Title: A DNA molecular printer capable of programmable positioning and patterning in two dimensions

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Abstract: Nanoscale manipulation and patterning usually require costly and sensitive top-down techniques such as those used in scanning probe microscopies or in semiconductor lithography. DNA nanotechnology enables exploration of bottom-up fabrication and has previously been used to design self-assembling components capable of linear and rotary motion. In this work we combine three independently controllable DNA origami linear actuators to create a nanoscale robotic printer. The two-axis positioning mechanism comprises a moveable gantry, running on parallel rails, threading a mobile sleeve. We show that the device is capable of reversibly positioning a write head over a canvas through the addition of signaling oligonucleotides. We demonstrate "write" functionality by using the head to catalyse a local DNA strand-exchange reaction, selectively modifying pixels on a canvas. This work demonstrates the power of DNA nanotechnology for creating nanoscale robotic components and could find application in surface manufacturing, biophysical studies and templated chemistry.

One-Sentence Summary: A nanoscale machine made from DNA moves under external control and prints by selectively modifying pixels on a canvas.

Main Text:

INTRODUCTION

The vision of future technologies for atomically precise manufacturing is built on the assumption that materials and devices can be built from the bottom up by chemical reactions orchestrated by precise physical manipulation of atomic or molecular components (1,2). Picometer-scale control of motion can be achieved by macroscopic devices such as the piezo-electric actuators used in scanning probe manipulation (*3*, *4*). However, top-down nanopositioning technology is costly with very limited scalability (*5*). A principal focus of molecular nanotechnology is the construction of synthetic machinery that can manipulate matter at the nanoscale with the parallelism intrinsic to molecular systems. DNA nanotechnology is one of the most robust techniques for bottom-up assembly of complex nanostructures (*6*). Specifically, DNA origami, where a long DNA strand of (usually) biological origin is folded by hybridization to hundreds of short, synthetic oligonucleotides, can be used to create complex nanoscale objects with high resolution and yield *(7).* The origami technique has been used to produce a number of mechanical modules: mechanically interlocked slider-rails (*8–11*), rotary arms (*12*, *13*), hinges (*14*) and closable containers (*15*). DNA nanostructures have been engineered to respond to external stimuli including: signalling oligonucleotides by means of strand-exchange reactions (*15*, *16*), light (*17*), electric (*12*) and magnetic fields (*18*), changes in chemical environment (*19*, *20*) and the specific binding of target molecules (*21*, *22*).

In this Article, we combine three DNA origami linear actuators to construct a machine capable of two-dimensional positioning. Our designs draw inspiration from the vision of atomically precise manufacture through molecular manipulation (*1*) and from macroscopic printers. We demonstrate that the machine can be locked at programmed locations by the introduction of signalling oligonucleotides ("signal strands") and that this can be reversed by the introduction of release strands. We functionalize the moving carriage with a hybridization catalyst to create a write head and demonstrate programmed patterning of a molecular canvas using an all-DNA system.

RESULTS

Design and assembly of DNA positioning devices

A DNA origami nanostructure comprises a multi-kilobase scaffold hybridized to hundreds of synthetic staple strands, synthetic oligonucleotides that each bind two or more distinct domains of the scaffold to fold it into the desired structure of parallel helices held together by staple crossovers (*7*, *23*). The origami architecture enables fabrication of a wide range of structural forms by self-assembly, programmed through staple design. We have explored two architectures for our molecular printer, based on Cartesian and polar coordinate systems, shown in Fig. 1. The Cartesian printer is described in detail below; characterization of the polar device is presented in Supplementary Material.

A core constraint for DNA origami designs is the available scaffold material: typical scaffolds derived from the single-stranded genome of bacteriophage M13 limit most origami structures to around 8000 base-pairs. Larger structures can be assembled from multiple DNA origami components (*24*). We chose to assemble our machines from three components: a flat canvas; a bounding frame with sliding cross-rail (gantry); and a small origami sleeve (carriage) that moves along the rail (Fig. 1). The canvas is a rectangular 2D origami comprising 30 helices which run parallel to its long dimension. The frame comprises three 9-helix-bundle beams linked by flexible scaffold regions. Two of the beams are connected to the short ends of the canvas (the helix ends) by hybridization of complementary 8-nt extensions of frame and canvas staples (Fig. S1); this forms the base of the printer. The circular scaffold of the frame runs from one base beam to the other along one long edge of the canvas forming a 31st helix where it links to the canvas through ten 3-nt staple crossovers. The scaffold returns through a third 9-helix bundle, the rail, via single-stranded scaffold domains which form flexible linkers between rail and base beams. The sleeve is formed from a 22-helix origami sheet with three double-layer regions. Three 18-nt strands, protruding from its inside, are designed to load the sleeve onto three complementary protruding strands in the middle of the central rail (Fig. S2). The sleeve can be closed through the introduction of seam staple strands which link its two long edges, locking it around the rail. The canvas and frame are full-size origamis; the sleeve is constructed using a 1496-nucleotide (nt) scaffold restriction digest fragment.

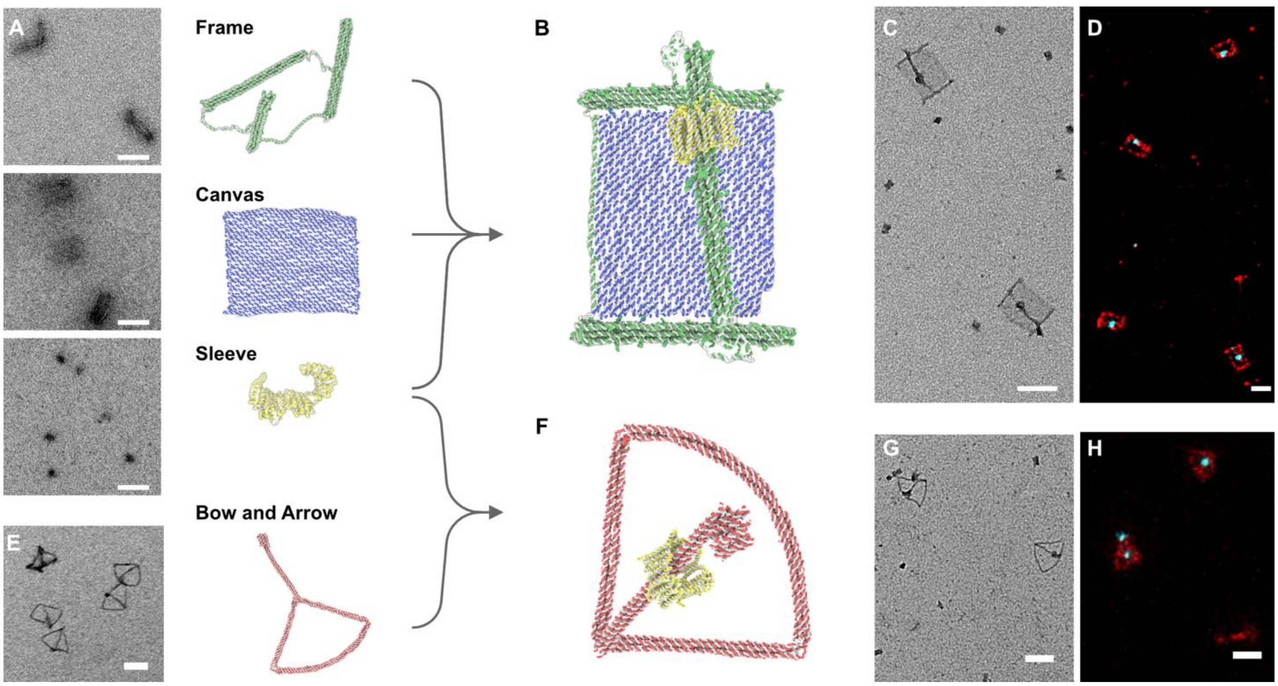

Fig. 1. DNA apparatus for two-dimensional positioning. (A) Three independent DNA origami components: frame, canvas and sleeve. **(B)** When mixed, the three components assemble to form a cartesian two-axis positioner: the cross rail moves along parallel side beams and spans the central canvas; the sleeve moves along the rail. Rendered images are snapshots of oxDNA (*29*, *30*) simulations. Assembled positioners are characterized by: **(C)** TEM (free sleeves are also visible); and **(D)** DNA-PAINT (frame and canvas red, sleeve blue). **(E-H)** A polar positioning device assembled from "bow and arrow" frame and the same sleeve. All scale bars 100 nm.

