## **Supplementary Information**

# Perforated mesoporous NiO nanostructures for enhanced pseudocapacitive performance with ultra-high rate capability and high energy density

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### 1. Experimental

The large area arrays of morphology-controlled NiO nanostructures were synthesized on ITO coated glass substrates via hydrothermal synthesis approach. 1M Nickel Sulfate (NiSO<sub>4</sub>. 6H<sub>2</sub>O, 99.9%, Sigma Aldrich) dissolved in the de-ionized water was reacted with the Ethanol (C<sub>2</sub>H<sub>5</sub>OH, 99.9%, SRL chemicals) for 10 min to form 1:1 solution. The pH of the solution was maintained to 12 after reacting the aqueous ammonia solution (NH<sub>3</sub>.H<sub>2</sub>O, Extra pure, 25%, SRL chemicals) for 30 min. at room temperature and then transferred to the autoclave containing well aligned ITO coated glass substrates. The hydrothermal reaction was carried out at 180 °C for different time intervals such as 6, 12, 18, 24, and 48 h to grow morphology controlled NiO nanostructures over the ITO coated glass substrate. After that, the effect of reaction time on the surface morphology was studied utilizing field-emission scanning electron microscopy (FESEM, JEOL JSM-6500F) and Transmission electron microscopy (TEM, JEOL JEM 3010). The electronic structure and chemical states of the NiO nanostructures were analyzed using an X-ray photoelectron spectrometer (XPS, Thermo Scientific Inc. Ka) with a microfocus monochromated Al Ka X-ray. The surface area and pore size distribution analysis of the NiO nanobelts were performed adopting N2 adsorptiondesorption isotherm (BET) and Barrett-Joyner-Halenda (BJH) methods, in an automated gas sorption analyzer (Quantchrome Autosorb  $iQ_2$ ). Fig. S1 shows the schematic of the prototype supercapacitor composed of NiO nanostructures grown on conducting glass (ITO/glass) substrate as a working electrode, saturated calomel electrode as a reference electrode and pristine ITO/glass as a counter electrode, was used to evaluate the electrochemical properties. The electrochemical measurements were accomplished at room temperature with the potentiostat (Autolab PGSTAT302N) in 2M KOH aqueous electrolyte to investigate the effect of controlled morphology of NiO nanostructures on the pseudocapacitive performance of electrochemical supercapacitor. The capacitance values, cyclic stability, and energy/power density performance of the prototype device were confirmed with two terminal measurement approach.



Fig. S1 Schematic diagram of the mesoporous NiO nanostructure-based supercapacitor.

#### 2. TEM analysis

The morphology and crystal structure of mesoporous NiO nanobelts were further characterized by High-Resolution TEM. The TEM image in Fig. S2 shows that the NiO nanobelts are composed of interlinked nanoparticles with well-defined crystal structures. The interlinking of the NiO nanoparticles has resulted in the formation of mesoporous nanobelts (Fig. S2(a)). These observations are in good agreement with the FESEM and BET analysis discussed in Fig. 1, and Fig. 2. The interplanar spacing of ~ 0.15 nm observed from HRTEM pattern (Fig. S2(b)) is assigned to the (220) plane is in well agreement with the Rhombohedral crystal structure defined for NiO (JCPDs: 43740).



**Fig. S2.** High-Resolution TEM image of the single nanobelts extracted from the large area array confirming (a) the mesoporous nature of nanobelts, and (b) interplanar spacing of the well-separated NiO nanoparticles of the nanobelts. The nanoparticles are traced with the dotted red lines.

#### 3. Cyclic voltammetry



Fig. S3 CV curves of the nanoflakes obtained at a reaction time of (a) 18 and (b) 24 h.

#### 4. Dependence of anodic peak current density on the scan rate



**Fig. S4** The variation of the peak current density  $(i_p)$  of the anodic reduction peak with the square root of the scan rate  $(v_{1/2})$  observed in CV curves.



#### 5. Galvanostatic charging-discharging

**Fig. S5** GCD curves of NiO nanoflakes synthesized at a reaction time of (a) 18 and (b) 48 h, respectively, at various current densities.

#### 6. Calculation of energy and power density

The power and energy densities of mesoporous NiO nanostructures were calculated using the equation

$$E = \frac{1}{2} \times C_{s} \times (\Delta V)^{2}$$
(1)
  
and
$$\Box P = \frac{E}{\Delta t} \times 3600$$
(2)

Where E is the energy density (Wh/kg),  $C_s$  is the specific capacitance (F/g),  $\Delta V$  is the operating potential range (V), P is the power density (W/kg), and  $\Delta t$  is discharge time (sec).