Electronic Supplementary Material (ESI) for Nanoscale.

Visible-light Driven Si-Au Micromotors in Water and Organic Solvents

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Supporting Videos

Video S-1: Si-Au micromotors moving in DI water without and with illumination, respectively, light intensity 13.6 mW/mm^2.

Video S-2: Si-Au micromotors moving in DI water, ethanol, methanol, isopropanol, propylene carbonate, respectively, light intensity 13.6 mW/mm^2.

Video S-3: Si-Au micromotors moving in DI water after illumination for 50 mins, after etching by 10% BOE solution, in the presence of 0.5 mM $NaNO_3$, respectively, light intensity 13.6 mW/mm^2.

Video S-4: Light triggered "on/off" control of Si-Au micromotors in DI water, light intensity 13.6 mW/mm^2.

Video S-5: Magnetic control of Si-Au micromotors in DI water, light intensity 13.6 mW/mm^2.

Supporting Figure

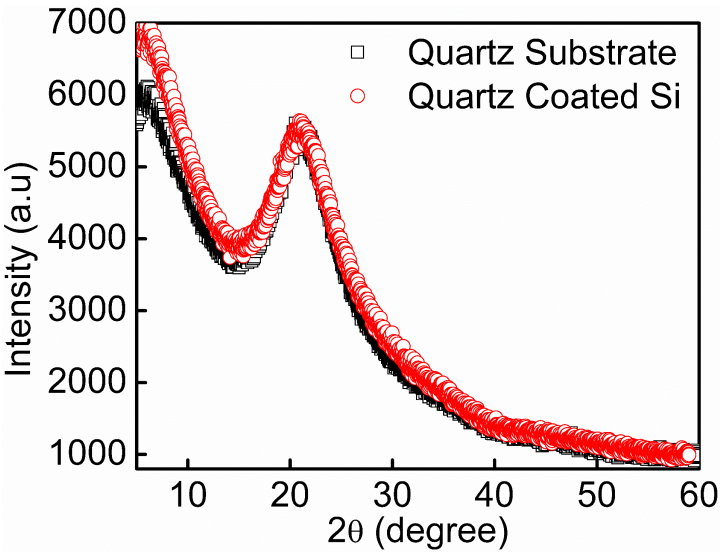

Fig. S-1 X-ray diffraction pattern of a 500 nm thick Si film.

