Supporting information

Photoluminescence (PL) study of ZnO nanowall array

Luminescence spectra were obtained by detecting the emission from the samples excited by the third harmonic pulses of 355 nm from a Q-switched YAG laser (Quanta, HYL-101) with an intensified CCD (Princeton Instruments, ICCD576G) of 2-ns gating resolution attached to a 0.5-m spectrometer (Acton Research, Spectrapro-500). In order to compare with the ZnO nanowall array, the ZnO nanorod array on the Si-substrate was prepared from the nucleus ZnO seed as our previous report.

As shown in Fig. S1, a strong UV emission was observed at 391.5nm ($\Delta\lambda_{fwhm}$ = 16.33nm) from the present ZnO nanowall array and at 398.9nm ($\Delta\lambda_{fwhm}$ = 29.82nm) from the ZnO nanorod array, respectively. Full width at half maximum (FWHM) of the UV emission of the ZnO nanowall array is 1.8 times as narrow as that of the ZnO nanorod array. It is indicating that the ZnO nanowall array more suitable structure for the opto-electronic nanodevices than the ZnO nanorod array. In addition, there are no green-emission around 510 nm and yellow-emission around 590nm in the PL spectrum of the ZnO nanowall array but broad green- and yellow-emission was observed from the ZnO nanorod array. Green- and yellow-emission are known to be caused by the recombination of a photo-generated electron with a hole trapped in a singly ionized oxygen vacancy.[1, 2] Such a specific defect could hinder the UV lasing action, since a high threshold power density is required for the stimulated emission in order to overcome the spontaneous broad green emission.[3, 4]

Thickness control of ZnO nanowall array

When the concentration of citrate solution decreased from 0.17 to 0.08 mM, thickness of the ZnO nanowall array was increased from 10 to 120 nm as shown in Fig. S2. Increasing thickness of the ZnO nanowall comes from the fact that a low concentration of citrate ions did not effectively protect the growth rate along the [0001] direction of the nucleus seed.[5]

Control experiment

In order to confirm the ZnO nanoplates growth from the nucleus seed, the Si-substrate without seed layer placed into the autoclave containing the mother solution. The autoclave was maintained at 95 °C for 6 hrs in a conventional furnace and was slowly cooled down to room temperature. Fig. S3(a) shows FE-SEM image of the resulting Si-substrate. There is no development of plate-like ZnO crystals and only amorphous shape crystals were observed as shown in Fig. S3(b). Meanwhile, the ZnO crystals produced from the nutrient solution was same as the pineapple-like ZnO crystals (Fig. S3(c)).

References

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Figure legends:

Figure S1. PL spectra of (a) ZnO nanowall array and (b) ZnO nanorod array. Excitation lasing power is 10μJ.

Figure S2. FE-SEM image of ZnO nanowall array produced from 0.08mM citrate solution.

Figure S3. FE-SEM images of (a), (b) the prepared Si-substrate without seed layer and (c) the resulting product produced from the nutrient solution.

