Title: Experimental and theoretical investigation of 2D nanoplatelet-based conversion layers for color LED microdisplays

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Note S1: EPCE Specifications

In our previous work published in reference [3] we have dimensioned a full color LED microdisplay for an augmented reality application headset corresponding to a real market need. In the RRGG quad white pixel configuration described in that work and assuming 15% electroluminescence efficiency (EL), a CMOS display driver delivering 2.6 W electric power, and a requirement of at least 20% of lit on pixels to enable video mode operation, we concluded that it was possible to reach ~0.35 Mcd/m² maximum in video mode. This calculation assumed an EPLQY for both color conversion of 60%, which means an EPCE of 49.5 and 41.7% for green and red, respectively. It also assumed D65 standard white light and a maximum bias voltage of 4V at pixel level.

The table below details in column A the necessary current and voltage specifications for each pixel type to reach 1,000,000 cd/m². From this calculation, the maximum luminance in video mode is deduced (335,000 cd/m²). In column B, same calculation is done with a more realistic EL value of 4.5% and same EPLQY. We can conclude that, in that case, 100,000 cd/m² should be reachable.

| For 1,000,000 cd/m² | A (EL 15%; EPLQY 60%) | B (EL 4.5%; EPLQY 60%) |
|---------------------|-----------------------|-----------------------|
| I(µA)/V(V): Blue pixel | 4.1/4 | 13.7/4 |
| I(µA)/V(V): Green pixel | 6.4/4 | 21.3/4 |
| I(µA)/V(V): Red pixel | 6.2/4 | 20.7/4 |
| Power (µW): White pixel | 91.7 | 305.6 |
| Rate of pixel max. (%) | 6.7 | 2 |
| Max luminance in video mode (cd/m²) (20% pixel max) | 335,000 | 100,000 |

Note S2: Optimization of green photoresist

The green photoresist composition was optimized in the same manner as done with the red photoresist. Fig S1 shows the variation of absorption coefficient spectral dispersion for different concentrations of NPLs and TiO2 nanoparticles. As for the red photoresist, we can observe an increase of layer absorption with NPL and TiO2 content. Similarly, beyond ~3% TiO2 content, the absorption tends to decrease.
Note S3: MicroLED array and pixel patterning

The micro-LED arrays used for color pixel patterning tests have been processed on a 1.85 x 1.85 cm² passive interconnect circuits (collectively manufactured on an 8-inch silicon wafer). The GaN epilayer grown on a 4-inch sapphire was directly transferred and stuck on the IC by metal-to-metal bonding and its sapphire substrate removed by laser lift-off. Then, pixelisation and electric connection were achieved. At the end, we get a smooth surface with arrays of 9.5 µm-pitch blue pixels that can be lit-on by groups of pixels (different patterns). Under 4V, the mean blue radiant power generated by the micro-LEDs is around 0.4 W/cm².

The color pixels are processed on top of this wafer in several steps

- PR spin-coating (1000 rpm), typically 3 ml PR ink per wafer.
- Drying at RT,
- Photolithography of pixel arrays: PAS 5500/100D/i-Line Stepper; dose: 200 mJ/cm²
- Developing of PR using IPA (removal of un-exposed PR).

Note S4: Analysis of red pixel emission

From the typical pixel emission spectrum of Fig. 8, we have deduced the color coordinates. We found x = 0.383 and y = 0.154, which corresponds to the star point highlighted in the CIE color space chromaticity diagram of Fig S2. On this diagram, we have also indicated the color points (circle) corresponding to a bicolor light (blue + red) containing 1, 10 and 50% blue component, respectively. The star coordinates coincide with a blue-red light containing ~40% of blue light. This is fully consistent with Fig.6 where a 4 µm-thick red conversion layer is found to absorb 60% of blue light.
Fig. S2. Color gamut (star) of light emitted by the 4 µm-thick red-pixel of Fig. 8.