Electronic Supplementary Material (ESI) for Nanoscale Advances.

Supplementary Information

High Efficiency and High Resolution Patterned Quantum Dot Light Emitting Diodes by Electrohydrodynamic Printing

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1. The effect of printing conditions and ink viscosity on line width

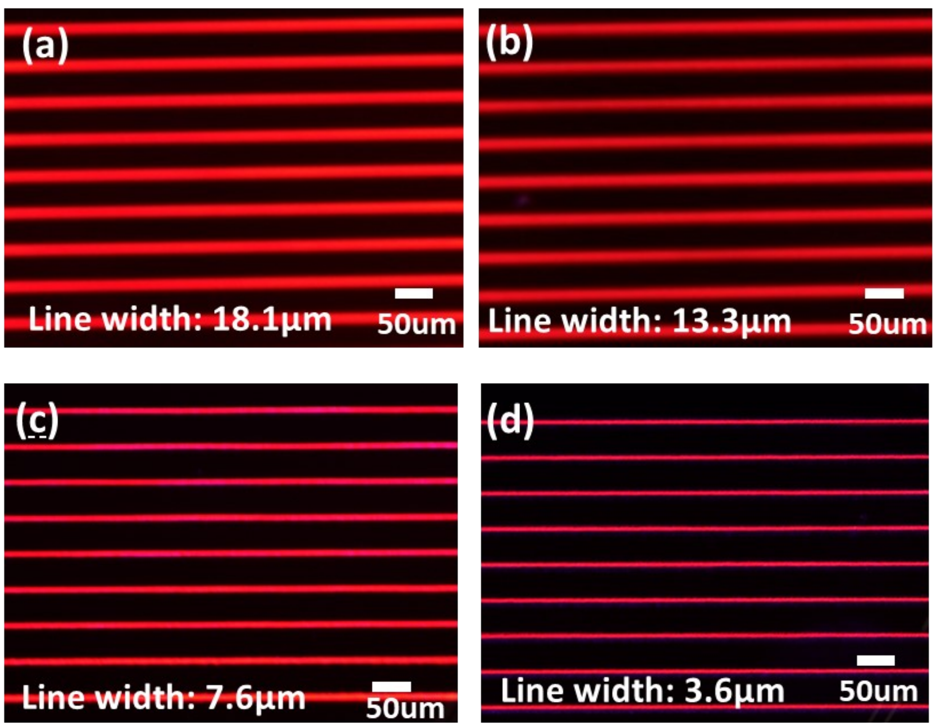


Figure S1. (a-d) Fluorescent images of of QDs ink (6 cP) at the voltage magnitude of 1000V, 850V, 700V and 550V, respectively.

