SUPPORTING INFORMATION

"Synthesis of titania embedded silica hollow nanospheres via sonication mediated etching and re-deposition"

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1. Experimental Section

Synthesis of titania embedded silica hollow nanospheres

In a typical synthesis of hollow nanospheres (HNSs), silica nanoparticles were firstly prepared according to the Stöber method. And then, 2.3 ml of titanium tetraisopropoxide (TTIP) was added into 80 ml of ethanol solution with silica nanoparticles (0.5 g). The above-mentioned TTIP-added silica nanoparticles were stirred for 3 h at room temperature and transformed into silica/titania core/shell nanospheres (CSNSs) through the modified sol-gel reaction of titania. The HNSs were synthesized by mild ultrasonic irradiation (Bransonic-1510, Branson) of CSNSs in ammonia solution (0.1 M) for 1 h. The final product of HNSs was then obtained by centrifugation at 5,000 rpm (Mega 17R, Hanil Science and Industrial). Isolated yields of SiO_2, SiO_2@TiO_2, and hollow TiO_2 colloids were 96, 95, and 89 %, respectively. To find the isolated yields, the samples were dried thoroughly in vacuum oven and the weights of dried samples were measured. For accurate isolated yields of the samples, the processes for the isolated yields were conducted 5 times.

Preparation and test of HNSs based organic bistable memory devices (OBDs)

The obtained HNSs (0.05 g) were re-dispersed in 10 ml in distilled water. And then, PVA (0.2 g) was added into solution dispersed with the hollow nanostructured materials. HNS with diameter of 25 and 50 nm were served in PVA/HNS25 and PVA/HNS50, respectively. The HNS dispersed PVA solution was spin-coated on induim tin oxide (ITO) coated glass substrate with a pixel size of 2 mm by 2 mm. The PVA/HNS solution was spin-coated at a spin speed of 2,000 rpm and the thickness of the spin coated film was 250 nm. The spin-coated film was dried at 60 ℃ for 2 h in vacuum to remove residual solvent and Al was thermally deposited as an electrode for the OBDs. The current density-voltage characteristics

of the fabricated OBDs were measured with Keithley 2400 source measurement unit. All measurements of the memory performances were carried out in ambient condition.

Instrumentation

The transmission electron microscopy (TEM) and scanning electron microscopy (SEM) images of nanomaterials were taken with a JEOL EM-2000 EX II microscope and JEOL JSM6700-F. The electron energy loss spectroscopy (EELS) mapping of HNS was examined by Carl Zeiss LIBRA 200FE. The scanning TEM/energy dispersive X-ray (STEM-EDX) line analysis data and EDX analysis data were obtained using a Technai F20 (FEI). For these observations, the nanomaterials were diluted in ethanol and the diluted solution was deposited on a copper grid coated with carbon film. X-ray diffraction measurements were carried out using an M18XHF-SRA (Mac Science) diffractometer equipped with a CuKa radiation source (λ=1.5406 Å) at 40 kV and 300 mA (12 kW).

2. Nitrogen Adsorption of CSNS and HNS

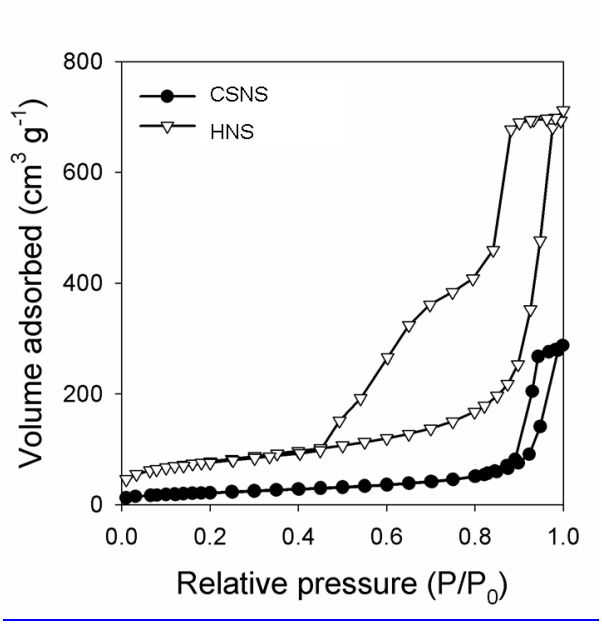

Fig S1. Nitorgen adsorption curves of CSNS and HNS.

