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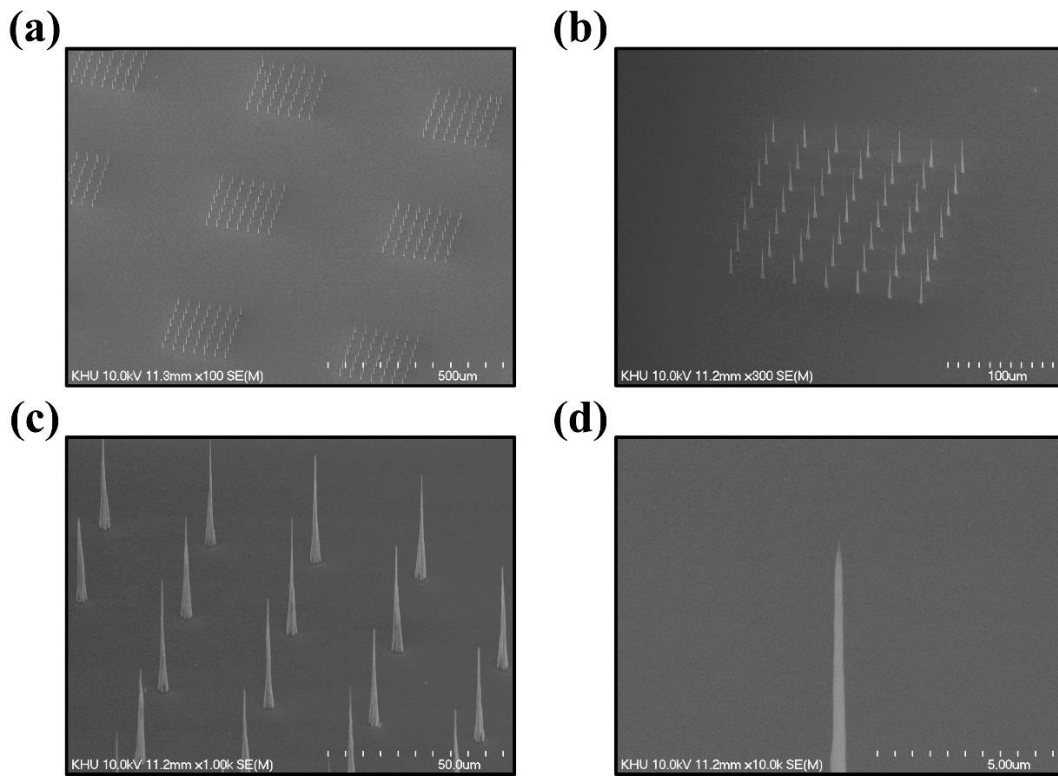
Sapphire wafer for 226 nm far UVC generation with  
carbon nanotube based cold cathode electron beam  
(C-beam) irradiation