Figure S1

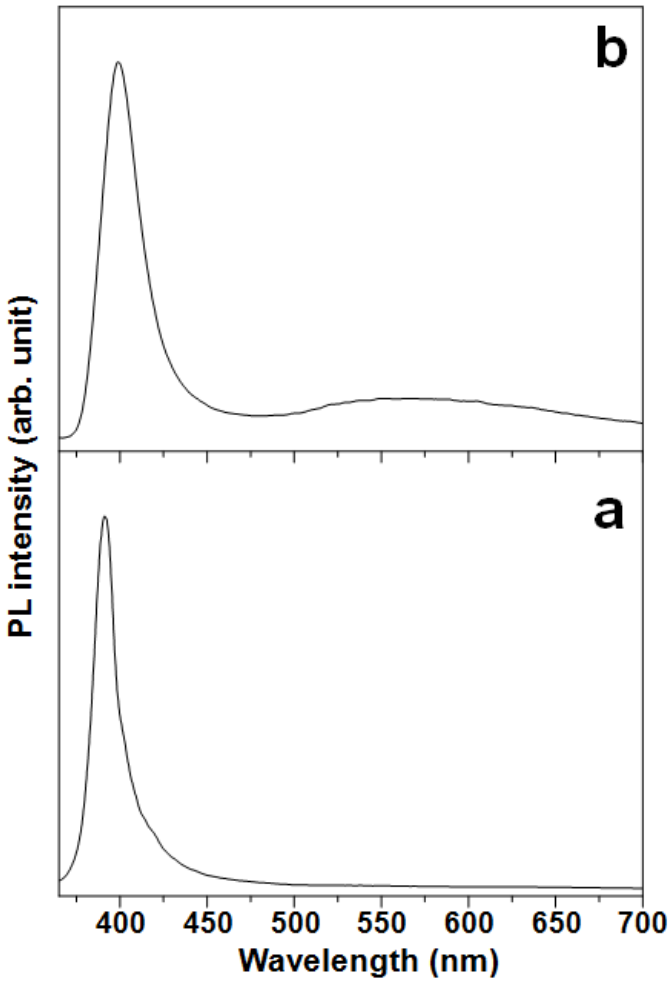

Figure S2

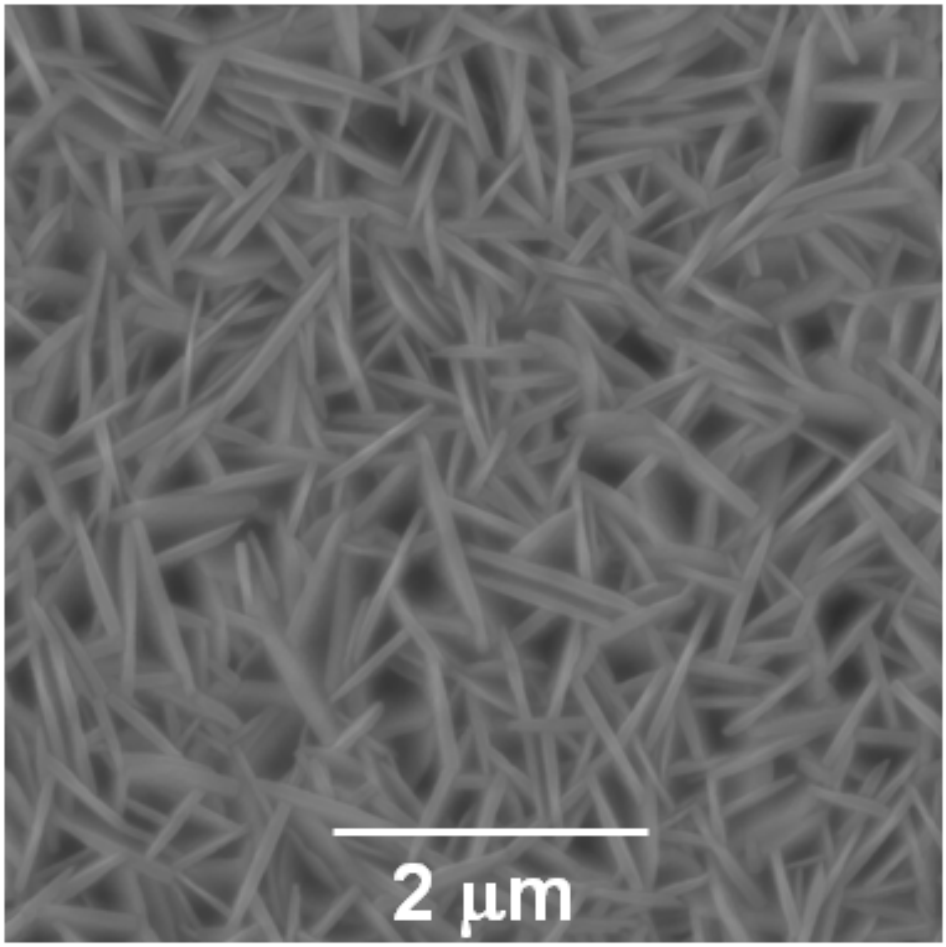

Figure S3