Tab S1.BET surface area and pore volume of CSNS and HNS.

	BET surface area [a] ($m^2 g^{-1}$)	Pore volume [b] ($cm^3 g^{-1}$)
CSNS	75	0.32
HNS	280	1.05

[a] Calculated by the BET method

[b] Total pore volume

3. Crystalline patterns of CSNS and HNS

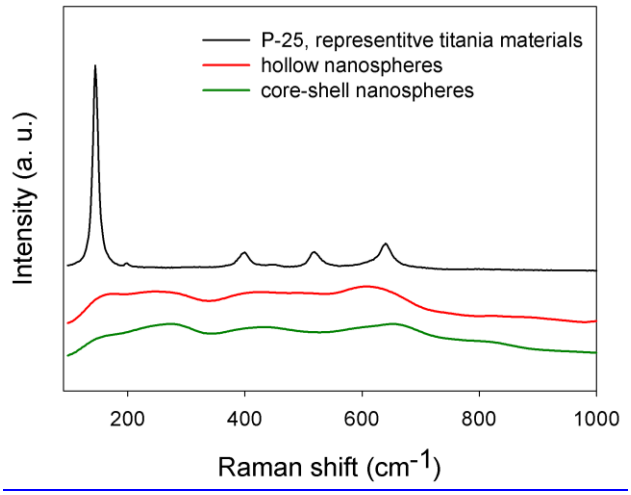

Fig. S2. Raman spectra of representative titania materials, P-25 (crystalline materials), hollow nanospheres, and core-shell nanospheres. Especially, P-25 was used as reference materials with anatase crystalline.

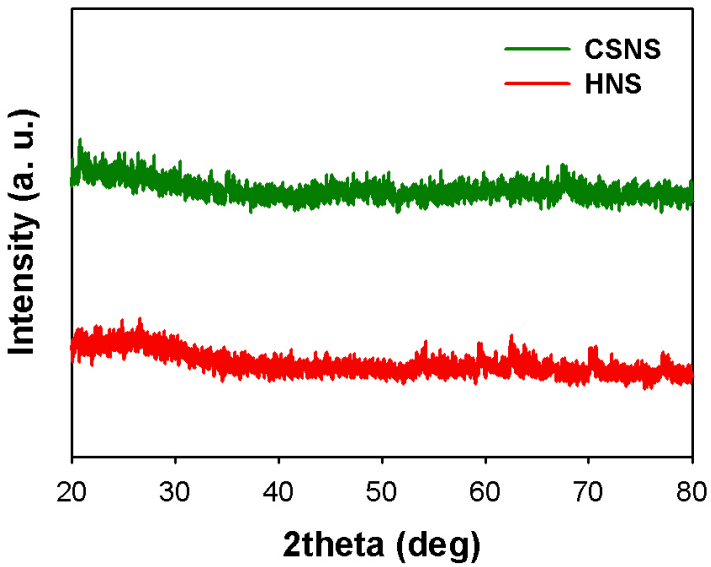

Fig. S3 Powder X-ray diffraction patterns of CSNS and HNS.

