Autonomous Motion of Metallic Micro-rods Propelled by Ultrasound

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Supporting Information (9 pp.)

FESEM images of samples tested, tracking results for AuPt rods, optical microscope images of chains formed in an acoustic field, illustration of pulsed-mode ultrasound experiments, description of video clips.

1. FESEM Images of samples tested

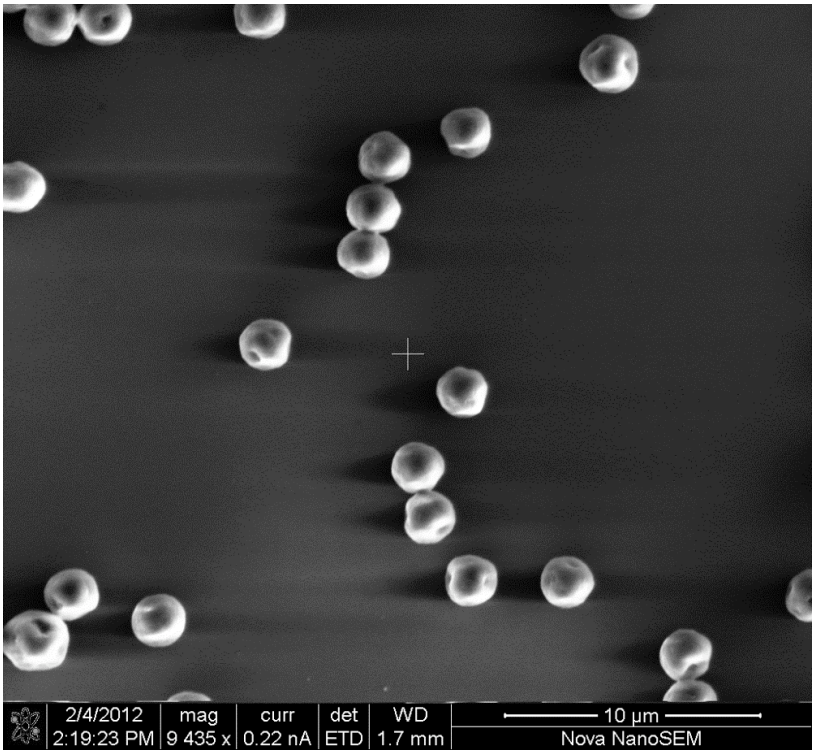

Figure S1. 2 µm diameter polystyrene tracer particles

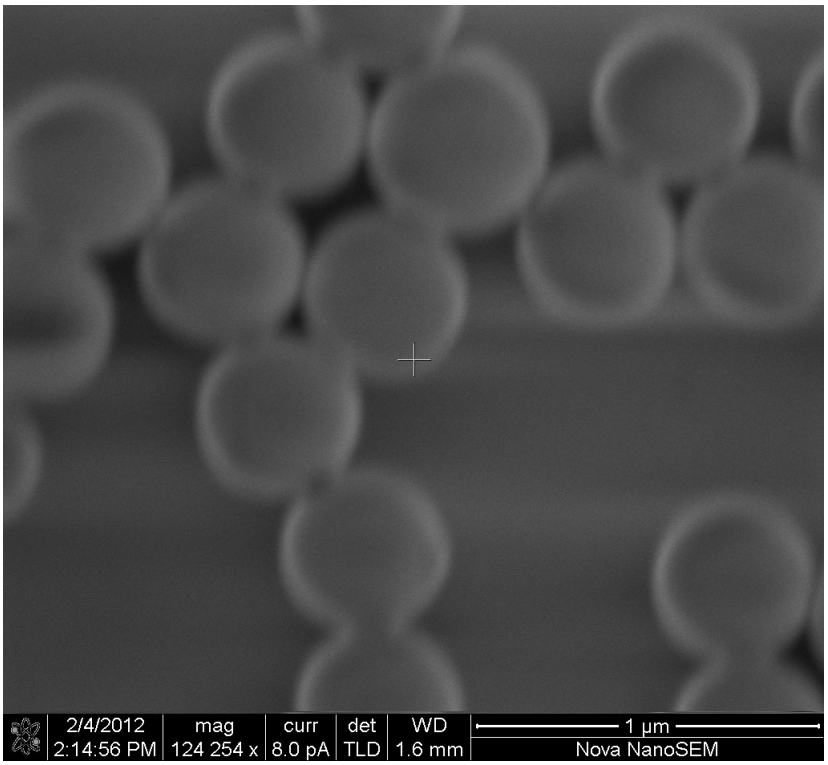