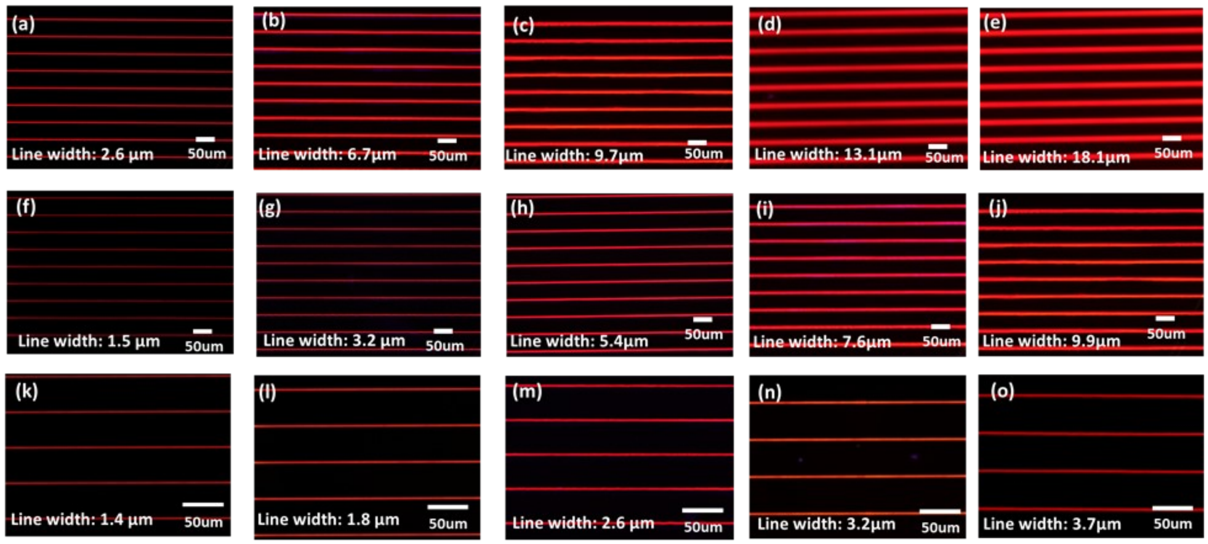


Figure S2. Fluorescent images of different printing speeds and different QDs ink viscosity. (a-e) fluorescent images of QDs ink with viscosity 6 cP at printing speeds of 10mm/s, 7mm/s, 5mm/s, 3mm/s and 1mm/s, (f-j) fluorescent images of QDs ink with viscosity 10 cP at printing speeds of 10mm/s, 7mm/s, 5mm/s, 3mm/s and 1mm/s, (k-o) fluorescent images of QDs ink with viscosity 20 cP at printing speeds of 10mm/s, 7mm/s, 5mm/s, 3mm/s and 1mm/s.

Table S1. Summarized line width with different printing speed and QDs ink viscosity.

Printing Speed / Viscosity of QDs ink	1 mm/s	3mm/s	5 mm/s	7 mm/s	10 mm/s
QDs ink (6 cP)	18.1 µm	13.1µm	9.7 µm	6.7 µm	2.6 µm
QDs ink (10 cP)	9.9 µm	7.6 µm	5.4µm	3.2 µm	1.5 µm
QDs ink (20 cP)	3.7µm	3.2 µm	2.6µm	1.8 µm	1.4 µm

2. TRPL and UPS of QDs film

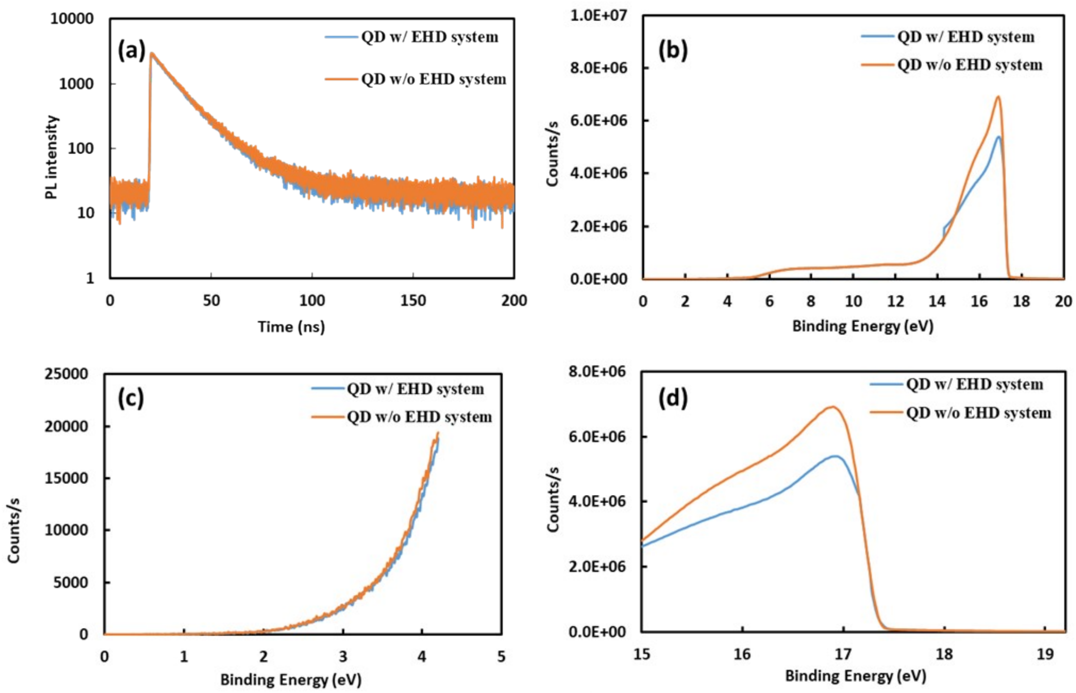
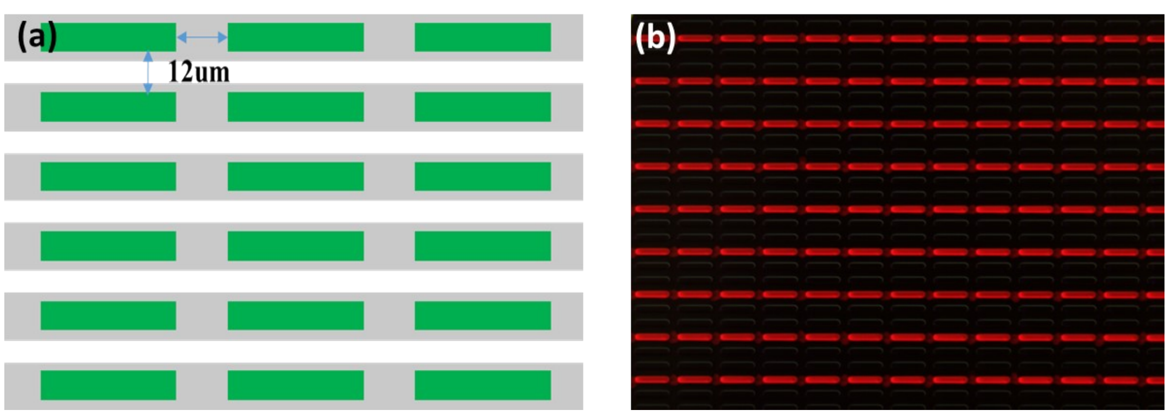


