# Particle array micro-transfer using stretchable PVA template capable of varying periods and over 3D topography

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Top-down and bottom-up fabrication approaches play a crucial role in shaping modern micro/nanofabrication techniques. A precise transfer of patterned structures is required for applications in flexible electronics, bio-integrated devices, and semiconductor manufacturing. Pick-and-place[1] techniques have been used for μLED fabrication for a long time. An intriguing approach published in *Science* reported a reflow-driven transfer technique using sugar-based carriers. This method not only enables the transfer of particles over complex topographical structures, which are challenging for conventional fabrication processes, but also facilitates their placement over sharp tips and high-curvature surfaces.

However, the use of melted candies for microfabrication is prohibitive for most applications. Here we present an alternative material platform[3] utilizing polyvinyl alcohol (PVA) hydrogel that avoids contamination and offers better control, unlike molten sugar, which flows uncontrollably. The platform acts as a water-soluble transfer medium for 5 μm square particles patterned on silicon wafers. This approach leverages the stretchability of the hydrogel, which can be used to adjust the spacing of the particle arrays different from that which was originally fabricated, allowing it to conform to underlying 3D topography during transfer. The hydrogel-assisted technique utilizes a chemical dissolution-based release mechanism, minimizing mechanical stress and ensuring uniformity in pattern replication. The elasticity of the gel allows for controlled transformations of the original pattern when transferred between substrates.

This method offers certain advantages, including high selectivity, controllable adhesion, and compatibility with various substrate materials, making it a promising candidate for the transfer-based fabrication processes. Our current results show that PVA hydrogel achieves transfer efficiencies exceeding 90%; and the material and process can be further refined. By leveraging the tunable properties of hydrogel materials, this approach provides an effective and biocompatible alternative to conventional methods to expand the possibilities for positioning microscale components onto integrated substrate.

[1] Kahler, Julian, et al. "Pick-and-place silver sintering die attach of small-area chips." *IEEE transactions on components, packaging and manufacturing technology* 2.2 (2011): 199-207.
[2] Zabow, Gary. "Reflow transfer for conformal three-dimensional microprinting." *Science* 378.6622 (2022): 894-898.
[3] Paik, Jennie J., et al. "A Transparent Poly (vinyl alcohol) Ion-Conducting Organohydrogel for Skin-Based Strain-Sensing Applications." *Advanced Healthcare Materials* 12.22 (2023): 2300076

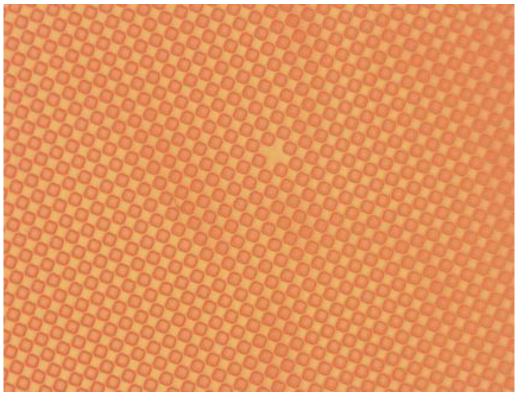

Figure 1: Particles on Wafer to be transferred

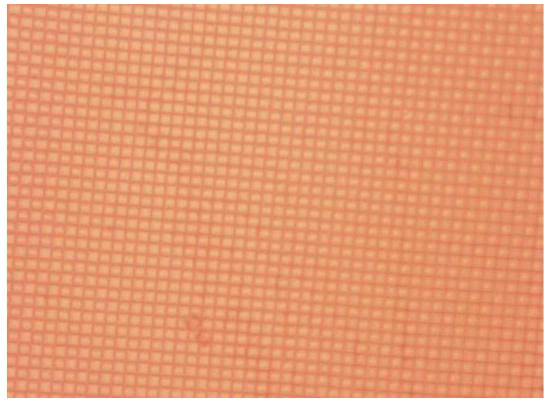

Figure 2: Particles deposited on a glass plate

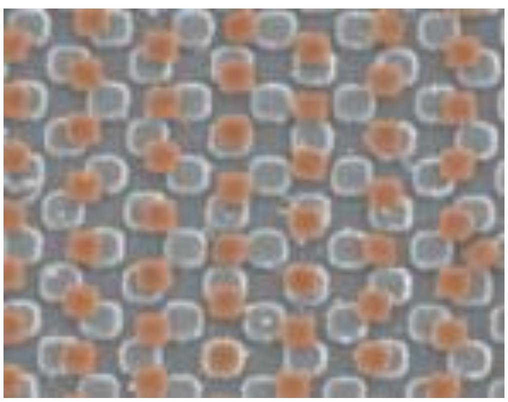

Figure 3: Micrograph showing the transferred particle array (orange colored) onto a grid array with doubled period of the original pattern as in Fig. 1

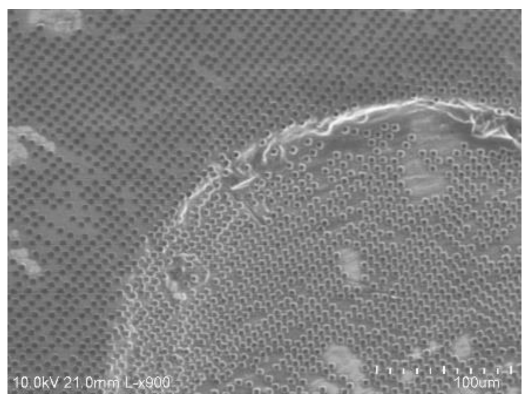


Figure 4: Particles transferred onto a surface with topography