Figure S2. 470 nm diameter polystyrene tracer particles

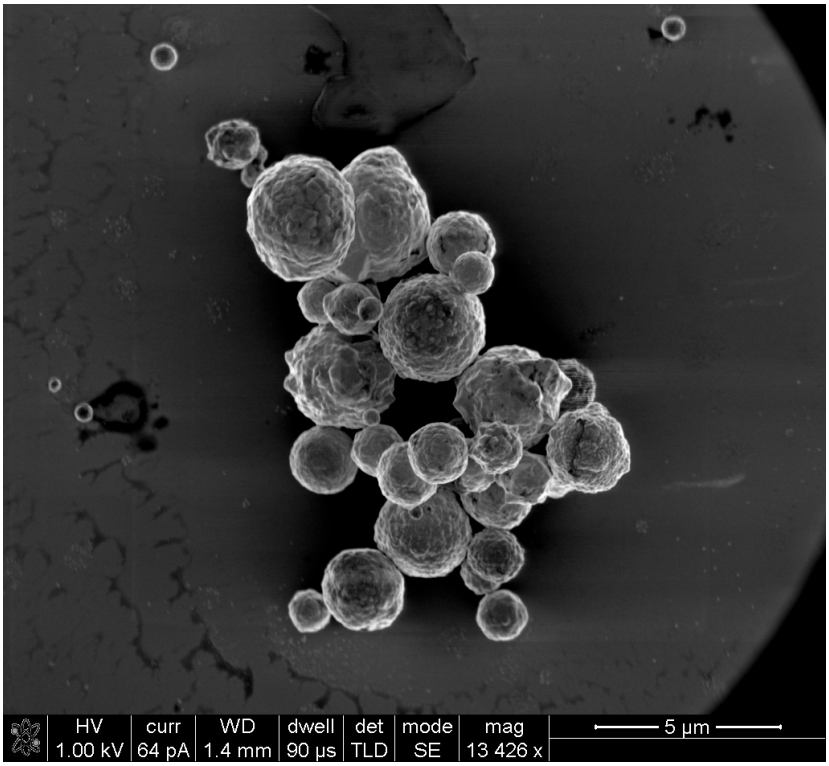

Figure S3. Gold microparticles

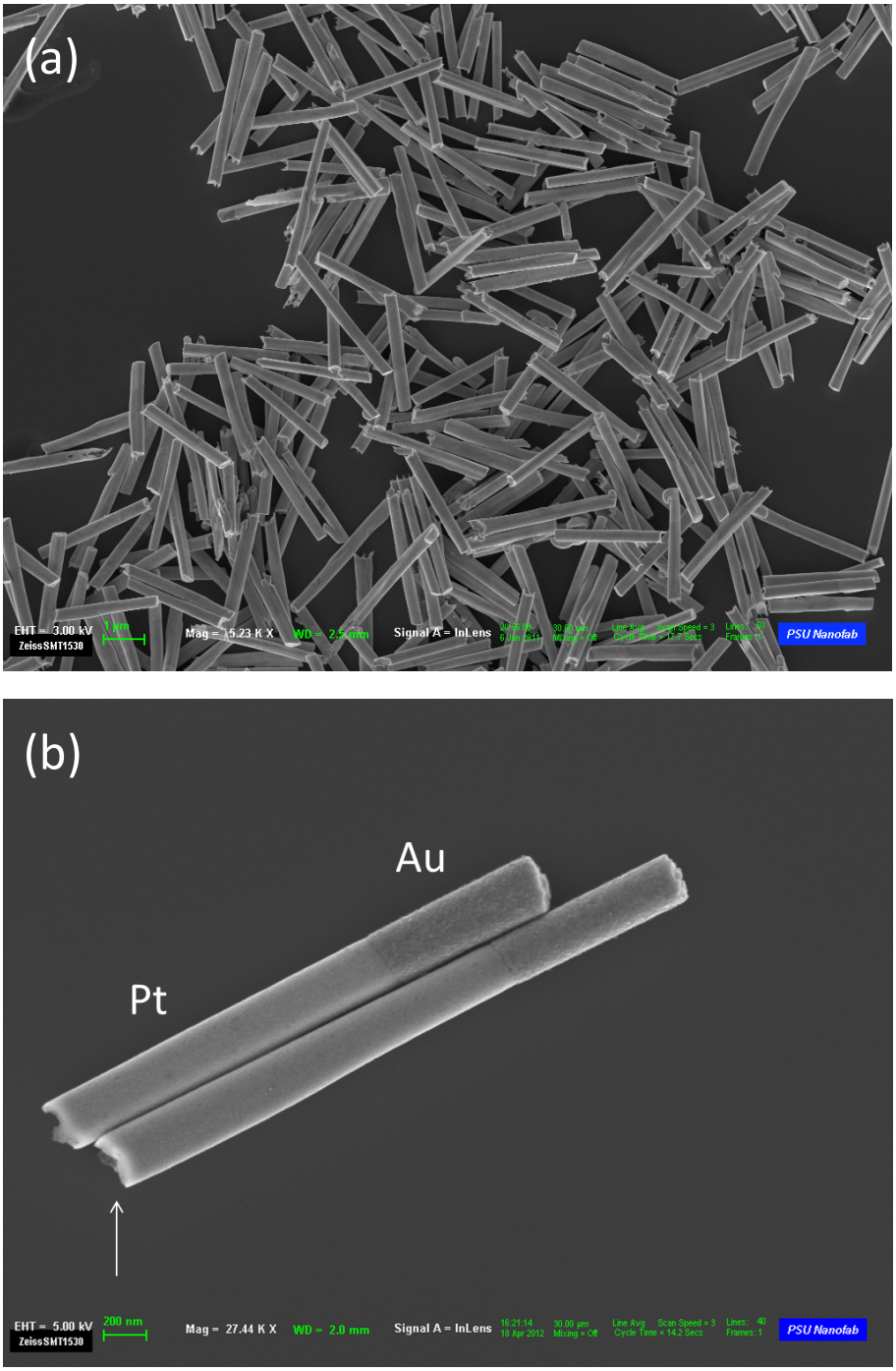

Figure S4. Electrodeposited AuPt (a) and PtAu (b) micro-rods. The arrow in (b) indicates the concave feature at the Pt end.

