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Supporting Information

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Superfast Near-Infrared Light-Driven Polymer Multilayer Rockets

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SI Video 1 The movement of a $(PAH/PSS)_{20}$AuNS rocket in pure water activated by the radiation of NIR laser with power of 20 mW/μm^2 (the movie has been decelerated to 30% for the clear demonstration). Scale bar = 20 μm.

SI Video 2 The "On/Off"movement of a $(PAH/PSS)_{20}$AuNS rocket in pure water under the switch of NIR irradiation.

SI Video 3 The movement of a $(PAH/PSS)_{20}$AuNS rocket in cell media under the NIR irradiation with laser power of 4 mW/μm^2. Scale bar = 10 μm.

Materials

Commercially available porous polycarbonate (PC) membranes with the pore diameter of 600 nm were purchased from Whatman Corp. Poly(allylamine hyhrochloride) (PAH, M_w = 70000) and poly(styrenesulfonic acid) (PSS, M_w = 70000) were purchased from Sigma-Aldrich. The propidium iodide (PI) was purchased from Shanghai Yuanye Biological Technology Co., Ltd. $HAuCl_4 \cdot 4H_2O$, citric acid monohydrate, $NH_2 \cdot H_2O$, and ethanol were used without further purification. The water used in all experiments was prepared in a Milli-Q purification system with the resistivity higher than 18.2 MΩ cm^{-1}.

Preparation procedure of $(PAH/PSS)_{20}$AuNS rockets

The $(PAH/PSS)_{20}$Au NS rockets were prepared by using our reported template-assisted Layer-by-Layer (LbL) assembly method.[1] The citrate-stabilized AuNPs prepared by the common methods.[2] The polycarbonate (PC) membranes as the template was alternatively immersed into PAH (1mg/mL in 0.5 M NaCl) and PSS (1mg/mL in 0.5 M NaCl) solution for 30 min as one (PAH/PSS) bilayer. The immediate washing step before immersing into polyelectrolyte solution was conducted for three times. After 20 bilayers of (PAH/PSS) were deposited into the template, the citrate stabilized Au NPs were assembled into the template. The method of hydroxylamine seeding was used to form the gold nanoshell on the outer surface of the $(PAH/PSS)_{20}$ Au NPs rockets, the $(PAH/PSS)_{20}$ Au NPs rockets were released in a 1.5 mL aqueous solution including 50 μL NH_2OH and 0.1% $HAuCl_4$ and the mixture was stirred slightly for about 10 min to allowed the reduction of $HAuCl_4$ to grow nanoshells on the outer surface of the rockets. The materials adsorbed on the top and bottom surfaces of the template, were removed by polishing and wiping the surfaces of the template with wet cotton swabs. The resulting $(PAH/PSS)_{20}$AuNS rockets can be obtained by dissolving the templates with CH_2Cl_2. The resulting solution was washed by using CH_2Cl_2 for 5 times. The $(PAH/PSS)_{20}$AuNS rockets were collected by applying centrifugation at 4000 g for 3 min, followed by redispersing in ethanol and water subsequently. The samples of solution of the $(PAH/PSS)_{20}$AuNS rockets were stored at 4 °C. The movement of $(PAH/PSS)_{20}$ AuNS rockets was recorded by a microscope coupled with a photometric camera.

Cell experiment

Standard cell culture procedure was conducted for *in vitro* experiments. The HeLa cells were cultivated in Dulbecco's modified eagle medium (DMEM) medium with 10% fetal calf serum and 1% penicillin and streptomycin at 37 °C in an atmosphere of 5% CO_2. The cells were diverted to a 60 mm polystyrene (PS) petri dish for test by using the standard trypsin technique.

The photothermal effect of $(PSS/PAH)_{20}$AuNS during the NIR propulsion was investigated by the modified PI staining method.[2] 5 μL of PI was added to 20 mL of the cell culture prior to the NIR irradiation, and the apoptosis of the HeLa cells was confirmed by the fluorescent imaging.

Reference

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3. Govorov, A. O.; Richardson, H. H. Generating Heat with Metal Nanoparticles. *Nano Today* **2007,** *2*, 30-38.