The three components were separately folded and purified by polyethylene glycol (PEG) precipitation (*25*) and characterized with transmission electron microscopy (TEM, Fig. 1A), and gel electrophoresis (Fig. S3). The machine was assembled by mixing and incubating all components for 72 h at 37°C followed by addition of seam strands to close the sleeve around the rail. Invader strands were then added to release the loading strands locking the sleeve to the rail, freeing it to move along the rail. Poly-thymine functionalized magnetic beads were used to bind poly-adenine extensions to two staples of the sleeve. After closing and releasing the sleeve, the assembled devices were incubated with the beads which were then washed to remove assemblies (frames and canvases) lacking sleeves. Bound structures were released from the beads by incubation with a poly-thymine invader strand. This procedure selected complete devices incorporating frame, canvas and sleeve, also free sleeves (Fig. 1C). Devices were immobilized on streptavidin-coated glass cover slips within flow cells via biotin covalently attached to staples at the base of the frame beams; during subsequent processing free sleeves were washed away. Immobilized devices were imaged by sub-diffraction-limit optical microscopy using DNA-PAINT (*26*), to localize fluorescent oligonucleotides transiently bound to single-stranded anchorages on the origami structure. PAINT docking sites are positioned on the three beams of the frame and in two lines along the canvas (Fig. 1D). PAINT docking sites with a different base sequence allow subsequent measurement of the sleeve position by replacing the imager strand solution (*27*).

In initial experiments the eight protrusions linking the frame to the short edges of the canvas formed weaker links, 6 base-pairs rather than 8. Gel electrophoresis and TEM of frame-canvas mixtures confirmed correct insertion of the canvas in the frame but at sub-nanomolar concentrations (after gel purification) the yield of complete structures was low. When purified devices were bound to a glass surface and imaged with DNA-PAINT most frames no longer had a canvas attached. However, many of the base beams were immobilized in a parallel configuration indicating that a canvas had been present when the structure bound the surface (Fig. S4). Transient assembly of canvas and frame may be useful for positioning devices such that the sleeve has free access to the surface.

Programmable positioning in two dimensions

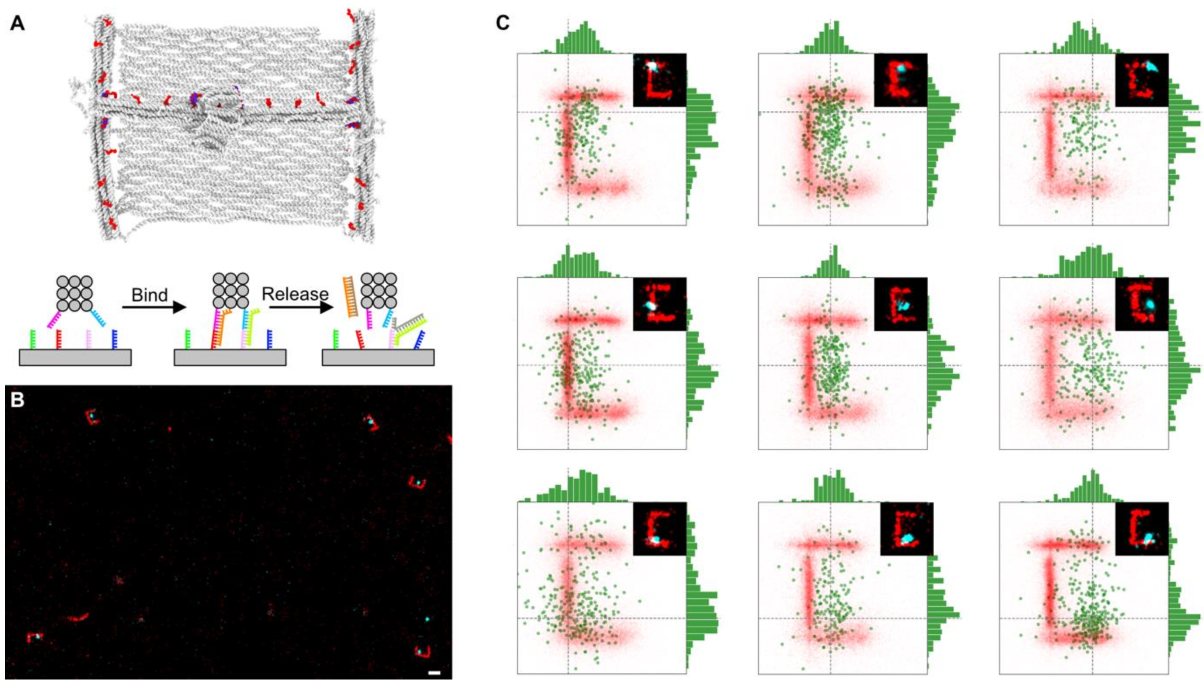

Fig. 2. Controlled 2D positioning. (A) By selectively linking unique address strands on the base beams, rail and sleeve, the write head can be positioned in 2D. The binding is reversible through toehold-mediated strand displacement. **(B)** DNA-PAINT image of devices (frame and canvas in red) with sleeve (blue) positioned in the centre. Scale bar 100 nm. **(C)** Sleeve positions from aligned DNA-PAINT images of devices with write head positioned in nine different locations: each green point corresponds to the mean position of the sleeve of one device. Insets show examples of DNA-PAINT images. Plot windows 200 × 200 nm.m

In order to control the position of the sleeve in two dimensions, each of the two base beams and the sliding rail of the frame is decorated with a track comprising nine unique single-stranded address strands as origami staple extensions. Address strands are also incorporated at the ends of the rail beams and the ends of the sleeve (Fig. 2A and Fig. S5). By adding two bridging strands that link sleeve and rail addresses, we can bind the sleeve to a programmed position between two address sites (straddling an intermediate site); using separate pairs of bridging strands, we can similarly position the rail between any pair of adjacent address sites along the base beams. Sleeve and rail can thus each be locked in seven and eight positions respectively giving a grid of 56 positions, separated by ~10 nm, of the sleeve over the canvas.

In order to be able to add and remove binding strands we performed positioning experiments using structures immobilized in glass-bottom flow chambers. We removed one line of DNA-PAINT docking sites on the canvas and the lines on the rail arm to create a "C"-shaped pattern that allows us to determine the position of the sleeve in relation to the frame and canvas. A complicating factor is that the sleeve can unthread the rail and move onto either of the single-stranded scaffold linkers connecting the rail to the base beams: if the beam is then locked to the base, the sleeve will not be able to move back onto the rail. The sleeve must therefore be locked onto the rail before the rail is locked to the base. In early positioning experiments most sleeves were trapped in a linker region at the top or bottom of the frame. We suspected that electrostatic repulsion between sleeve and rail played a role in preventing the sleeve from threading onto the rail, so increased the concentration of divalent cations in the buffer used for positioning (Fig. S6). At 25 mM $MgCl_2$ we could see the sleeve successfully threading the rail. Fig. 2 shows the results of tests in which we used three positions each for sleeve and rail, that is 9 possible write head positions. Using DNA-PAINT we are able to capture wide field images containing hundreds of devices. We selected devices where a sleeve is present (85% yield) and used a script to fit fluorescence localizations corresponding to docking sites on the frame and canvas to rotate and align data from multiple structures to create averaged images (Fig. S7). 51 % of sleeves were localized in their programmed positions (Figs S8-S17). We also tested positioning based on the polar coordinate system of the bow and arrow device (Fig. S18).