4. The behavior of silica and titania single particles

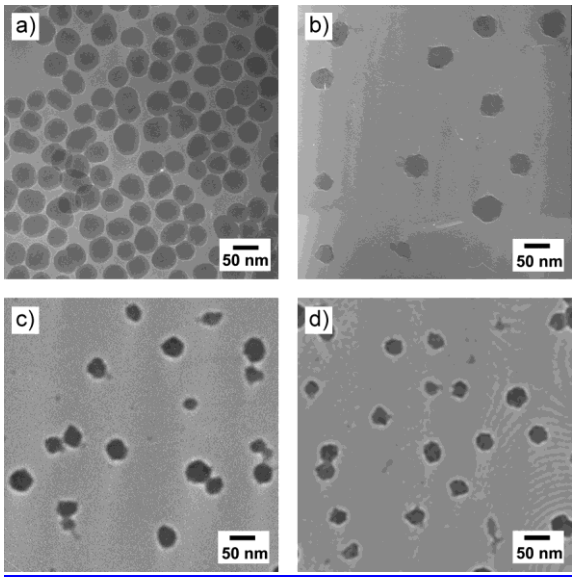

Fig. S4. TEM images of (a) silica, (b) silica in 0.1 M ammonium hydroxide solution after 5 days, (c) titania, and (d) titania in 0.1 M ammonium hydroxide solution after 5 days, respectively.

5. TEM and SEM images of HNSs with diameter of 25 nm

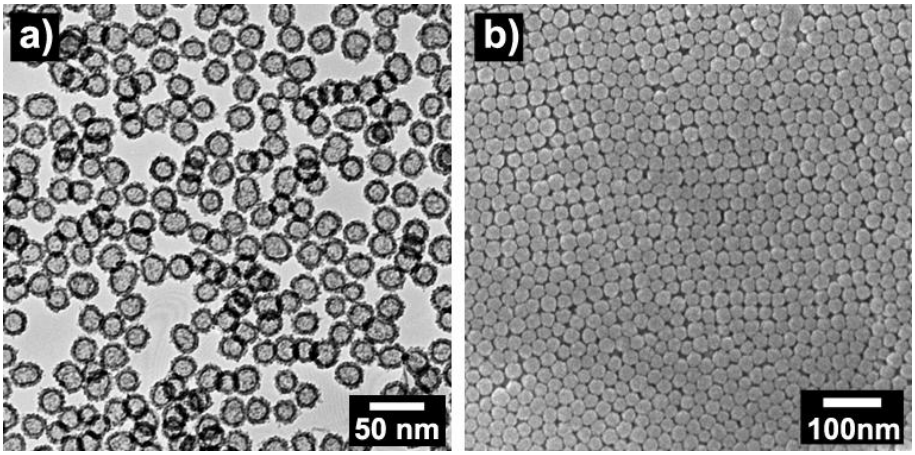

Fig. S5 TEM and SEM images of silica-titania based hollow nanospheres with diameter of 25 nm (HNS25) from SMER method.

6. Charge trapping of CSNS and HNS

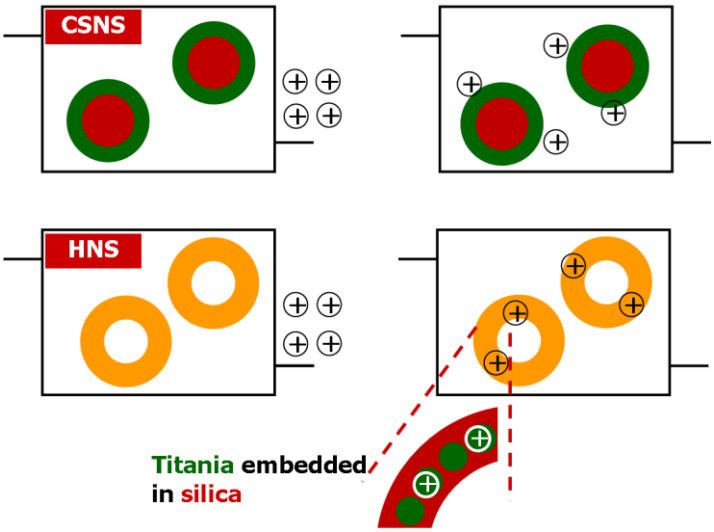

Fig. S6. Schematic illustration for displaying charge trapping in different nanostructured materials.