Supplementary Information

High Resolution Dynamic Pressure Sensor Array Based on Piezo-Phototronic Effect Tuned Photoluminescence Imaging

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Contents:

1. The pressure sensor structure based on the InGaN/GaN MQW pillars

After state-of-the-art top-down fabrication, the large-area and high density InGaN/GaN MQW pillars have been orderly formed. Notably, the pressure sensor structure can be constructed by controllable size, shape, period and height of pillar array. As shown in Figure S1, each MQW pillar (circle area) only occupies a portion of individual sensor unit (square area). The blank area outside of the pillars doesn't participate in the pressure sensing. In this paper, the diameter, height of each pillar and distance between two adjacent pillars are 0.8 µm, 1.2 µm, and 4 µm, respectively. So, the a_s and a_p values are around 16 µm^2 and 0.5 µm^2, respectively.

2. The stability and reproducibility of all-optical pressure sensor array

The stability and reproducibility of our all-optical pressure sensor array were studied by examining its PL image of 2D pressure distribution when apply/remove external pressure (5 MPa) for 1000 cycles. A patterned '8' pressure stamp was used to apply external pressure on the all-optical pressure sensor array. As shown in Figure S2, we take its pressure imaging at different times of pressing/releasing cycles such as 0, 500 and 1000 for the study of device stability. The PL imaging of pressure stamp '8' do not have obvious change in these photographs. Besides, the recovery of PL mapping can be well achieved when we remove external pressure/strain. As a result, it demonstrated our sensor array has a high stability and repeatability of all-optical pressure sensing with good mechanical robustness.

3. The pressure-sensitive images of our MQW pillar array by patterned 'PYC' stamp under applied pressure/strain

Except the 'BINN' stamp used in context, another convex patterned 'PYC' stamp was also utilized to provide pressure/strain for the MQW pillar array. Figure S3a shows the bright-field imaging of the 'PYC' stamp in contact with our array device. A series of high resolution pressure images of the 'PYC' logo character under different compressive stresses of 0, 1.55 and 6.21 MPa, respectively. As increasing the compressive stress by pressing the 'PYC' stamp, the PL intensity of the compressed pillars gradually decreased, while that of the uncompressed ones didn't have any change as shown in Figure S3b-d. The patterned 'PYC' logo became more and more distinct as the pressure/strain increases, exhibiting good pressure sensitive characteristics.

4. Three-dimensional dynamic pressure sensing by PL imaging

In order to investigate the 3D dynamic pressure sensing, both vertically and laterally dynamic PL imaging experiments were carried out to real-time record pressure/strain evolution process. The vertically dynamic pressure sensing has been implemented by cyclic pressing/releasing the 'BINN' stamp on the MQW pillar array. Movie S1 has readily recorded the pressure/strain evolution process from 0 to 14.94 MPa and then returning to 0 MPa by PL imaging. The vertically dynamic response of pressure sensing corresponds to the real-time image changes of patterned 'BINN' stamp.

5. Real-time signature record

On the other hand, laterally dynamic pressure sensing has been carried out to real-time record movement track like personal signature. After pressing a pen point (using a rectangle stamp) on the pillar array, a lateral motion was exerted by 3D micromanipulation stages. The full trajectory of the pen point was clearly observed by PL imaging in Movie S2. According to the motional trajectory of pen point, the signature symbol ‘2’ was clearly outlined as shown in Figure S4. Therefore, the PL imaging method demonstrates excellent capability and versatility for 3D dynamic pressure/strain sensing.