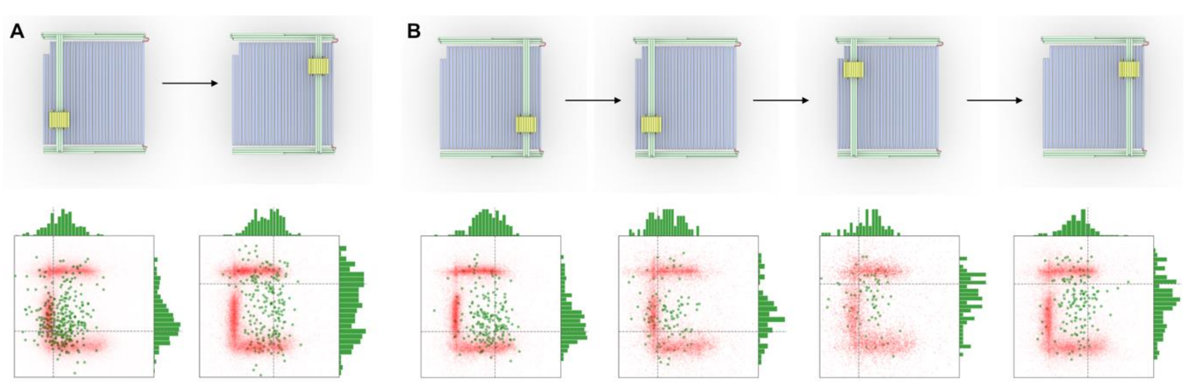

Fig. 3. Programmed 2D motion of sleeve. Top: schematic illustration of sleeve position, bottom: corresponding positions measured from aligned DNA-PAINT images of devices. Each green point corresponds to the mean position of the sleeve of one device. Plot windows are 200 × 200 nm. **(A)** Diagonal motion through release and rebinding of both sleeve and rail. **(B)** Four consecutive steps of the sleeve.

In order to be able to re-position the write head, all bridging strands incorporate a 6-nt overhang to enable their removal by toehold-mediated strand displacement (*28*) on addition of a completely complementary removal strand. Since we have independent control of the two axes of motion, we can choose to release just one axis (sleeve or rail) or both at the same time. We attempted to release and reposition the sleeve while keeping the rail locked, thus ensuring that the sleeve remained threaded on the rail. This strategy had low yield: many sleeves remained in their original positions, probably due to non-specific interactions between canvas and sleeve when the rail is locked down (Fig. S19). By moving the sleeve after releasing the rail, giving it enough clearance to move freely, we were able to reposition the sleeve in two dimensions (Fig. 3A). We then positioned the same device four times sequentially to move between the four corners of the canvas (Fig. 3B) and were able to see the corresponding movement of the sleeve.

Programmed patterning through DNA strand-displacement reactions

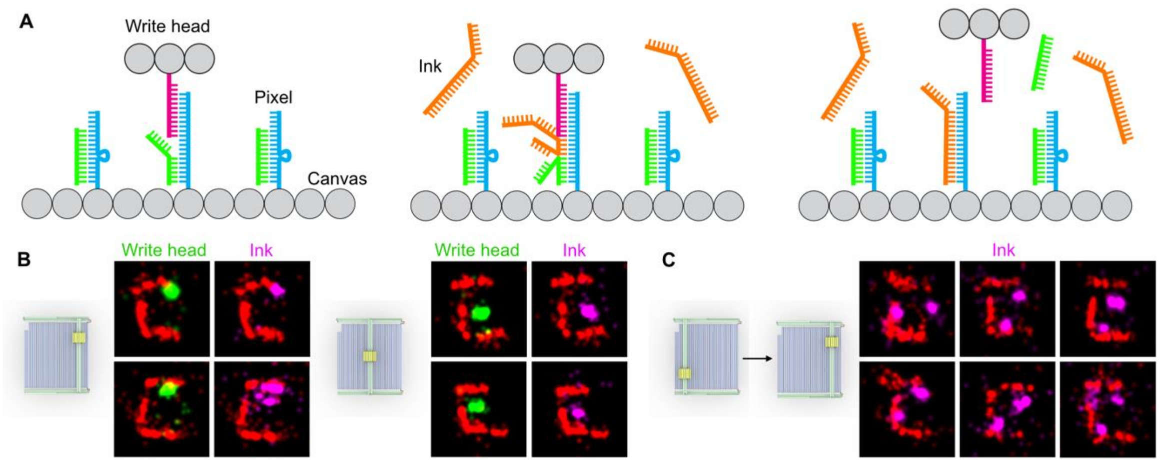

Fig. 4. Programmed printing. (A) Printing by means of a toehold catalyst, carried by the write head, which enables local incorporation of an ink strand (orange) through a strand-displacement reaction. **(B)** Examples of printing a single dot, in the top right corner and centre of the canvas: slider localization in green and ink localization in magenta. **(C)** Examples of sequential printing of two dots in diagonally opposite corners of the canvas on the same device. The ink is imaged after the second printing step. All data cropped in 200 nm boxes.

Our goal was to use the 2D positioning system as a prototype printer by adding write-head functionality to the sleeve. We implemented an all-DNA surface patterning system. We functionalized the sleeve with a protruding strand which acts as a catalyst for toehold-mediated strand exchange (*28*). The top of the canvas was decorated with 56 pixels spaced 10 nm apart comprising identical extensions of 56 staples (Fig. S20). Each pixel strand was initially hybridized to a blocking strand, leaving a 6-nt single-stranded toehold exposed (Fig. 4A). The write-head catalyst is capable of binding to this toehold and partially displacing the blocking strand to reveal a second toehold on the pixel strand which is initially hidden in a bulge in the pixel strand-blocker duplex. The ink strand is fully complementary to the revealed toehold and to the flanking domains of the pixel strand covered by the blocker: hybridization of the ink strand to the revealed toehold initiates its displacement of both blocker and catalyst (*28*). The initial site-specific interaction of the catalyst with the pixel-blocker duplex, which is transient and reversible, thus catalyses complete removal of the blocker by an ink strand. By using the write head to catalyse addition of functionalized ink strands at selected sites, the canvas could be decorated by, for example, fluorophores, nanoparticles or proteins. Here, in order to enable the written pattern to be imaged, the ink strand contained a DNA-PAINT docking domain.

The pixel-modifying strand-displacement reaction was characterized by adding fluorophore-labelled ink strands, with or without free strand-exchange catalysts, to pixel-decorated canvases in solution. Canvases were then separated from ink by gel electrophoresis and the incorporation of the ink strand in the canvas monitored by measuring fluorescence from the corresponding gel band. We observed a low background incorporation of ink when no catalyst was present, and up to 60 times increase in incorporation with increasing catalyst concentration (Fig. S21). When complete devices incorporating the pixelated canvas were immobilized in a flow chamber the rate of leak reaction leading to background patterning on our canvases was higher than expected from the solution-based controls (Fig. S22). It was nevertheless possible to distinguish patterns with two sites on the canvas selectively modified by sequential positioning of the write head (Fig. 4C).

DISCUSSION

Positioning precision is difficult to estimate from PAINT images in which imprecision in device operation is convolved with uncertainty in PAINT localization. The Exchange-PAINT (*27*) measurements presented here rely on localization of the frame in one imaging step to provide a reference coordinate system to assess write-head and ink positioning recorded in later steps. Microscope drift during exchange of the imaging strand and buffer, and during imaging, is corrected using gold nanoparticles as fiducial markers, but errors in the alignment of sequentially recorded images of frame, write head and ink are greater than imaging uncertainty achievable using a single PAINT channel. Rotation and alignment of data from multiple devices, and structural variations resulting from the flexibility of the canvas and of its linkages to the two base beams, introduce further distortion. A better way to assess device operation would be to use the 10 nm pattern of modified pixels to provide its own coordinate system to measure positioning errors; this will require optimization the writing operation to enable modification of multiple pixels.

We used coarse-grained molecular dynamics simulations (*29*,*30*) to simulate the device when locked into position (Fig. S23) and found that play in the device is anisotropic, around 5 nm along the rail axis and 2.5 nm orthogonal to it. The play of the rail arm is mostly along its axis, attributable to the linkage to the base frame. Motion of the sleeve relative to the rail is more isotropic and is associated with the relatively large clearance between sleeve and rail.