Figure S3. (a) The TRPL spectra of the QDs ink with and without EHD system, (b) UPS spectra of QDs film with and without EHD system, (c) and (d) UPS spectra of QDs film with and without EHD system zoomed-in spectra of the secondary electron threshold and valence band regions are shown.

3. Pixel diagram of PM substrate and film morphology



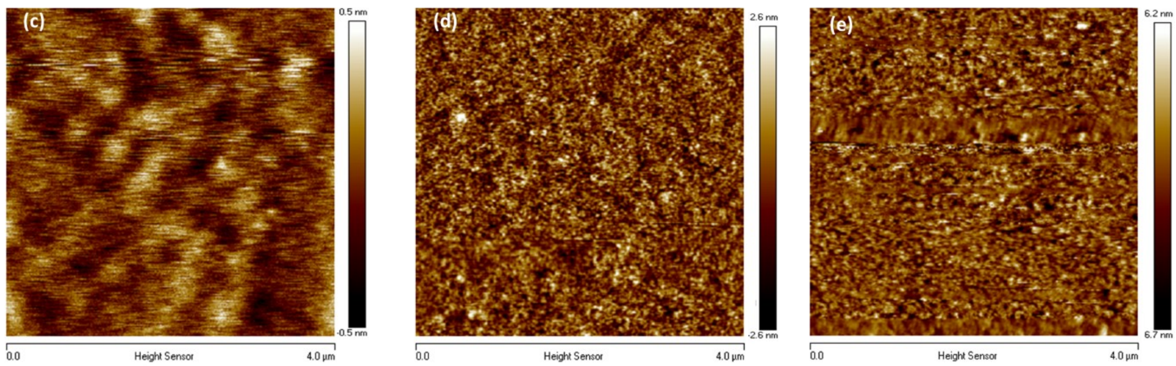


Figure S4. (a) Diagram of the pixel arrangement of the PM substrate, the green rectangles represent pixels defined by PDL, the pitch of pixels in vertical and horizontal directions is 12um, the gray strips represent ITO, (b) the fluorescent microphotograph of red QDs patterns, (c, d, e) the AFM images of ITO, ITO/ZnO and ITO/ZnO/QDs surface

4. The QDs film thickness measured by stylus profiler

The thickness of the luminescent layer of quantum dots was very important to the device performance, and we changed the thickness of the luminescent layer by adjusting the printing speed. Figure S4 (a) showed the schematic diagram of the cross section structure of the red, green and blue sub-pixels. We scan the sub-pixel regions of red, green and blue with the stylus profiler to get the film thickness information of the pixel region. Figure S4 (b) showed the substrate without printing any QDs ink and R, G, B represented the sub-pixels of red, green and blue, respectively and we can see that the R, G and B sub-pixel areas have the same film thickness. Figure S4 (c), (d), (e) and (f) showed the pictures of R sub-pixel regions with printing QDs ink and G, B sub-pixels without printing QDs ink. The printing speed of Figure S4 (c), (d), (e) and (f) were 1mm/s, 3mm/s, 5mm/s and 7mm/s, respectively. As shown in Figure S4, the R sub-pixels with the QDs printed are higher than the G, B sub-pixels without the QDs ink.

