Localization of microparticles by a patterned drying process surface energy techniques

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Typical fabrication approaches involve either top-down or bottom-up methodologies. Top-down fabrication is widely used in microelectronics. In the macroscopic world, components are pre-fabricated and assembled to the final structure. This strategy can be applied to the micro-world, especially when heterogeneous integrations of different material systems are required. As one example, Micro-LED (µLED) display has the promise to become next-generation display technology due to their brightness, stability, and lower power consumption[1]. However, LED chips must be fabricated on separate wafers and transferred to the display substrate. Traditional pick-and-place and laser selective-release transfer techniques are limited by their throughput due to their serial nature. In comparison, fluidic self-assembly can enable parallel mass transfer of µLED chips. Such a process exploits electrostatic force, magnetic force, and dielectrophoretic forces[3] to trap the µLEDs in the pre-defined wells on the receiving substrate. However, such techniques are not effective for chips under 10 µm size. A new method is reported to confine size-matching particles in the inscribed nanovoid patterns exploiting the electrostatic energy and ionic entropy[4], but only works for submicron particles that can undergo Brownian motion.

To fill this gap, we propose a novel process to pattern hydrophobic and hydrophilic regions selectively. Upon solution evaporation, particles can be localized within the center region of the enclosed pattern, with the control of the surface tension and the geometry/size of the pattern. Fig 1(a) shows a honeycomb pattern with an edge length of 17 µm. The lighter area is silanized to render it lower surface energy. A fluidic chamber enclosing the substrate is designed for particle confinement[4] and the solution containing the particles was injected into the chamber. It was observed that the particles are successfully localized to the center of the pattern (Figure 1 (b)(d)). This may pave a way of the effective assembly of micron-sized microparticles, to guide and localize them to the right positions on a substrate.

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3. Chang, Wonjae, et al. "Concurrent self-assembly of RGB microLEDs for next-generation displays." *Nature* (2023)
4. Chen, Long, et al. "Size-selective sub-micrometer-particle confinement utilizing ionic entropy-directed trapping in inscribed nanovoid patterns." *ACS nano* 15.9(2021):14185-14192.

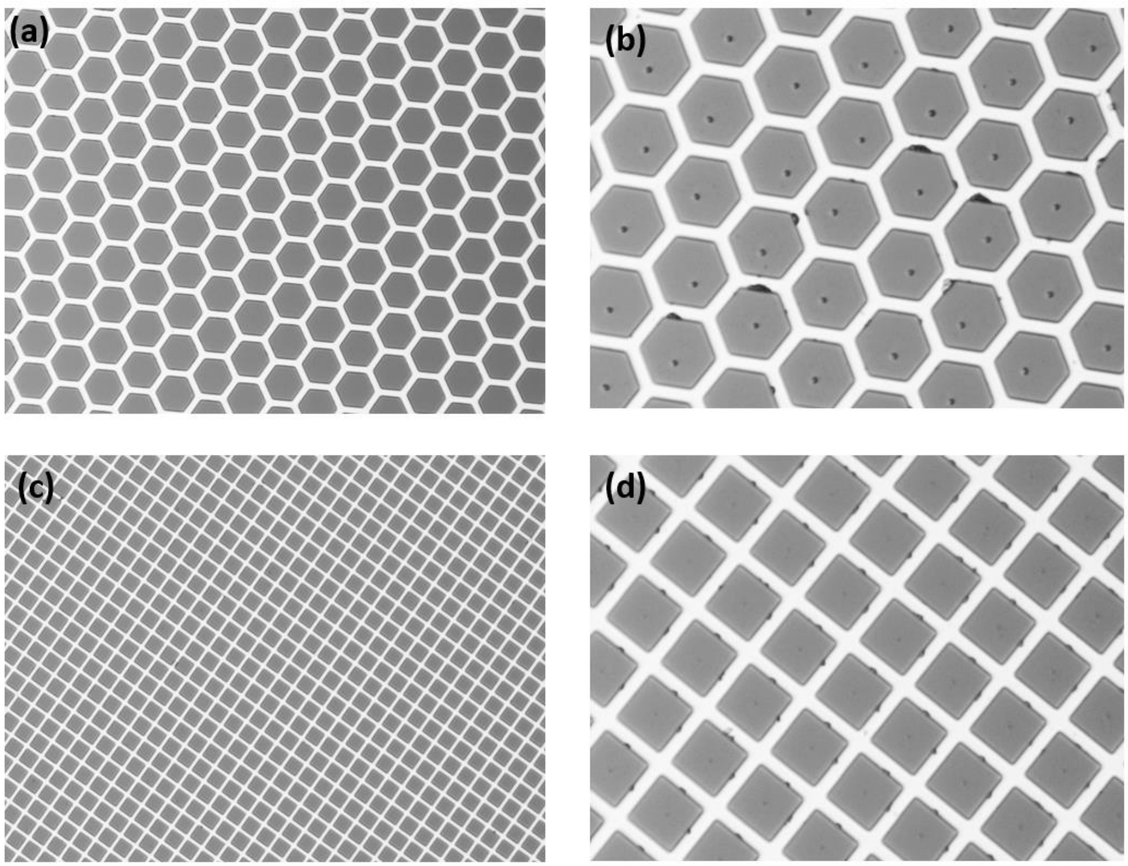

Figure 1: Microscope images of honeycomb pattern (a) and square pattern (c) before and (b)(d) after particle localization at the center of each pattern.