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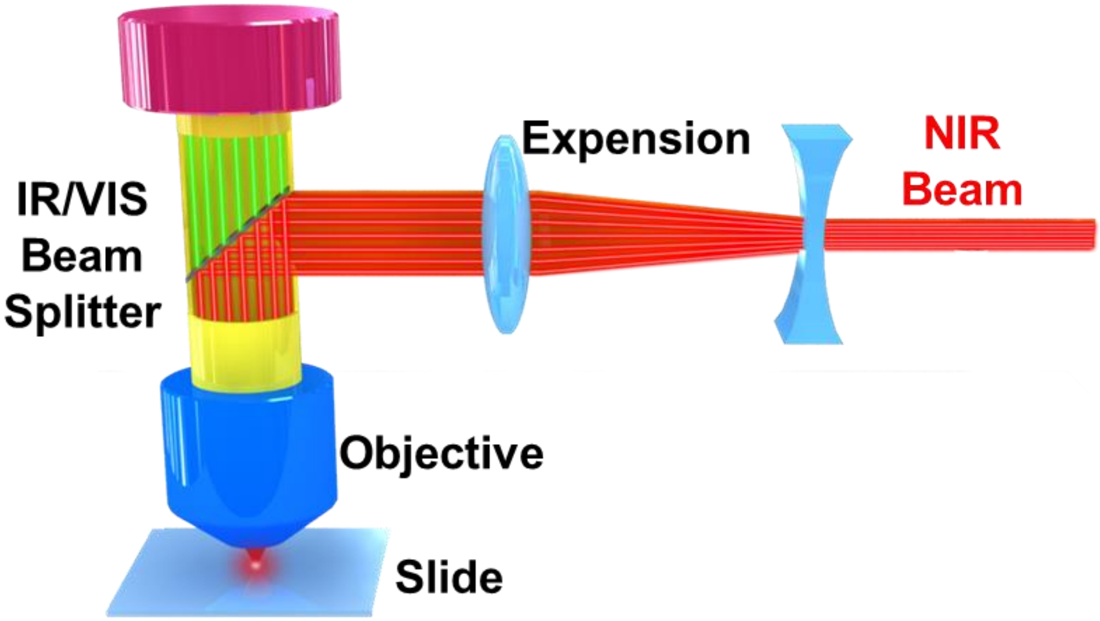

Figure S1. Setup of the NIR laser beam.

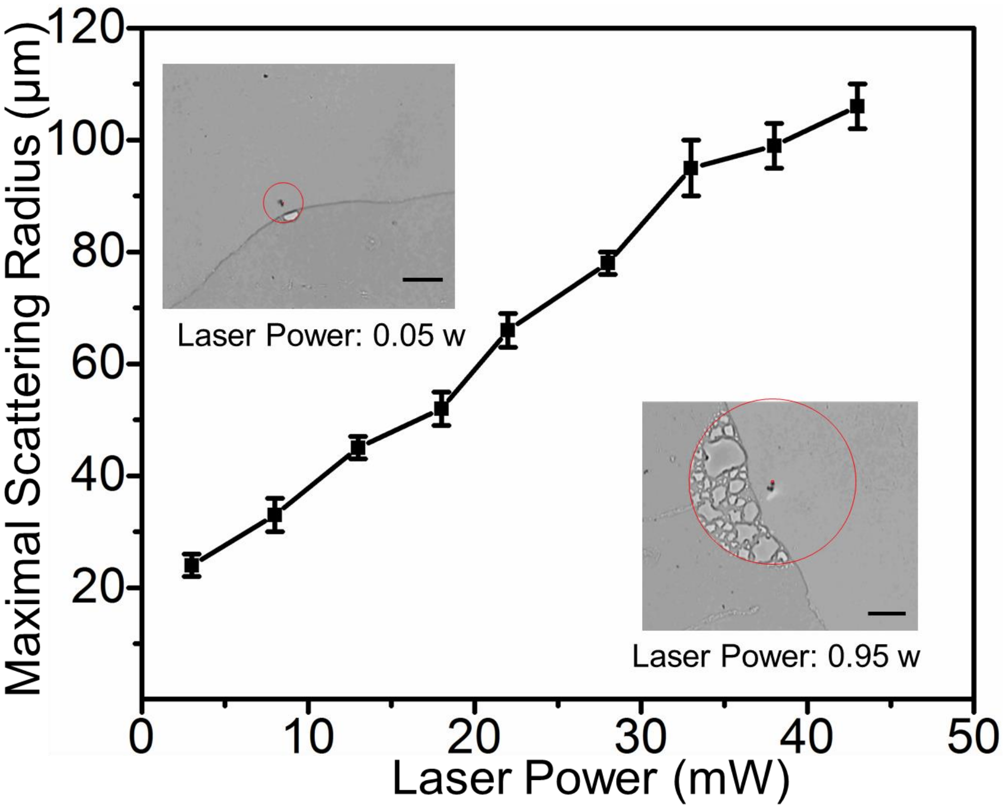

Figure S2. The maximal scattering radius of the ejecting superheat water under different laser powers. The scale bars of the inset images, 50 μm.

