

Two-dimensional positioning and patterning with DNA origami printer devices

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A principal focus of molecular nanotechnology is the construction of synthetic machinery that can manipulate matter at the nanoscale. We draw inspiration from a vision of atomically precise manufacture through molecular manipulation and from macroscopic machinery in combining multiple DNA origami linear positioning elements to construct nanoscale 2D positioning devices. Our first two-axis positioning mechanism comprises a moveable gantry, running on parallel rails, threading a mobile sleeve: this allows the sleeve to be positioned using a cartesian coordinate system. We have also developed a dial-like device in which the mobile sleeve is positioned on a radial rail, anchored at one end and moving along an arc segment at the other, allowing positioning in a polar coordinate system. These machines can be locked at programmed locations by the introduction of bridge strands and unlocked by release strands, allowing the sleeve to be repositioned in two dimensions. We introduce “write” functionality by decorating the canvas with an array of pixels, origami staple extensions capable of binding “ink” strands but inactivated by hybridization to blocker strands. The sleeve is functionalized with a strand-displacement catalyst that enables toehold-mediated strand exchange of a blocker with an ink strand. The sleeve now functions as a write-head, catalyzing deposition of ink strands at programmed positions. Ink strands carry DNA-PAINT docking sites, enabling the printed pattern to be imaged by TIRF microscopy.

This first-generation DNA origami printer further demonstrates the power of DNA nanotechnology to create nanoscale robotic components. Future printers could incorporate alternative modes of control and incorporate other modes of catalysts to find applications in surface manufacturing, biophysical studies and templated chemistry.

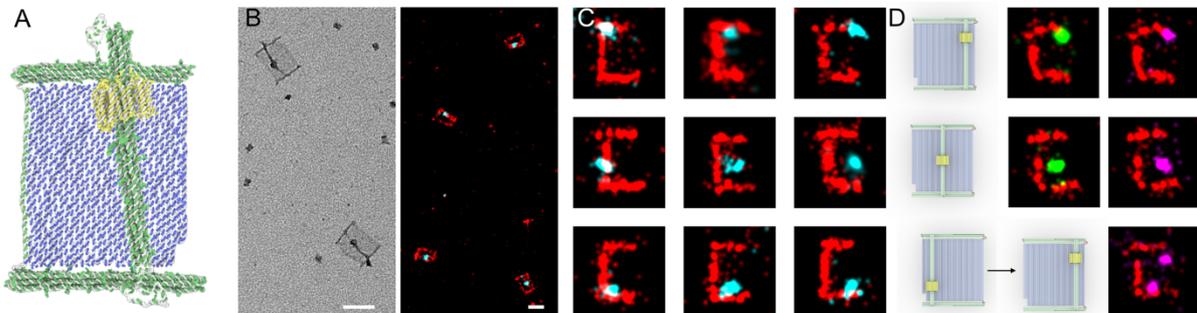


Figure 1. Printer device constructed from DNA, A) rendering or oxDNA simulation of device, constructed from three DNA origami components. B) TEM and DNA-PAINT image of assembled device, scale bars 100 nm. C) Example DNA-PAINT images of devices with sleeve in different positions. D) Programmed patterning of a DNA origami canvas through a strand displacement catalyst placed on the sleeve.