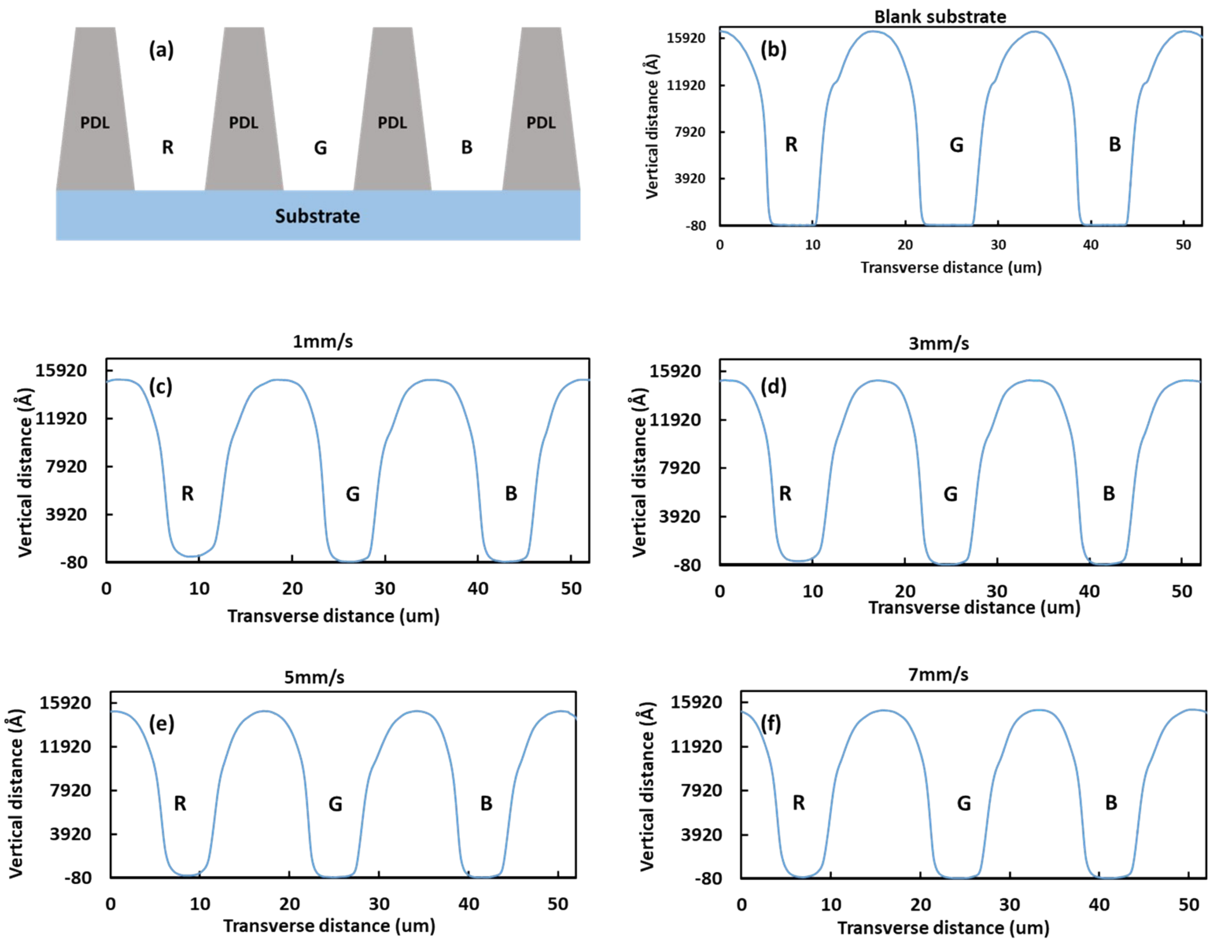


Figure S5. (a) the schematic diagram of the cross section structure of the red, green and blue sub-pixels, (b) the substrate without printing any QDs ink, (c), (d), (e) and (f) the red sub-pixels printed with QDs ink at the speeds of 1mm/s, 3mm/s, 5mm/s and 7mm/s, respectively.