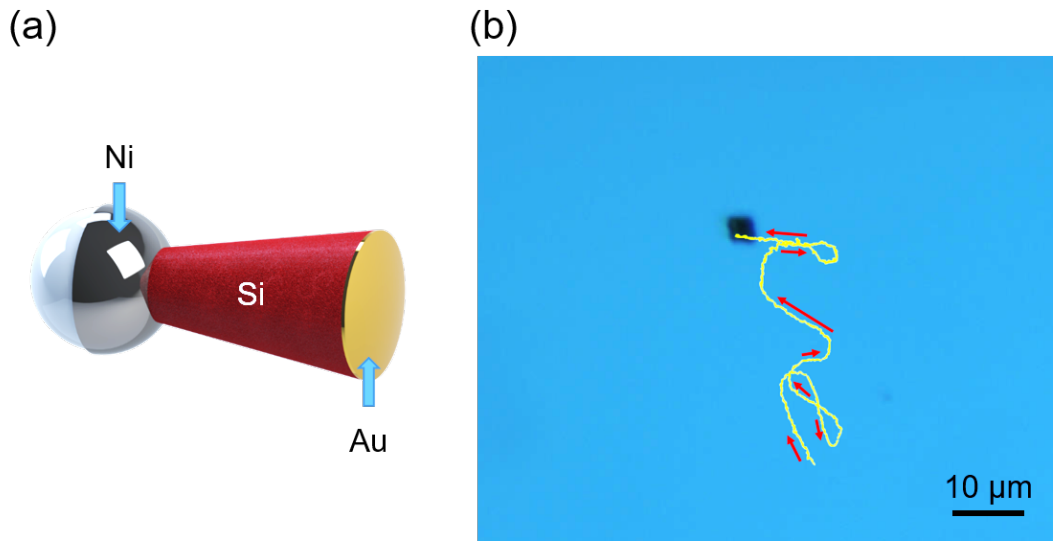

Fig. S-2 (a) Schematic illustration of the Ni-Si-Au micromotors. (b) Magnetic control of a Si-Au micromtor following a specific trajectory in DI water under mercury light illumination at 13.6 mW/mm^2; the red arrow line represents the direction of the magnetic field.

Experimental

Sample preparation

Si-Au micromotors were synthesized by modification of a method reported previously. [1-3] First, 0.5 mL of 2 μm polystyrene microspheres (Sigma-Aldrich Inc.) were washed in ethanol 3 times and dispersed by sonication. Then 2 mL of DI water was injected into a 5 mL petri dish and 20 μL of hexane was dropped onto the water to form a thin film. After that, the polystyrene microsphere solution was dropped into the water from the edge of the petri dish until the spheres formed a monolayer and transferred to a Si wafer, then the water and hexane were dried in an oven at 40 °. 3 μm of Si was evaporated on the polystyrene microspheres by a Kurt Lesker Lab 18 electron-beam evaporator at an 85° angle relative to the horizontal direction. After that, 30 nm of Au was evaporated onto the Si and then the micromotors were released in DI water with sonication.

Materials characterization

The morphology and elemental composition of the Si particles and the Si-Au micromotors were characterized by FEI NanoSEM 630 scanning electron microscopy and energy dispersive X-ray spectroscopy. X-ray diffraction patterns of the 500 nm Si film on quartz substrate was recorded on a Philips Empyrean, Cu Kα radiation. UV-vis diffuse-reflectance spectra of a 10 nm thick Si film on a quartz substrate was measured by using a Perkin-Elmer Lambda 950 spectrometer.

Optical Imaging and Tracking

The motion of the Si-Au micromotors was tracked by using video spot tracker V08.11 software. Motors were tracked for 30 s and mean square displacements (MSD) were calculated at different light intensities. All speeds were calculated by averaging the instantaneous speeds of 30 different micromotors. The motion of the Si-Au micromotors was observed with an Olympus BX60 M optical microscope and recorded with a video capture device (Dazzle Video Creator Plus). Videos of the Si-Au micromotors were captured at 30 frames per second. The motion videos of the Si-Au micromotors were analyzed by PhysMo software (PhysMo - Video Motion Analysis Package). All speeds were calculated by averaging the speeds of at least 10 different micromotors.

Gas Chromatographic Test

In a GC experiment, 5 mg Si-Au micromotors were mixed in 5 mL of DI water and then the suspension was transferred to a 10 mL glass test tube that was air-tight. Argon was then injected into the void space of the test tube to purge out all air for 30 minutes. The test tube was irradiated with a 100 mW/cm^2 Xe lamp for 1 hour and then 500 μL of the gas sample was extracted from the head space of the test tube with air lock syringe and injected into the GC. Hydrogen gas was detected with a thermal conductivity detector and argon carrier gas. Two additional control experiments were performed, the first one was in the absence of Si-Au micromotors and the other was in the absence of light illumination. While all the other experimental parameters were the same.

References

1. J. G. Gibbs and Y. Zhao, *Small*, 2010, **6**, 1656.
2. H. K. Raut, V. A. Ganesh, A. S. Nair and S. Ramakrishna, *Energ. Environ. Sci.*, 2011, **4**, 3779-3804.
3. C. Wongchoosuk, A. Wisitsoraat, D. Phokharatkul, M. Horprathum, A. Tuantranont and T. Kerdcharoen, *Sens. Actuators B*, 2013, **181**, 388-394.