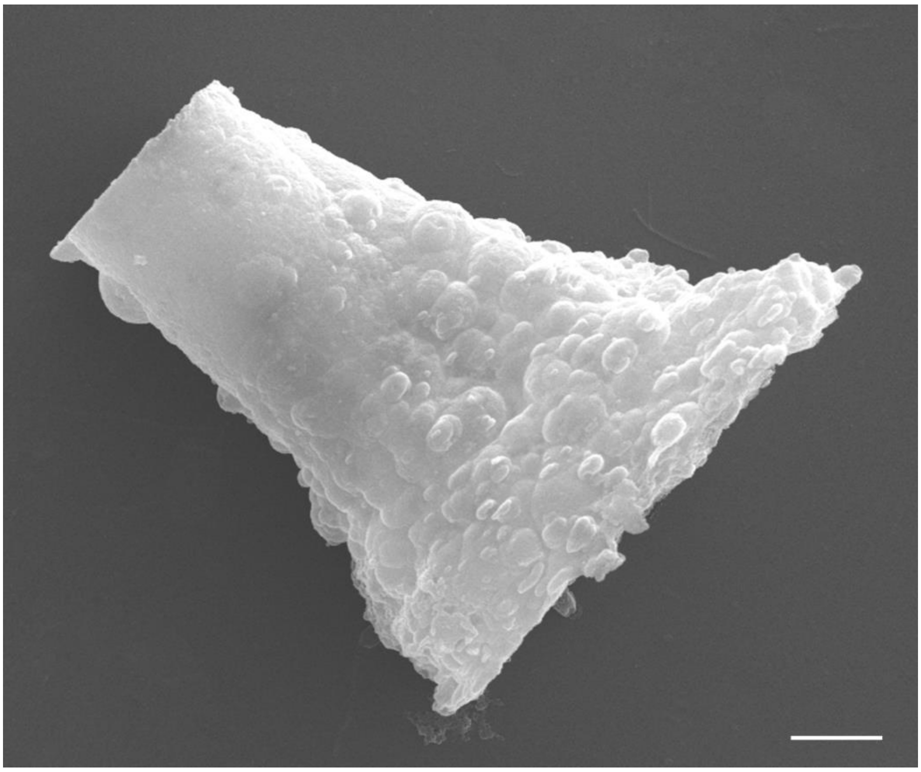

Figure S3. SEM image of the rocket upon 30 times of NIR irradiation. Scale bar =2 μm.

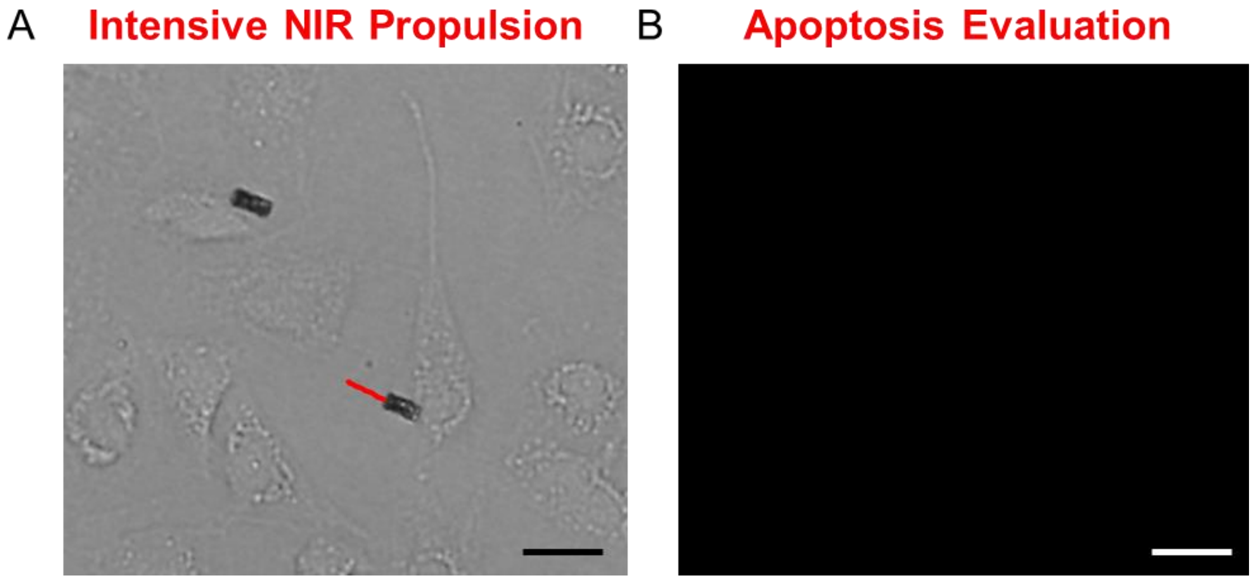

Figure S4. (A) The time lapse image illustrating the NIR-triggered movement of rocket. (B) Corresponding fluorescence image in in a propidium iodide channel. Scale bar =20 μm.