Figures in Supplementary Information

Figure S1

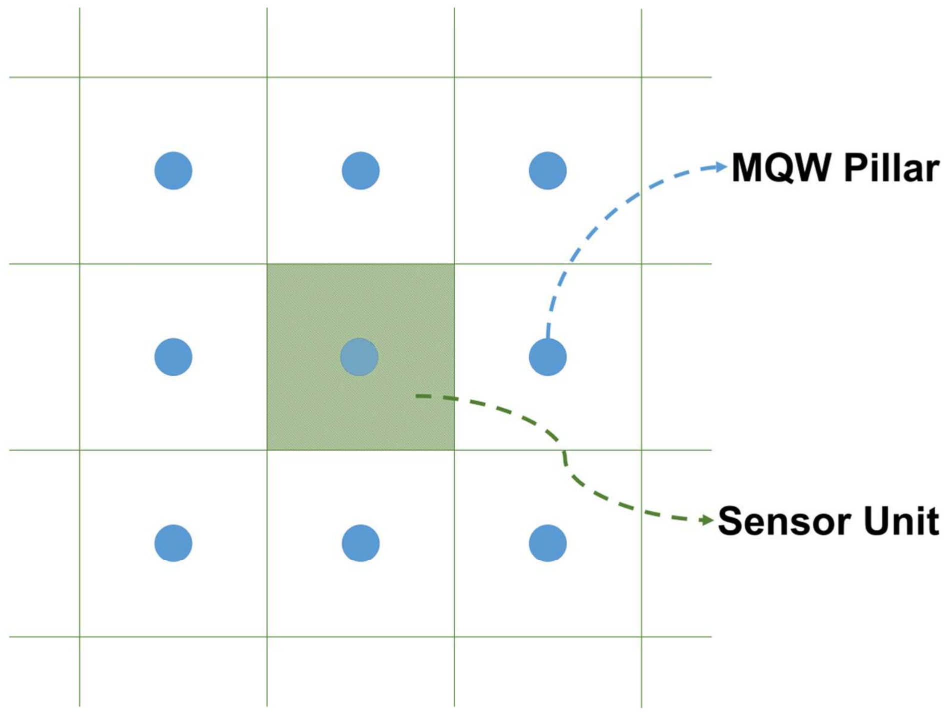

Figure S1. The pressure sensor structure of the InGaN/GaN MQW pillars. Each MQW pillar and sensor unit is represented by circle and square area, respectively.