We can draw several mechanical design lessons. While the assembled sleeve remained topologically locked to the frame, its control was complicated by the omission of bulky stoppers to keep it from sliding off the rail onto flexible linker domains. Future designs could incorporate stoppers made from DNA tiles (*31*) to retain the sleeve while conserving scaffold material. Stoppers may increase the speed of repositioning by limiting motion of the slider. We made our device as large as possible, given the number of origami components, to enable reliable characterization by optical microscopy: a smaller device incorporating more rigid DNA origami beams might achieve higher precision on a smaller canvas. Precision could also be enhanced by reducing the flexibility of linkages between components and by experimental optimization of sleeve and rail to minimize play while ensuring that the sleeve loads effectively and moves freely. The pixel writing operation could be more tightly localized by moving the toehold engaged by the strand-exchange catalyst to the other end of the pixel duplex, next to the origami substrate.

The printer is a Brownian ratchet (32) that relies on diffusion to explore possible binding positions and hybridization of signalling oligonucleotides to alternately release components and lock them in place. There is considerable scope for optimization of the cycle time. The limiting step is likely to be toehold-mediated strand displacement, used for release. The rate constant for these reactions could be increased to ~10^6 $M^{-1}s^{-1}$ by increasing toehold lengths (33) potentially decreasing repositioning times to a few seconds for typical micromolar strand concentrations if interfaced to a microfluidic signal delivery system. Higher signal concentrations could be explored. Nanostructures actuated by light (17), electric (12) or magnetic (18) fields can respond more rapidly to external signals, but it would be difficult to achieve the same fine control of positioning that can be achieved by use of information-bearing signalling molecules to encode positioning instructions.

Characterization of the printing on the canvas by means of the write head was limited by a background of off-target ink incorporation. This could be improved by optimization or redesign of the strand-displacement reaction (*34*, *35*) to reduce leakage or by use of the head to produce a localized covalent reaction between colocalized reactants (*36*–*38*) or by positioning a catalyst, sensitizer (*39*) or enzyme (*40*, *41*). Direct modification of the surface to which the device is bound could be achieved using a porous wireframe canvas (*42*) or by removing the canvas after deposition.

Externally controlled motion at the nanoscale is an important goal for molecular nanotechnology. In this work, we have drawn inspiration from macroscale engineering by coupling multiple linear positioning elements to create a DNA nanomanipulator capable of programmable 2D motion. Our devices exemplify characteristic strengths of DNA nanotechnology - programmable assembly and orthogonal control of structural transitions through sequence-specific strand displacement reactions to steer motion. We show that multiple DNA origami positioning elements can be combined and independently controlled. We also show that the positioner is capable of acting as a molecular printer by using the write head to catalyse local incorporation of a fluorescent label. Although these first-generation devices are slow and limited in function, their low cost, extreme scalability through parallelization and compatibility with aqueous conditions make such devices attractive for development towards applications in nanoscale additive manufacturing.

MATERIALS AND METHODS

DNA nanostructure design

Individual nanostructure components were designed using cadnano (*43*) on a square lattice with deletions every 42 bp for twist correction. The canvas and frame were designed around the 8064-nt p8064 scaffold; the sleeve was designed around a 1496-nt restriction digest fragment from the same scaffold. The canvas was designed around 30 parallel helices threaded by the scaffold. In the frame, the scaffold is divided between top and bottom base-beams, rail beam, and three linker regions joining them. The linker joining the two base beams runs parallel to a helix at the edge of the canvas and is joined to it by ten staple extensions that cross over between scaffolds to form 3-basepair duplexes. The two linkers between the rail beam and base beams are each 237 nt in length. In order to maximize the flexibility in these regions we used mfold (*44*) to calculate secondary-structure free energies for all pairs of 237-nt scaffold domains separated by 2767 nt (the length of scaffold in the rail) and selected the pair for which the secondary structure free energy of the highest member of the pair is minimal. To further reduce the risk of strong secondary structure in the linkers we added 16-nt staples every 32 nt to make them partially double stranded. The sleeve was designed as a flat 22-helix sheet with three 4-helix double-layer regions.

After initial design in cadnano, all structures were imported to a single vhelix (*45*) file to design the inter-structure linkages. Helices of the base beams and canvas are orthogonal. The canvas is connected to each base rail through staple links from the rail to the ends of four canvas helices. Links were initially designed by assuming a helix to helix spacing in the canvas of 3 nm (*46*); designs were simulated in oxDNA and the linkages manually reconfigured to minimize strain between frame and canvas. All scaffold and staple sequences, as well as the sequences of protruding staple extensions used for sleeve loading, positioning and DNA PAINT docking sites, were assigned in vhelix.

DNA nanostructure assembly

Scaffold strands (p8064) were purchased from tilibit nanosystems GmbH. Staple strands were purchased from Integrated DNA Technologies, Inc. The linear 1496-nt scaffold fragment was prepared by: mixing 50 µL of scaffold (100 nM) with a 20× excess of 20-nt and 30-nt oligonucleotides, complementary to the scaffold in the regions to be digested, in NEB CutSmart® buffer; 90-minute incubation with 5 µL (20 U μL^{-1}) XmnI restriction enzyme (NEB) at 37 °C; 90-minute incubation at 60 °C with 5 µL (10 U μL^{-1}) BsaBI (NEB); 20-minute incubation at 80 °C to heat-inactivate the enzymes. All structures were folded with a scaffold concentration of 5 nM and a staple concentration of 50 nM (each) in TE buffer with 10 mM $MgCl_2$. The folding protocol started with a 5-minute incubation at 80 °C followed by a rapid decrease to 60 °C over 20 minutes and slow cooling to 20 °C over 14h.

After folding, structures were purified from excess staple strands using PEG precipitation (*25*). Separately, 300 µL of canvas and frame sample and 450 µL of sleeve sample were each diluted to 500 µL in 1.5 mL centrifuge tubes using folding buffer; 5 µL of 1 M $MgCl_2$ were added to bring the $MgCl_2$ concentration up to 20 mM. After this, 500 µL of PEG precipitation mixture was added (1× TE, 10 mM $MgCl_2$, 15 % W/V PEG-8000, 500 mM NaCl). Samples were centrifuged at 20,000g for 25 minutes and the supernatant immediately removed. The pellet was resuspended in folding buffer (supplemented to 20 mM $MgCl_2$) and the process repeated. After removing the supernatant, the frame was resuspended in 225 µL of folding buffer with 10 mM $MgCl_2$, the sleeve was resuspended in 300 µL folding buffer with 10 mM $MgCl_2$ and the canvas was resuspended in 225 µL folding buffer with the magnesium concentration reduced to 5 mM $MgCl_2$. After adding the buffers, the samples were placed in a 37 °C water bath for 1 h to resuspend the pellet. When a canvas with print pixels was used, a blocker strand (50× excess w.r.t. pixel strands) was then added to block the pixels for printing and the sample incubated for a further 1h in the water bath.

Devices were assembled by mixing the frame, canvas and sleeve, each at a concentration of approx. 5 nM, in a 1:1:1.38 ratio, adding $MgCl_2$ to bring the concentration up to 12 mM, and incubating at 37 °C for 72 h to link the structures. The sleeve was then closed around the rail by adding a 4× excess of seam strands (3.96 µL at 1 µM each added to 660 µL of device mixture) and incubating at 37 °C for 24 h. The sleeve was then released from the rail by addition of 2.25 µL invader strands (33.3 µM each) to 640 µL of device mixture and incubation at 37 °C for 3 h. In order to enrich devices with a sleeve, 150 µL of poly-T magnetic beads (Dynabeads™ Oligo(dT)25, Thermo Scientific) at the supplied concentration was placed on a magnetic rack and the supernatant removed. The device sample added to the beads and the mixture put on a rotary mixer overnight at room temperature to capture device structures on the beads. The beads were then washed four times with 400 µL of folding buffer and resuspended in 150 µL of folding buffer. To release the structures from the beads, 4 µL of 100 µM release invaders were added and the samples incubated 3h in room temperature on a rotary mixer. The final sample was split into 10 µL aliquots for further experiments.