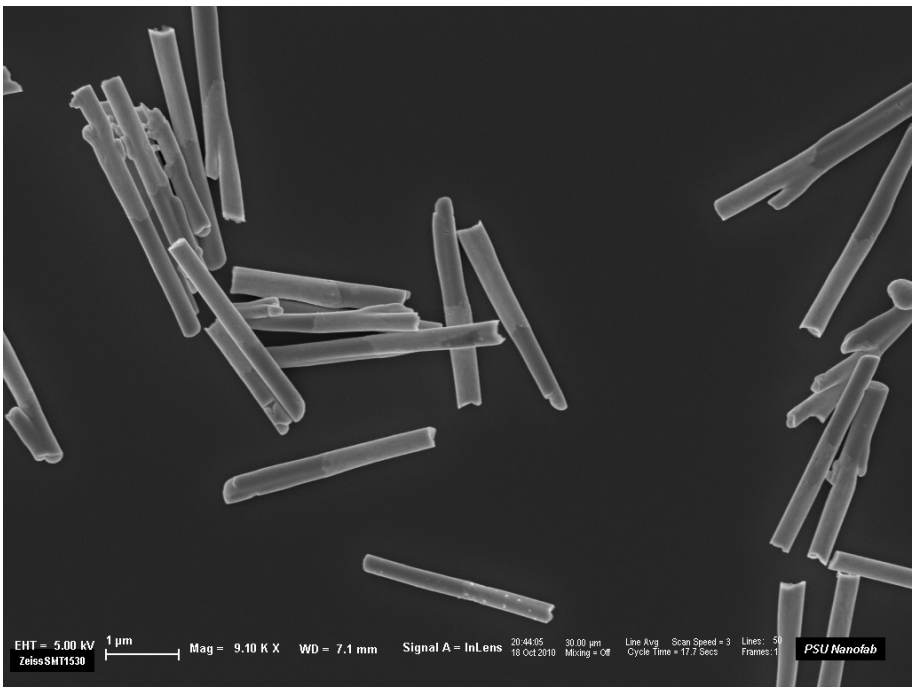

Figure S5. Electrodeposited AuRu micro-rods

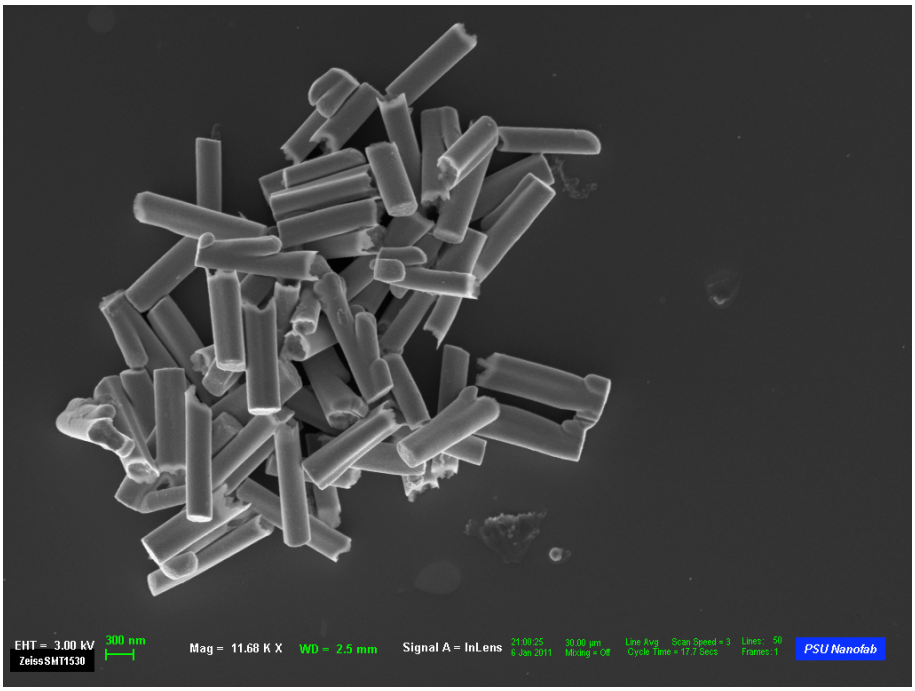

Figure S6. Electrodeposited Ru micro-rods

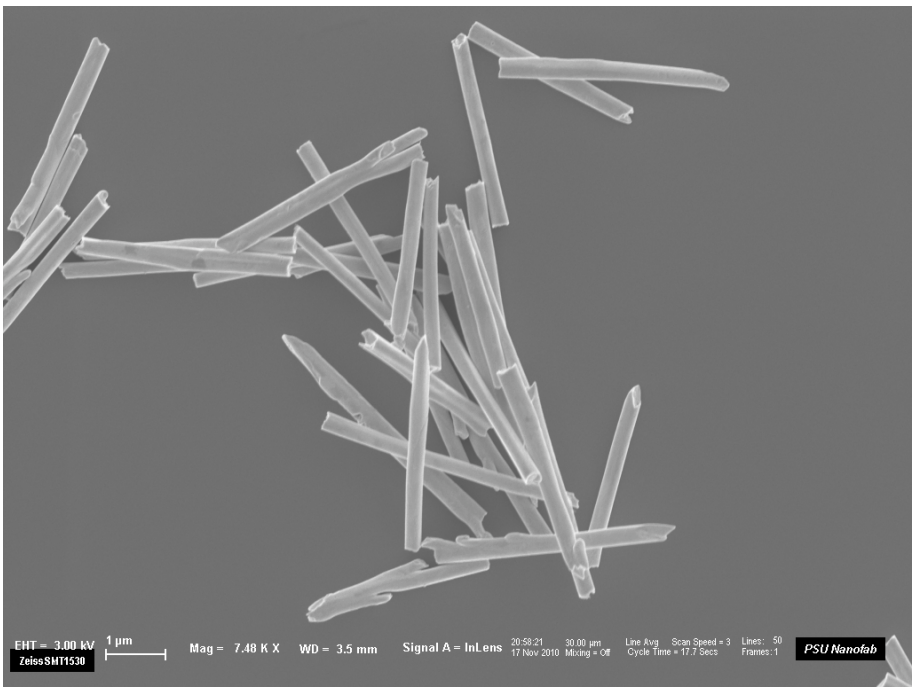

Figure S7. Electrodeposited Au micro-rods

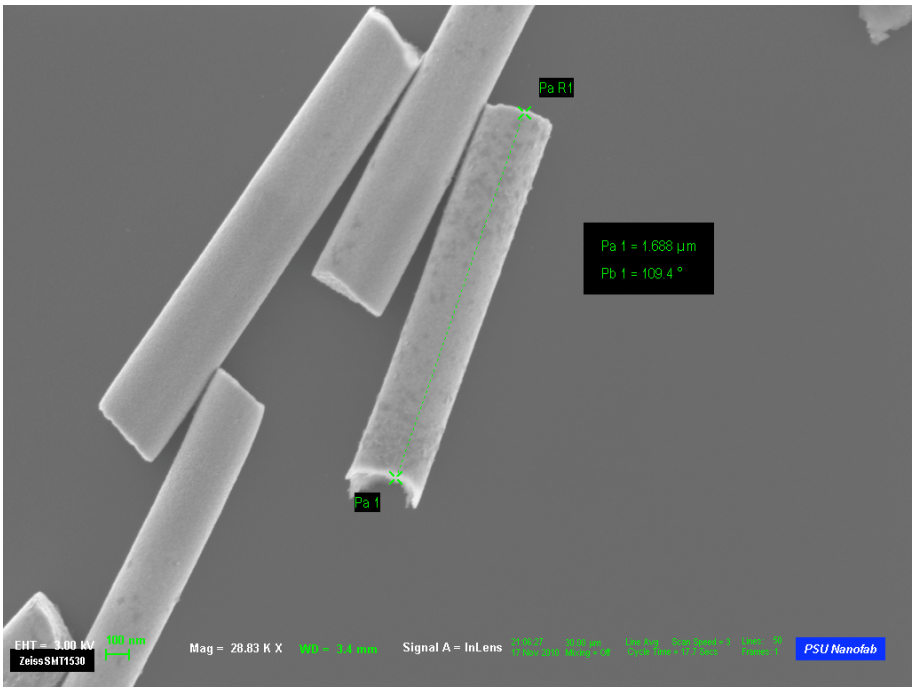

Figure S8. Electrodeposited Pt micro-rods

