Compared Fig. S1 (a) and (b), there are three key points need to be explained. One, the red-arrow marked diffraction peak in Fig. S1 (a) only appeared if the film has been annealed at the temperature higher than 600 °C. Two, Fig. S1 (c) and (d) is the SEM images of the fabricated porous ZrO$_2$ thin films if it has not been annealed again at high temperature or has been only dried at room temperature. The surface covered a layer of organic residues. Thus the XRD data for this sample only has signal of the substrate. Further SEM investigations of Fig. S1 (c) and (d) support this conclusion. Three, the narrow Half-peak width illustrates a smaller average particle size and a narrower size distribution of ZrO$_2$ for Fig. S1 (a) compared to Fig. S1 (b). ZrO$_2$ for the dip-coating were purified from the raw materials that tested in the Fig. 2. Thus it will inevitably own a smaller size and a narrower size distribution. Also, the results suggested that the purification process in our article is effective and efficient. Also, it is interested to found that the film shows a high [011] orientation. This phenomenon will be discussed elsewhere in our other related works.
Fig. S2 Two structure models and the FDTD simulated optical properties. (a) Model 1, which
composes a smooth surface. \( h_1 \) is the film’s thickness. (b) Model 2, a cubic close-packing structure.
The number of layers is fixed, while the particle diameter of \( d \) varied from 80 nm to 150 nm.

The disordered structure was built via a simple method. First, we supposed that the particle were spherical
and close packed as shown in Fig. S3. Every square cell thus contains one single spherical \( \text{ZrO}_2 \) nanoparticle
in its center. Then the coordinate of the center point of every \( \text{ZrO}_2 \) was changed. Its value was randomly
produced by the computer, but it should be confined within the square cell. Also, the diameter of \( \text{ZrO}_2 \) was
varied from 30 to 80 nm accordingly. After these transformations, a series of belts which composed by
randomly distributed \( \text{ZrO}_2 \) particles are achieved (Fig. S3 step 2 shows one of these belts). Finally, we
randomly stacked these \( \text{ZrO}_2 \) belts layer by layer to form a disordered film structure (see Fig. S3 step 3).