Transmission electron microscopy

Samples were diluted to approx. 1 nM and deposited on glow-discharged formvar-supported carbon-coated Cu300 TEM grids (Agar Scientific). A pseudo-positive staining method was used whereby the grids were incubated with the sample for two minutes, blotted with filter paper, then incubated for 3 seconds on a drop of water. This was followed by a 20-second incubation on a 20 µL drop of 2 % uranyl acetate. After blotting, the sample was placed for 3 seconds on another drop of water followed by filter blotting and air drying. Samples were images in a FEI Tecnai T12 microscope (120 kV) and images recorded on a 16 megapixel Gatan OneView CMOS camera.

Device positioning

A 10 µL aliquot of bead-purified structures was diluted with 40 µL of buffer B+ (*26*) (10 mM $MgCl_2$, 5 mM Tris, 1 mM EDTA and 0.05 % Tween 20). An ibidi sticky-Slide VI 0.4 (ibidi GmbH) was attached to an oven-baked #1.5 glass coverslip to form flow channels. The flow channels include reservoirs at the top and bottom that are used as inlet and outlet: buffer replacement is performed by adding new solutions to one reservoir and removing buffer from the other by direct pipetting; when the reservoirs are emptied the flow channel itself remains filled with buffer. To one channel, 80 µL of biotinylated BSA solution (1 mg mL^{-1} biotinylated BSA (Merck Life Science) in Buffer A+ (10 mm Tris-HCl, 100 mm NaCl, and 0.05% vol/vol Tween 20 at pH 8.0)) was added and incubated for 5 minutes. The channel was then emptied and washed with 180 µL of buffer A+ followed by addition of 40 µL streptavidin solution (0.5 mg mL^{-1} streptavidin (ThermoFisher scientific) in Buffer A+). The streptavidin solution was incubated for 5 minutes, then removed and replaced followed by a further 5-minute incubation. The channel was again washed with 180 µL of buffer A+. A 50 µL sample of gold nanoparticles (60 nm, BBI Solutions) was diluted in 50 µL of buffer A+, and 50 µL of this was immediately added to the channel and incubated for 2 minutes. The channel was then washed with 180 µL of buffer A+ and 180 µL of buffer B+, followed by the addition of the diluted DNA sample. The chamber slide was capped with the included lid and incubated on an orbital shaker at room temperature for 60 minutes, then washed with 180 µL of B+ buffer to remove non-bound devices.

To position the sleeve on the rail a linker mixture was prepared with 0.5 nM each of the address linkers in buffer B+ with 25 mM $MgCl_2$. To make sure the devices were equilibrated in this solution, 100 µL was first added to the inlet reservoir and removed from the outlet reservoir followed by the addition of a further 100 µL. The flow channels were then plugged and the slide placed in a 37 °C incubator overnight, followed by double washing with 180 µL of buffer B+. To position the rail on the frame base, address strand mixtures were prepared with 5 nM each of the linkers in buffer B+ with 25 mM $MgCl_2$. Again, 100 µL of this mixture was added and removed followed by the addition of a further 100 µL to equilibrate the devices in the buffer. The slide was closed and incubated at 37 °C for 1 h.

The sleeve and rail can be released separately or at the same time. A mixture of 5 µM each of the release strands was prepared in buffer B+. The channel was equilibrated to the invader mixture through adding and removing 100 µL followed by the addition of 100 µL. The slide was closed using the included lid and incubated at 37 °C for 1 h.

The canvas was patterned by diluting an ink strand functionalized with a R3 DNA-PAINT docking site in buffer B+ with 30 mM $MgCl_2$. This mixture was added to the channel by first adding and removing 100 µL and then adding a further 100 µL. All patterning experiments were performed by incubating the mixture in the channel for 10 minutes at room temperature followed by washing 3 times with 180 µL of buffer B+. The quantity of ink needed was titrated by locking the device in place and adding successively higher concentrations of ink, first 1 nM then 5 nM and 10 nM. DNA-PAINT was used to image frame, sleeve and ink after each addition. For patterning in multiple positions, a solution with 10 nM ink was added for 10 minutes after the sleeve had been positioned.

DNA-PAINT microscopy

DNA-PAINT imager strands functionalized with Cy3B were purchased from Eurofins Genomics. Imaging buffer was prepared by adding Trolox (0.25 mg mL^{-1}, MP Biochemicals), protocatechuic acid (PCA) (0.385 mg mL^{-1}, MP Biochemicals) and protocatechuate-3,4-dioxygenase (PCD) (7 µg mL^{-1}, MP Biochemicals) to buffer B+. An Oxford Nanoimager S microscope was used in TIRF mode to image the samples with a 532 nm laser. 100 µL of imager strands were added to the slide channel: imaging strand P1 (CTAGATGTAT-CY3B) was used at 4 nM to image the frame and canvas; R1(AGGAGGA-CY3B) was used at 1 nM to image the sleeve; and R3 (GAGAGAG-CY3B) was used at 2 nM to image patterning. A 200 ms exposure time was used, with 12 000 / 5 000 / 8 000 frames recorded for the frame/sleeve/patterning. Between imaging rounds, the channel was washed twice with 180 µL of buffer B+. The data was reconstructed using Picasso (*26*) with the 'lq' fit method and a gradient of 5000. Drift correction was performed using the redundant cross correlation (RCC) with a segment size of 200 frames. Localizations were linked with a max distance of 1 pixel and a maximum of 1 transient dark frame.

Supplementary Materials

Figs S1-S22

Tables S1-S6

Analysis code (ZIP archive)

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Data and materials availability: All data needed to evaluate the conclusions in the paper are present in the paper or the Supplementary Materials. Raw microscopy data is available upon request.

