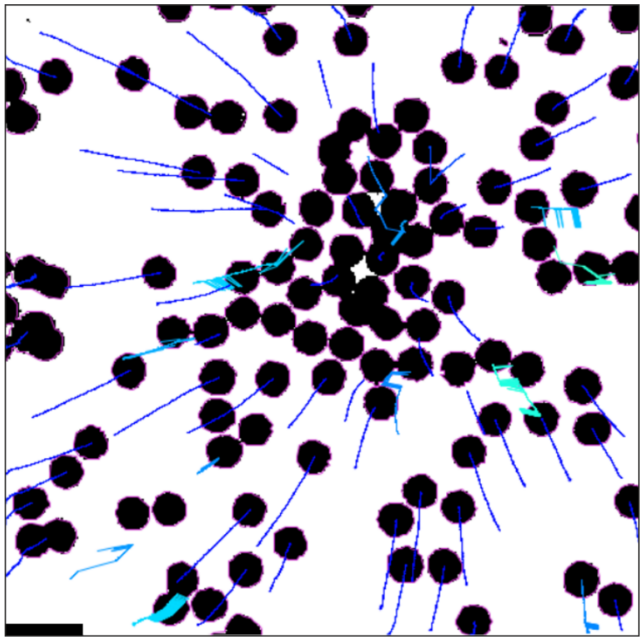

Figure S7. Tracked motion and speed of multiple microrobots. Blue line shows a speed of 2µm s^{-1} at 3.8 µW/$µm^2$ and 10x magnification. Scale Bar: 60 µm.

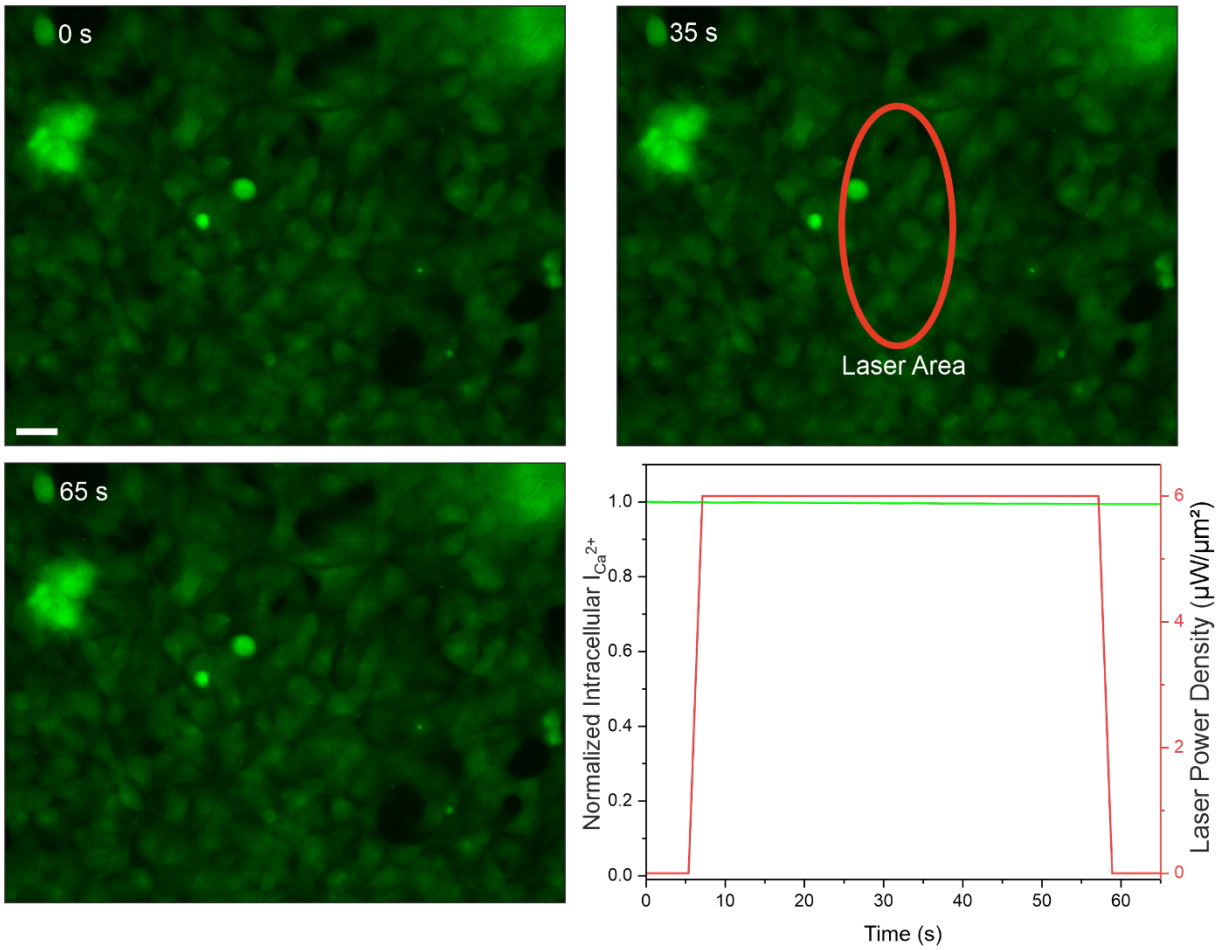

Figure S8. Negative control experiment showing Calbryte 520 AM treated cells before, during, and after being subjected to 785 nm laser, in the absence of TACSI microrobots. The fluorescent probe becomes sensitive to calcium once it is taken up by the cell, indicated by the stable baseline intracellular calcium signal in Calbryte 520 AM treated cells. Intracellular calcium intensity stayed constant throughout the experiment. The area illuminated by the 785 nm laser is shown with a red ellipse. Scale Bar 15 μm.

Supporting Information Movie S1 Rapid fabrication of TACSI microrobots

Supporting Information Movie S2 TACSI microrobot rolling in x- and y- axis, speed 5 μm/s.

Supporting Information Movie S3 Example of convection around the TACSI microrobot

Supporting Information Movie S4 Example movement in z-axis of the TACSI microrobot

Supporting Information Movie S5 TACSI microrobot showing Marangoni motion at the surface-liquid interface

Supporting Information Movie S6 TACSI Microrobot Swarm Motion in x and y direction

Supporting Information Movie S7 TACSI microrobot is guided onto a layer of cells and photothermally actuated, triggering calcium signaling