5. The operational lifetime and EQE-voltage characteristics of the bottom-emission QLED

As shown in Figure S6 (b), the initial luminance (L0) is 450nits, for the device with a printing speed of 3 mm /s, the LT95(the time for luminance to reach 95% of L0) was found to be 2.2h. The relatively low lifetime was mainly due to the fact that QDs ink were printed in an atmospheric atmosphere, which greatly affected the lifetime of the device.

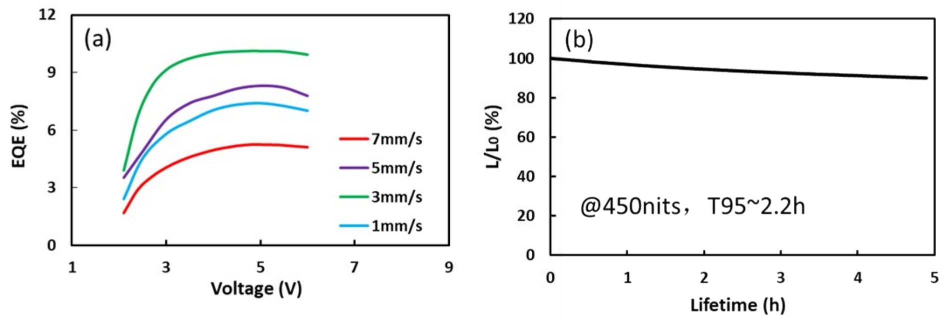


Figure S6. (a) EQE-voltage curves of QLED with different printing speed and (b) the operational lifetime the device with a printing speed of 3 mm /s

6. J-V-L characteristics of the two-color bottom-emission QLED

The current density-voltage-luminance (J-V-L) characteristics and current efficiency of those QLED devices with different printing speed were shown in Figure S2. Currently, the maximum current efficiency of green QLED is 5.72 cd/A and there is a lot of room for the improvement of green QLED performance.

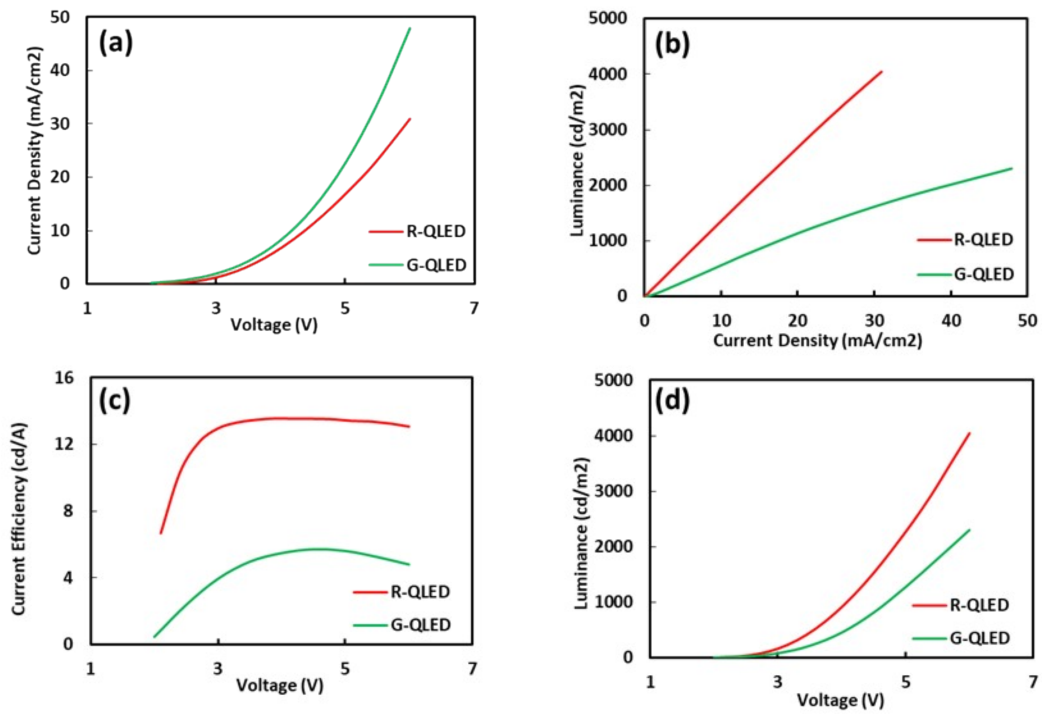


Figure S7. Performance of the two color bottom-emission QLED devices: (a) current density- voltage curves (b) luminance- voltage curves (c) current efficiency– voltage curves and luminance– current density curves with different printing speed.