Supplementary material for

Two-dimensional positioning and pattering with a DNA molecular printer

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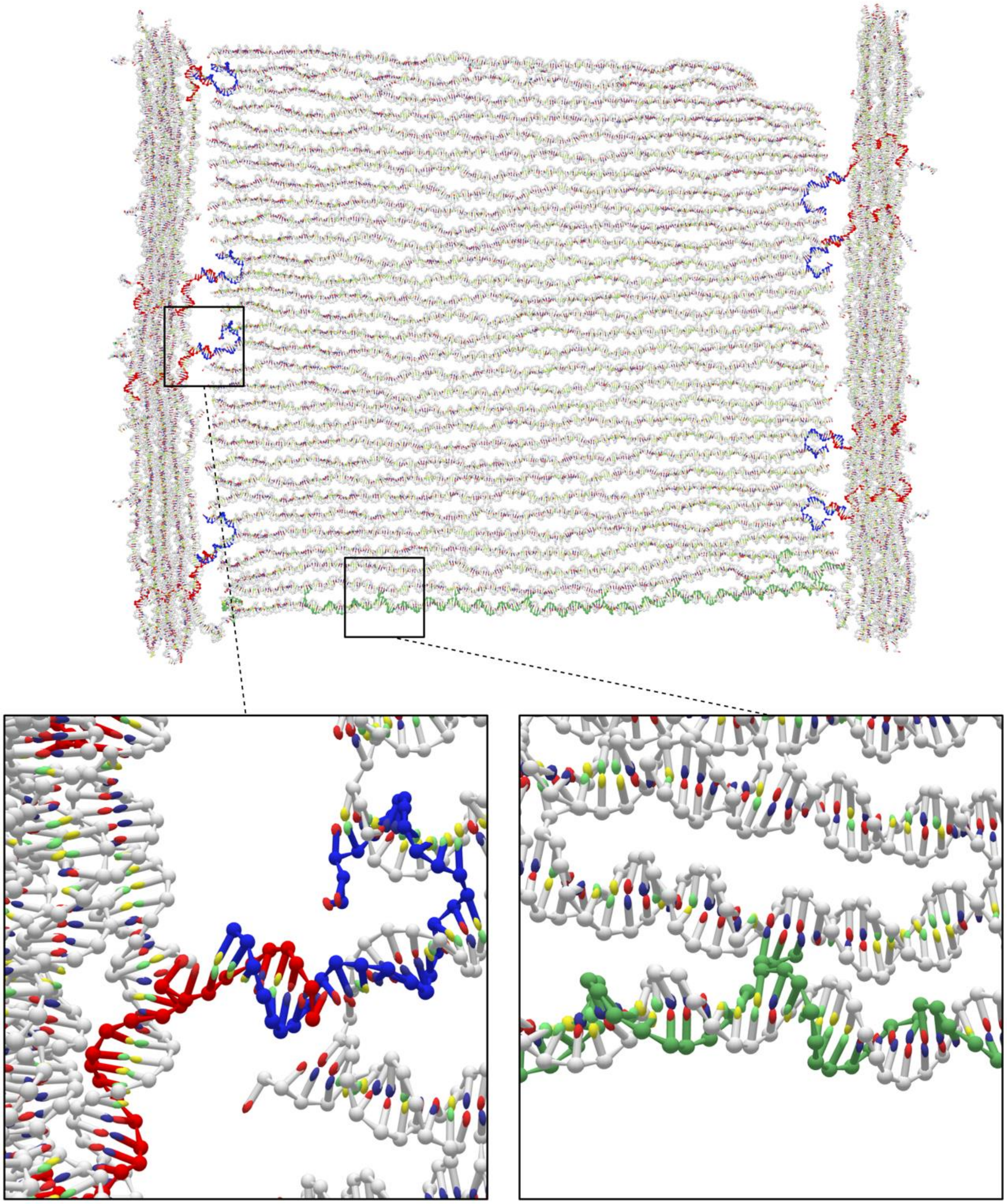
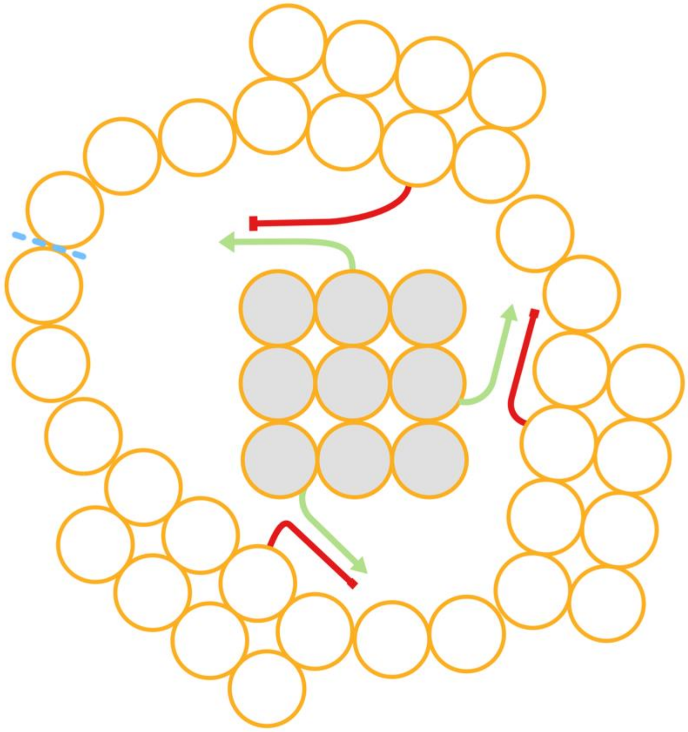
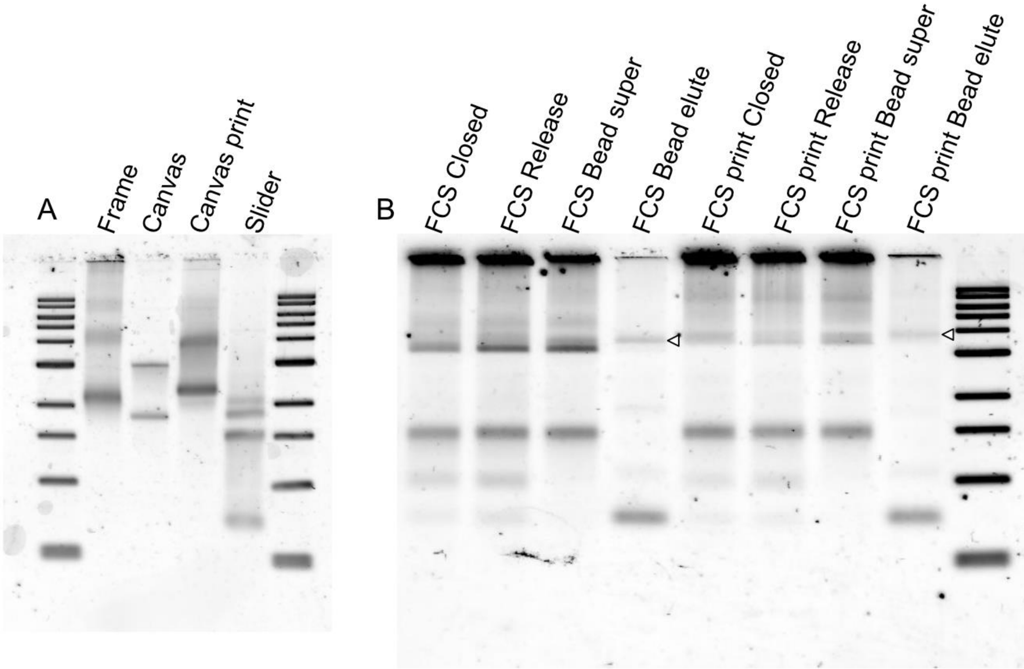


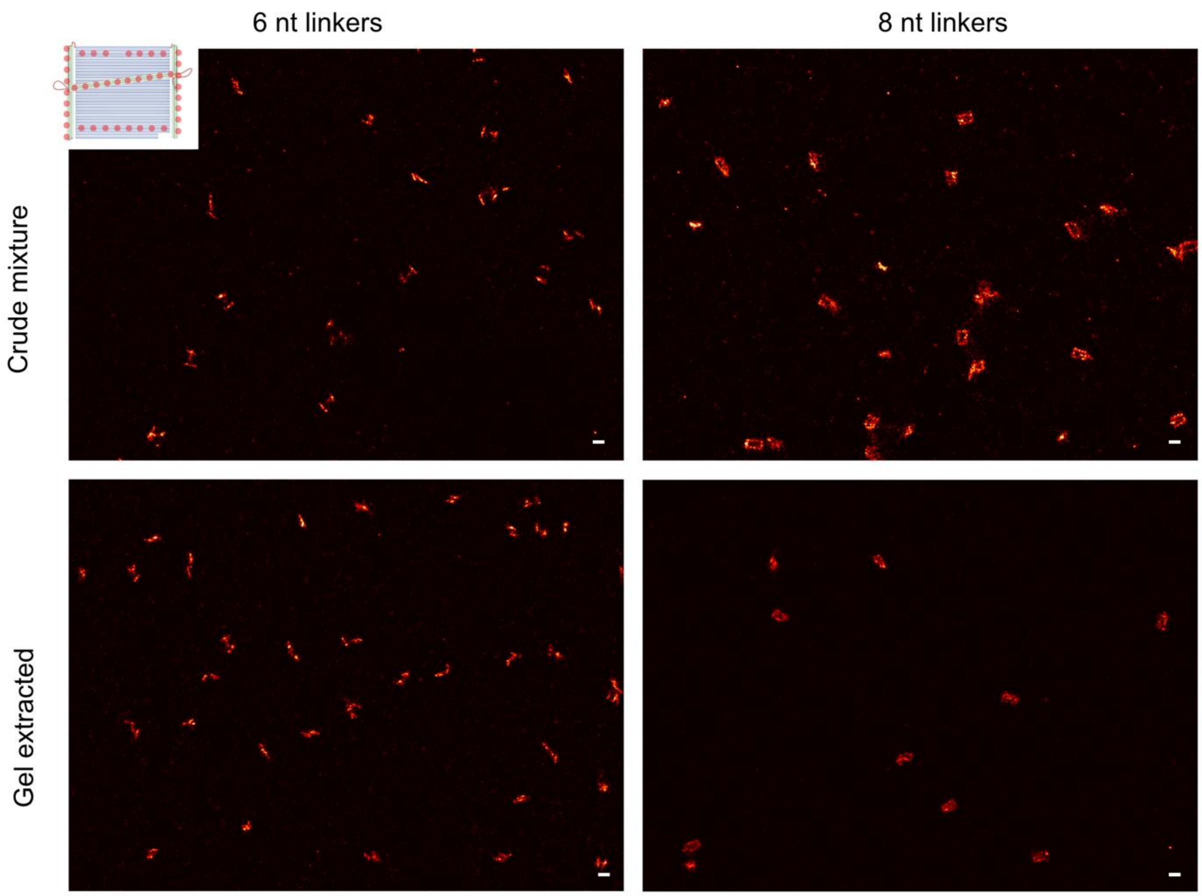
Supplementary figure 1. Connections between base frame and canvas. Rendering *(29,30)* of snapshot of oxDNA simulation; the rail arm and linkers are removed for ease of view. The canvas is connected to the frame on three edges. Hybridization of staple extensions protruding from the side of the base-beams and helix ends along the short edges of the canvas (red and blue) form unique 8-bp double-stranded links. A scaffold domain connecting the two base beams runs parallel to a long edge of the canvas: staple extensions make ten 3-bp links (green).