Figure S2

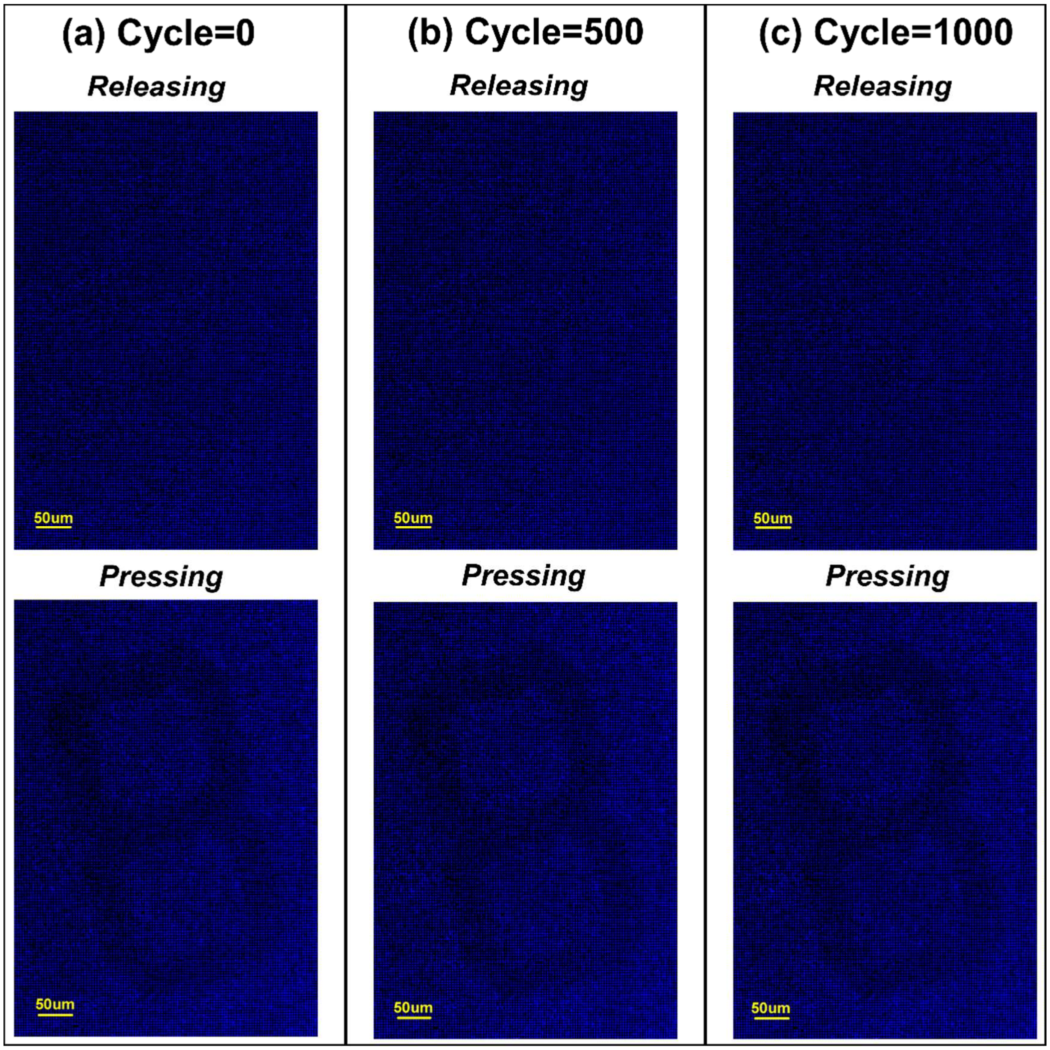

Figure S2. The stability and reproducibility of all-optical pressure sensor array. A patterned '8' pressure stamp was used to apply external pressure (5 MPa) to the sensor array in cycles. No obvious change was found at different cycle of pressing/releasing such as 0, 500 and 1000.