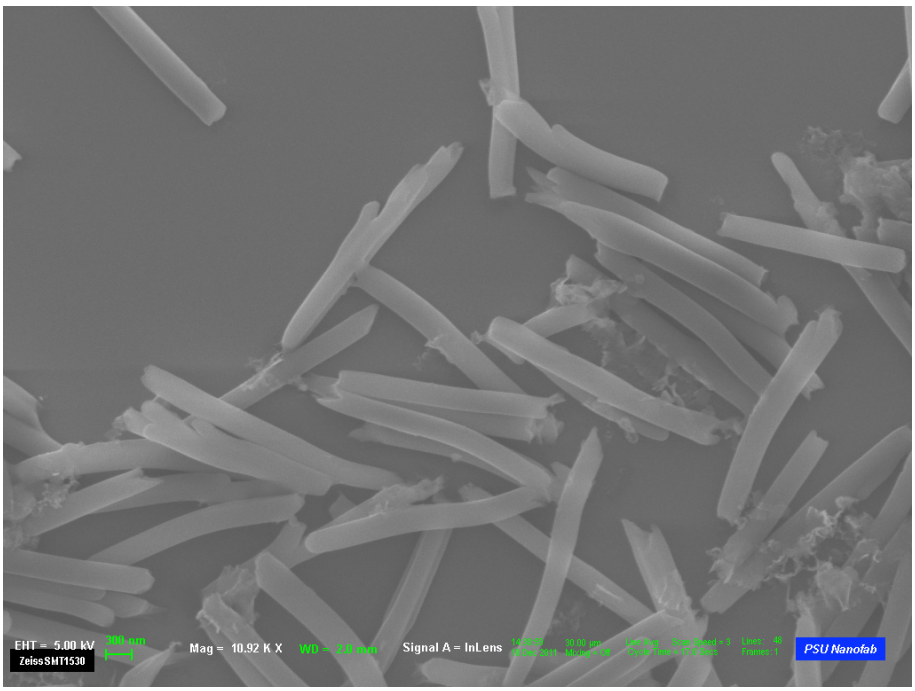

Figure S9. Electrodeposited polypyrrole micro-rods

2. Sample tracking results for AuRu rods

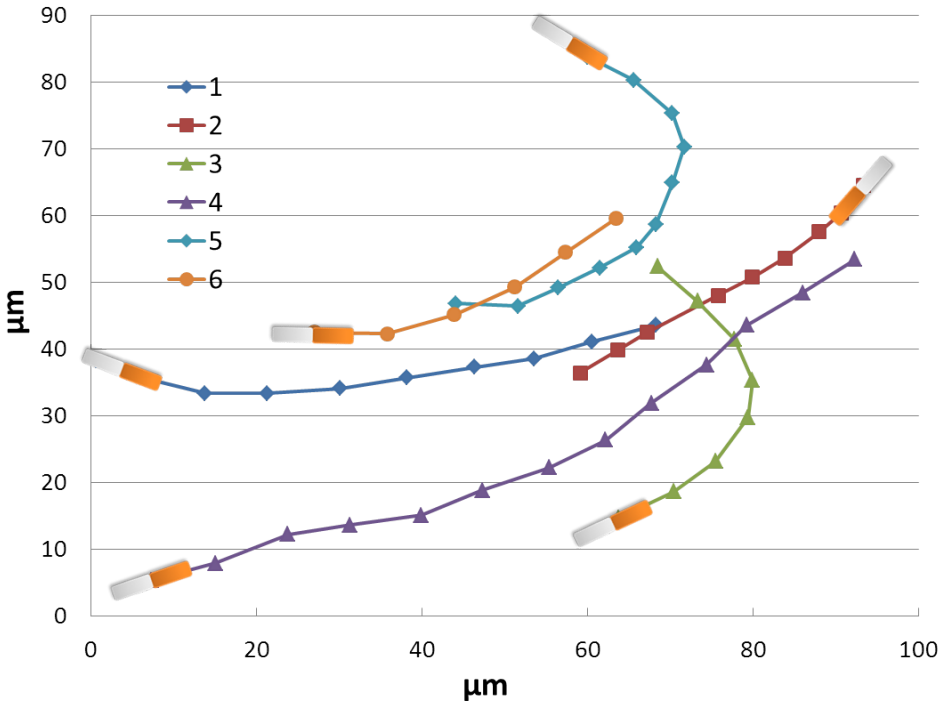

Figure S10. Trajectories of six AuRu micro-rods showing directional motion in the levitation plane in the acoustic field at the resonance frequency (3.7 MHz). Data points in successive frames are separated by 0.033 s. Cartoons of the rods are superimposed on the plot to illustrate the directionality of the rods, which consistently moved with the Ru end (silvery end) forward. The tracking is based on the video frames captured from Video S2, part 2. The x and y axis correspond to the actual x and y coordinates on the levitation plane.