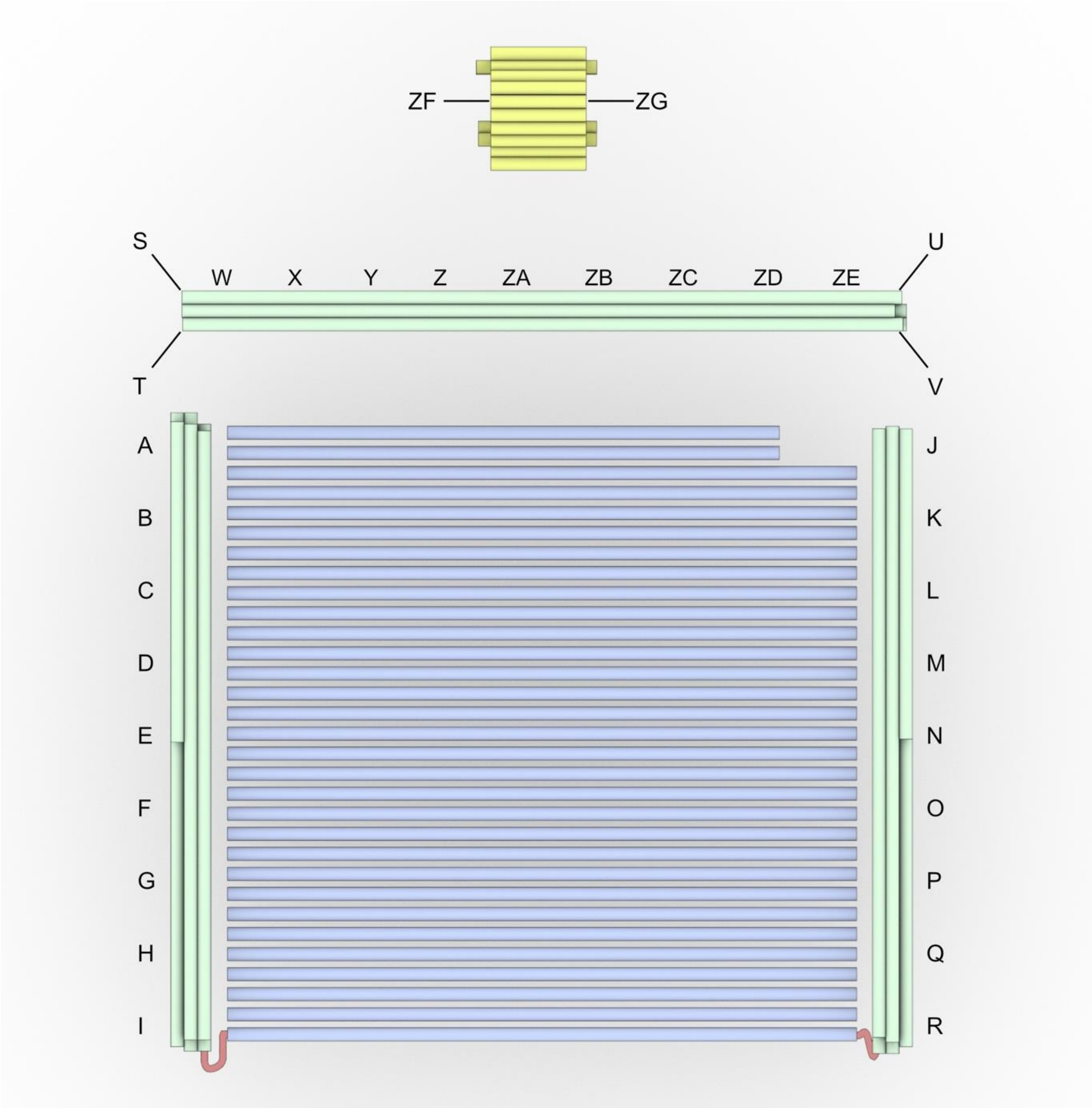
Supplementary figure 2. Schematic of sleeve design. The circumference of the sleeve comprises 22 parallel helices which form double layers in three regions, each four helices wide. Three 18-nt ssDNA protrusions on its inside are complementary to three protrusions on the rail arm. This linkage is used to load the sleeve on the rail and can be reversed through the addition of invader strands to release the sleeve. The sleeve is designed to close around the rail when seam staples are added to link helices on either side of the seam (marked by a blue dashed line).



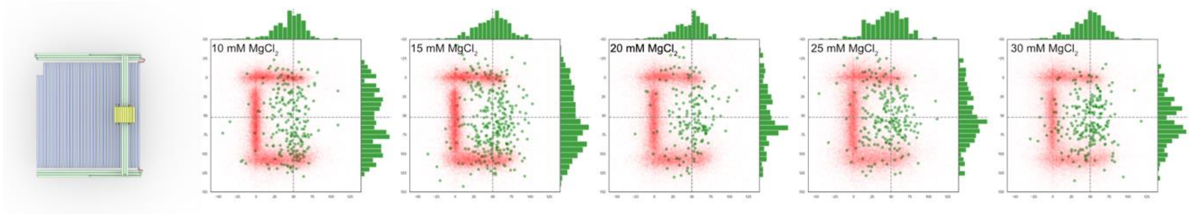
Supplementary figure 3. Analysis by agarose gel electrophoresis of components and assembled devices. Both gels are 2% agarose in 1× TAE with 10 mM $MgCl_2$, run at 80V for 150 minutes and post-stained with SYBR® Gold. A) Device components after folding and purification through PEG precipitation. B) Sequentially assembled and purified devices with and without print pixels. From left: devices after closing sleeve around rail, devices after closing and then releasing sleeve from rail, sample recovered after addition of poly-thymine magnetic bead (non-bound supernatant), sample recovered after washing beads and using toehold exchange to recover bound sample from beads. FCS = frame + canvas + sleeve. Arrows point to device band.



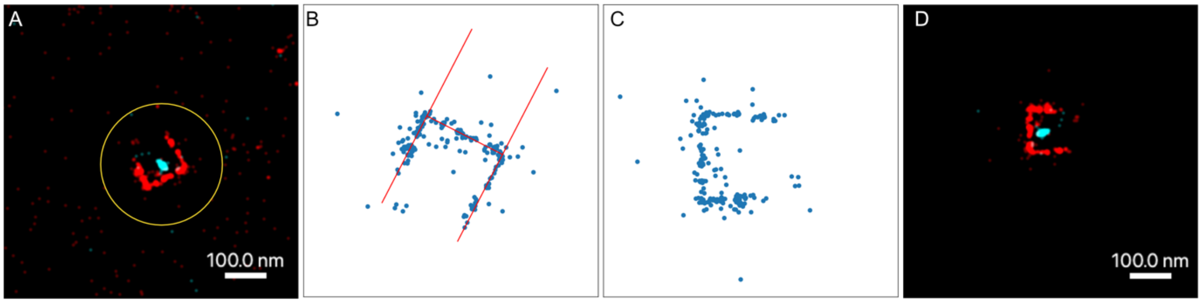
Supplementary figure 4. DNA-PAINT Images of devices with 6- and 8-nt linkages. The linkages between the bottom beams and the top and bottom of the canvas were initially designed to be 6 nt long. This resulted in an unstable complex between the two origamis: after gel extraction, the complex dissociated. The design was revised to include 8-nt linkages. All scale bars 100 nm.