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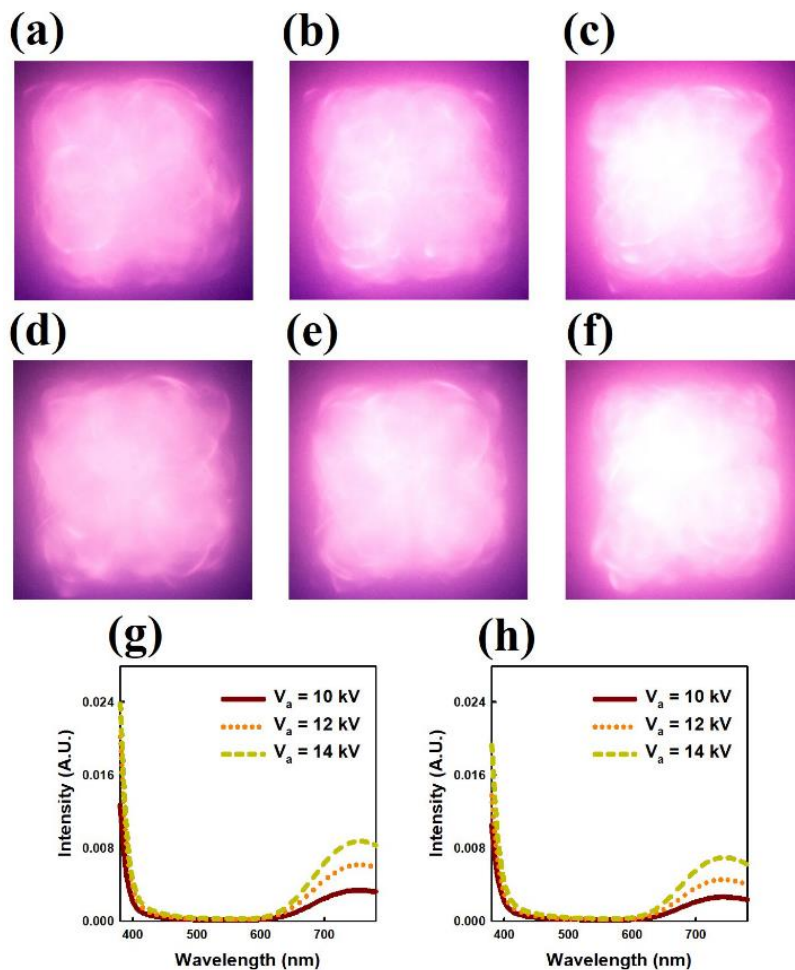
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1. The CNT emitters have dot size of  $3\ \mu\text{m}$  and height of about  $40\ \mu\text{m}$ . Cone-shaped CNT emitters are arranged horizontally and vertically at intervals of  $30\ \mu\text{m}$  in order to reduce field screening effect. The total number of CNT emitters in the square shape is 49 ea, including CNT emitters with the horizontal and vertical directions of 7 ea, respectively. We call group of these CNT emitters as island. These islands were fabricated on the Si wafer at  $0.5\ \text{mm}$  intervals and the total area of CNT emitters was  $188\ \text{mm}^2$ .



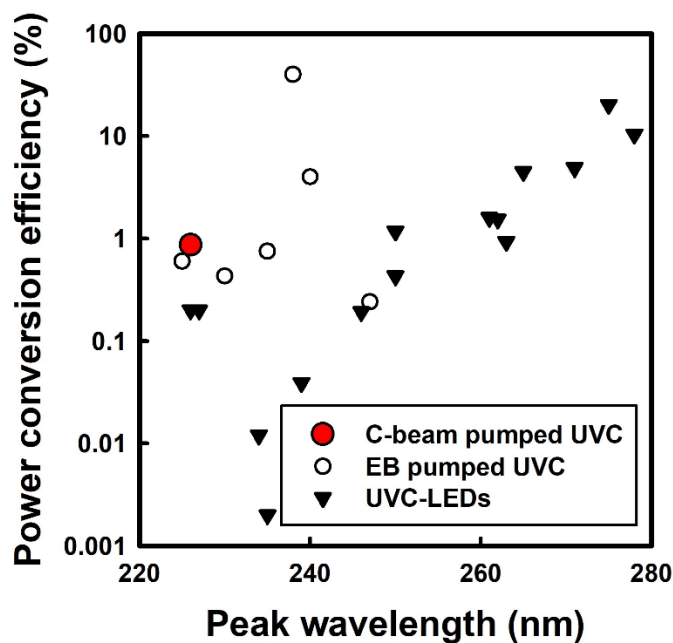
**Figure S1.** The SEM image of CNT emitters with variable magnification. The magnifications of the respective SEM images of (a), (b), (c), and (d) are 100, 300, 1,000, and 10,000 times.

2. The visible light produced by the PL in the sapphire wafer does not depend on the window materials. When the visible light generated with 5 mm thick quartz and 10 mm thick glass as the window was compared with the photograph and spectra measured by spectroradiometer (Konica Minolta, CS-1000), there was no difference.



**Figure S2.** (a), (b) and (c) are photographs when  $V_a$  is 10kV, 12 kV and 14 kV, using 5 mm thick quartz as the window, respectively. (d), (e) and (f) are photographs when  $V_a$  is 10 kV, 12 kV and 14 kV using 10 mm thick glass as window. (g) and (h) are spectra when using quartz and glass as window materials, respectively.

3. Power conversion efficiency (PCE) comparison of different UVC light sources.<sup>1-18</sup> The PCE of 226 nm UVC light produced by C-beam pumping is 0.87%, which is the highest PCE at wavelengths below 230 nm.



**Figure S3.** PCE with different UVC light sources.

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