7. The electroluminescence images of red and green sub-pixels

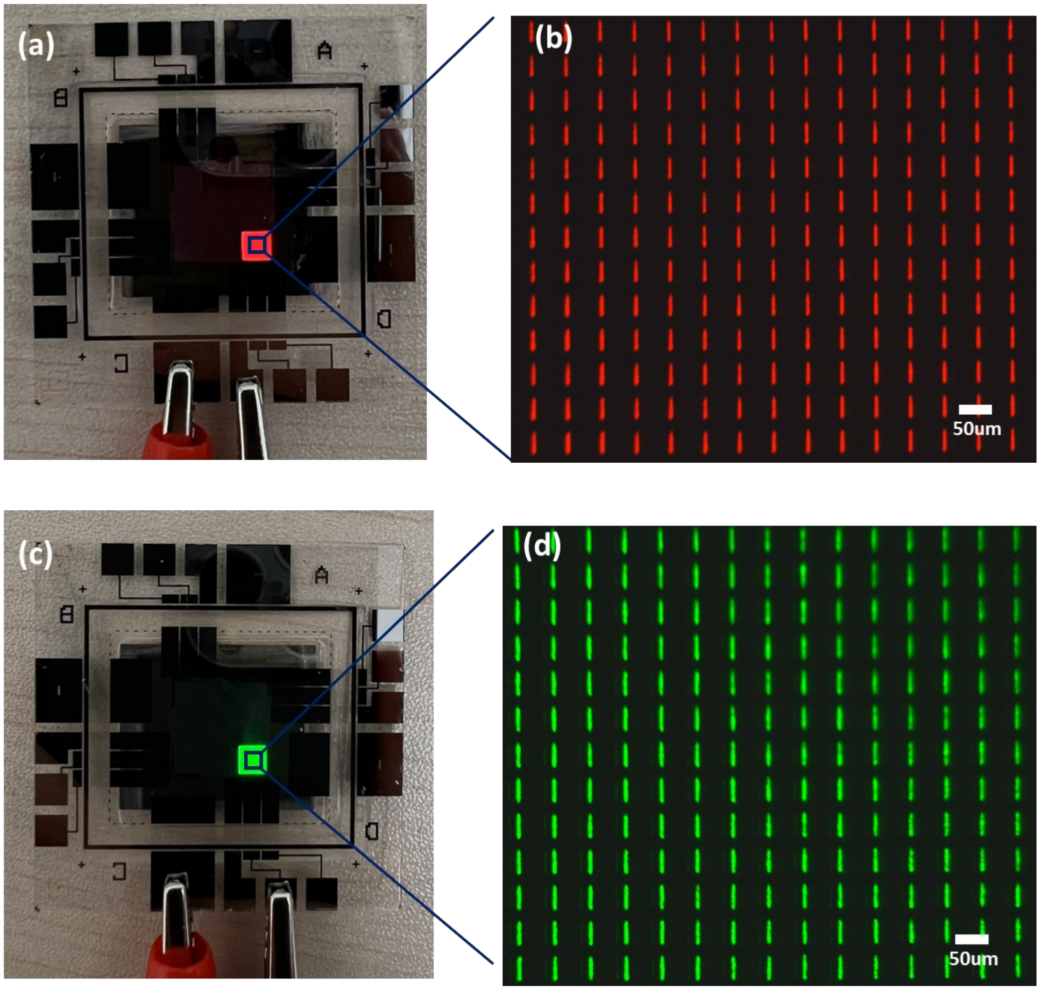


Figure S8. (a) The photo and (b) the magnified electroluminescence images of red sub-pixels, (c) the photo and (d) the magnified electroluminescence images of green sub-pixels.