3. Optical microscope images of chains formed in an acoustic field

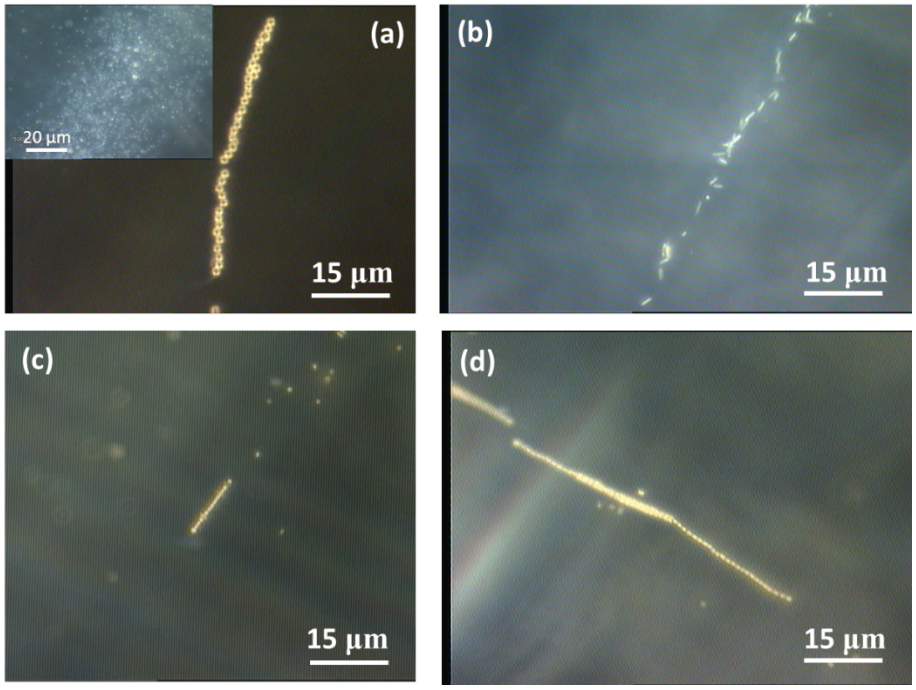

Figure S11 Chains formed by different samples in an acoustic field. (a) 2 µm polystyrene microparticles (inset: 470 nm polystyrene particles); (b) polypyrrole micro-rods; (c) gold microspheres; (d) gold micro-rods

4. Illustration of pulsed-mode ultrasound experiments

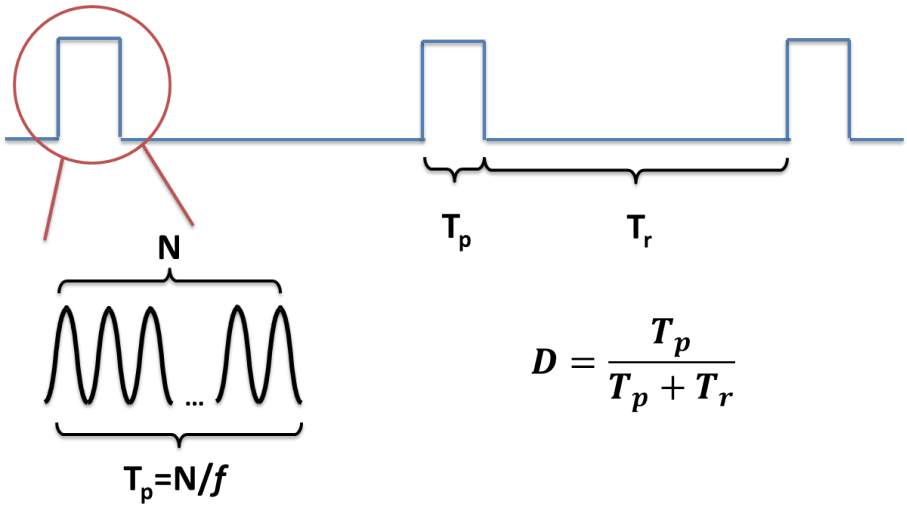

Figure S12. An illustration of the parameters used in the pulsed-mode experiments.

5. Video clips

Video S1

Typical behaviors of 470 nm and 2 μm polystyrene microspheres in a cylindrical ultrasonic cell (Brownian motion, acoustic streaming, pattern formation).

Video S2

Typical behaviors of metal rods (AuRu) (Brownian motion, acoustic levitation, fast directional motion, fast in-plane rotation, pattern formation and chain formation).

Video S3

Mixing metal rods with 470 nm polystyrene spheres.

Video S4

Chain formation by different samples (polystyrene microspheres, polypyrrole micro-rods, Au microspheres and Ru micro-rods).

Video S5

Motion of AuRu rods induced by pulsed-mode ultrasound. Parameters: pulse repetition rate ($1/(T_r+T_p)$) 10Hz, each pulse contains 800 cycles of 3.76 MHz ultrasonic waves (N=800). The pulses in this video are much slower than in a typical pulsed-mode experiment in order to highlight the effect of pulsing on the instantaneous motion of the rods. The video was taken in bright field, therefore particles appeared dark. The magnification was 200 X.