Figure S3

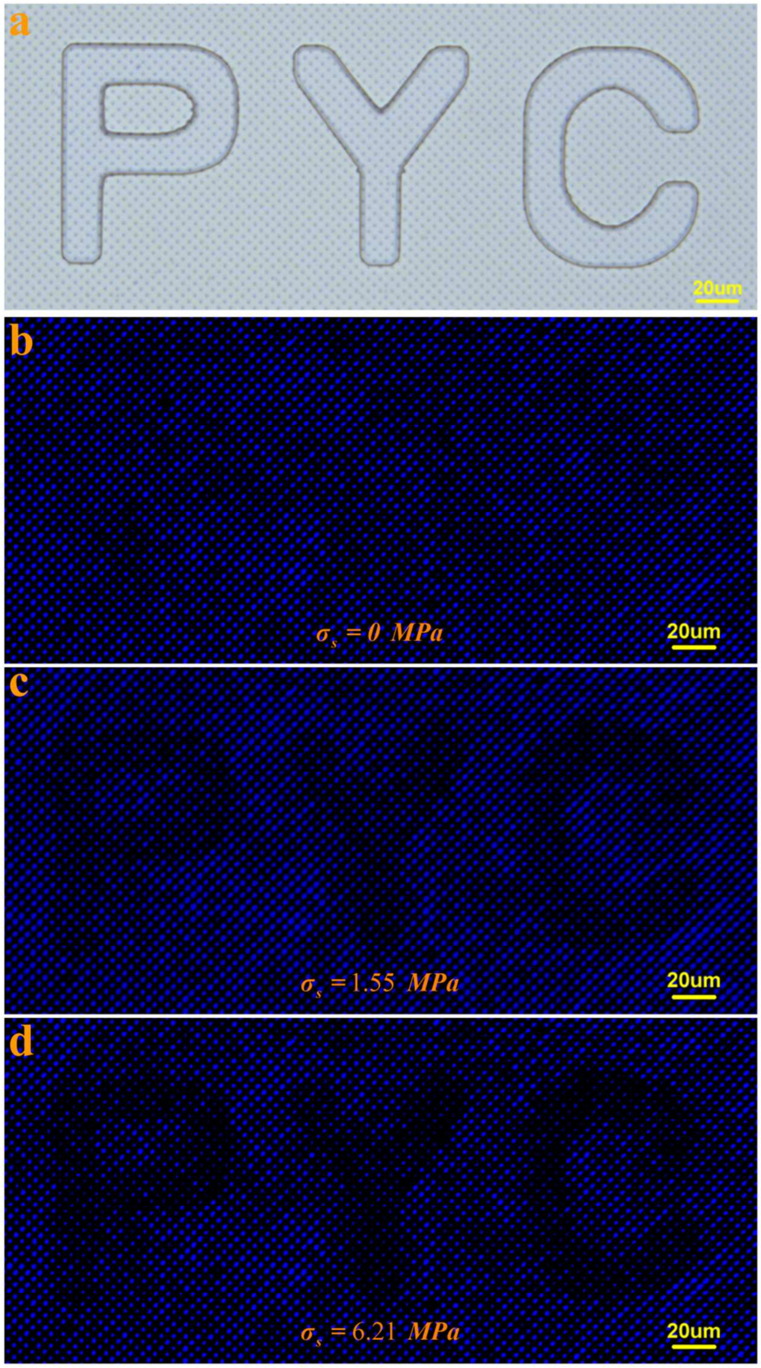

Figure S3. High resolution PL imaging of pressure/strain distribution. a, The bright-field image of the 'PYC' stamp in contact with the MQW pillar array. **b-d,** The PL images of the MQW pillar array by pressing the 'PYC' stamp under different pressure/stresses of 0, 1.55 and 6.21 MPa, respectively.

Figure S4

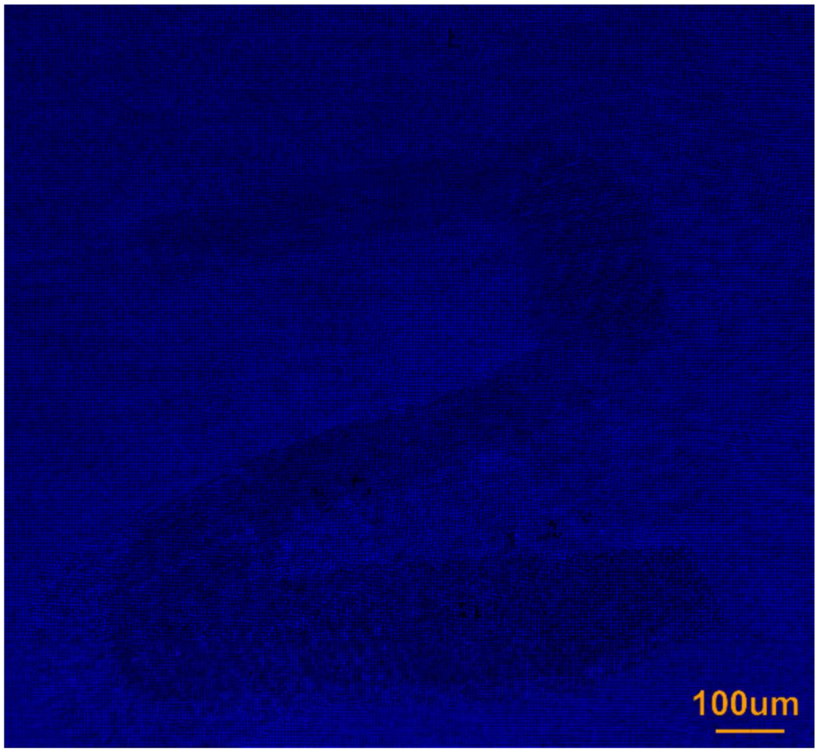

Figure S4. The full trajectory of the personal signature recording by laterally dynamic PL imaging. A rectangle SU-8 stamp, just like a pen point, was pressed on the pillar array, and then, loaded a lateral motion. Its movement clearly outlines the signature symbol “2”.

Movies in Supplementary Information

Movie S1. Vertically dynamic PL imaging of the pressure sensor array by cyclic pressing/releasing the 'BINN' stamp on the MQW pillars. The applied compressive stress changes from 0 to 14.94 MPa and then returns back to 0 MPa.

Movie S2. Laterally dynamic PL imaging of the pressure sensor array for real-time record movement track of personal signature. A pen point, using a rectangle SU-8 stamp, was pressed on the pressure sensor array under compressive stress of 3 MPa and then loaded a lateral motion for the simulation of personal signature.