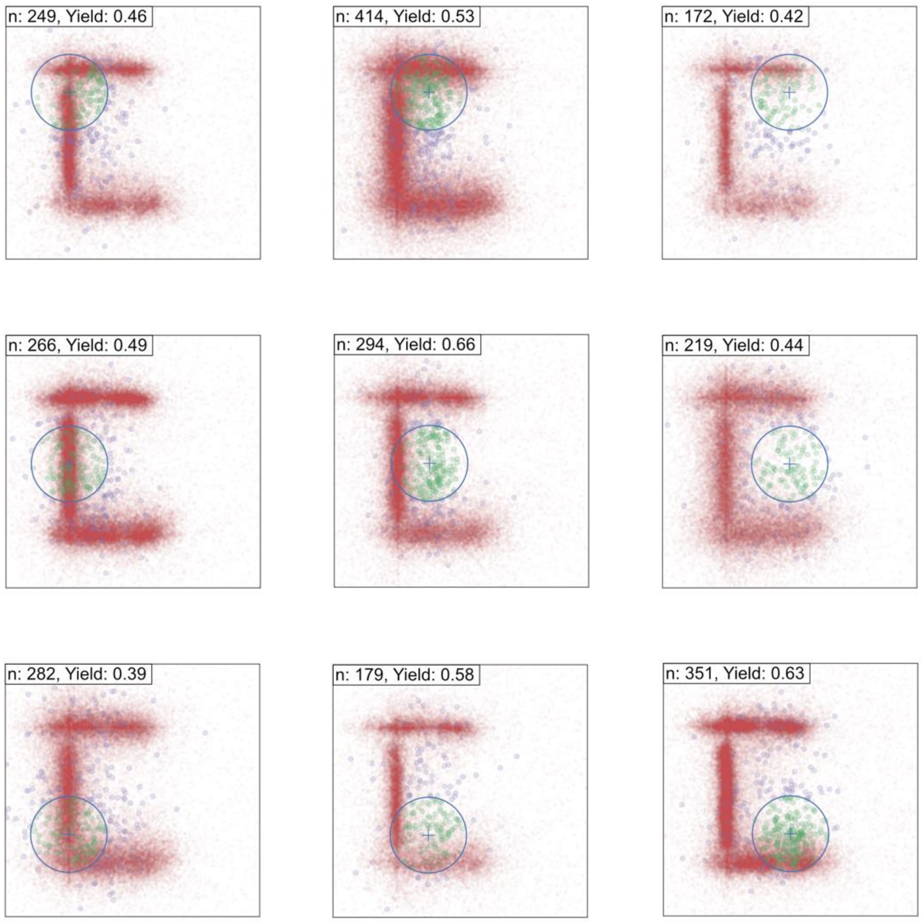
Supplementary figure 5. Schematic showing positions of address sites. The device incorporates 33 address strands: each is a single-stranded staple extension with a unique 12-nt sequence. Adjacent pairs of addresses on each beam of the canvas (labelled A-I and J-R) can be linked to addresses S,T and U,V on the rail. Adjacent pairs of addresses on the rail (labelled W-ZE) can be linked to addresses ZF, ZG on the sleeve. Address strand sequences are found in supplementary table 1)



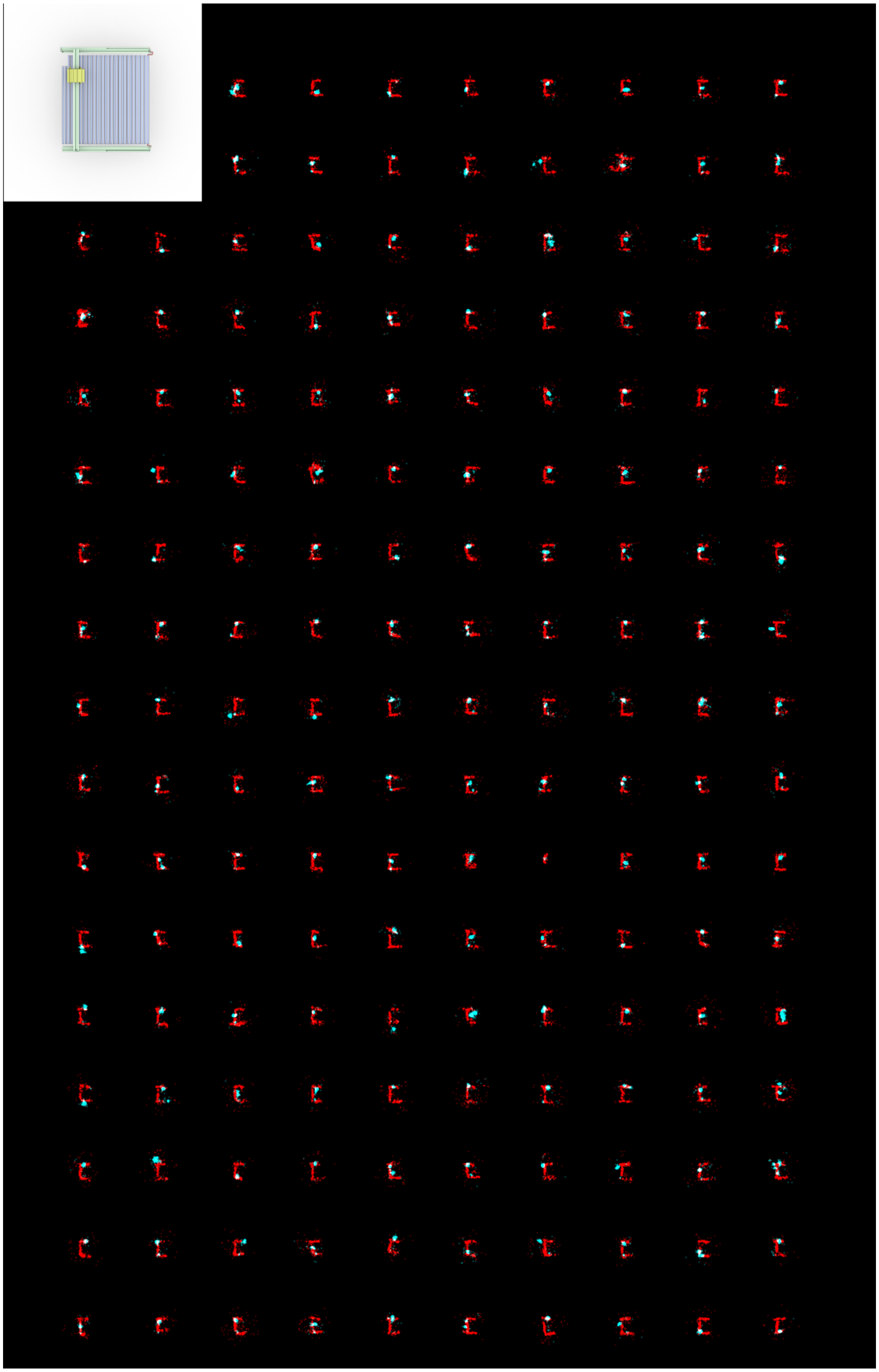
Supplementary figure 6. 2D positioning of sleeve with increasing magnesium concentration. Signalling strands were added to position the device in a centre, right position as described in the Methods section, but with buffers prepared with different $MgCl_2$ concentration. At low magnesium concentrations, the sleeve has a higher risk of being trapped in the loop regions between the rail arm and base beams, visible as sleeves in the top or bottom of the arm.



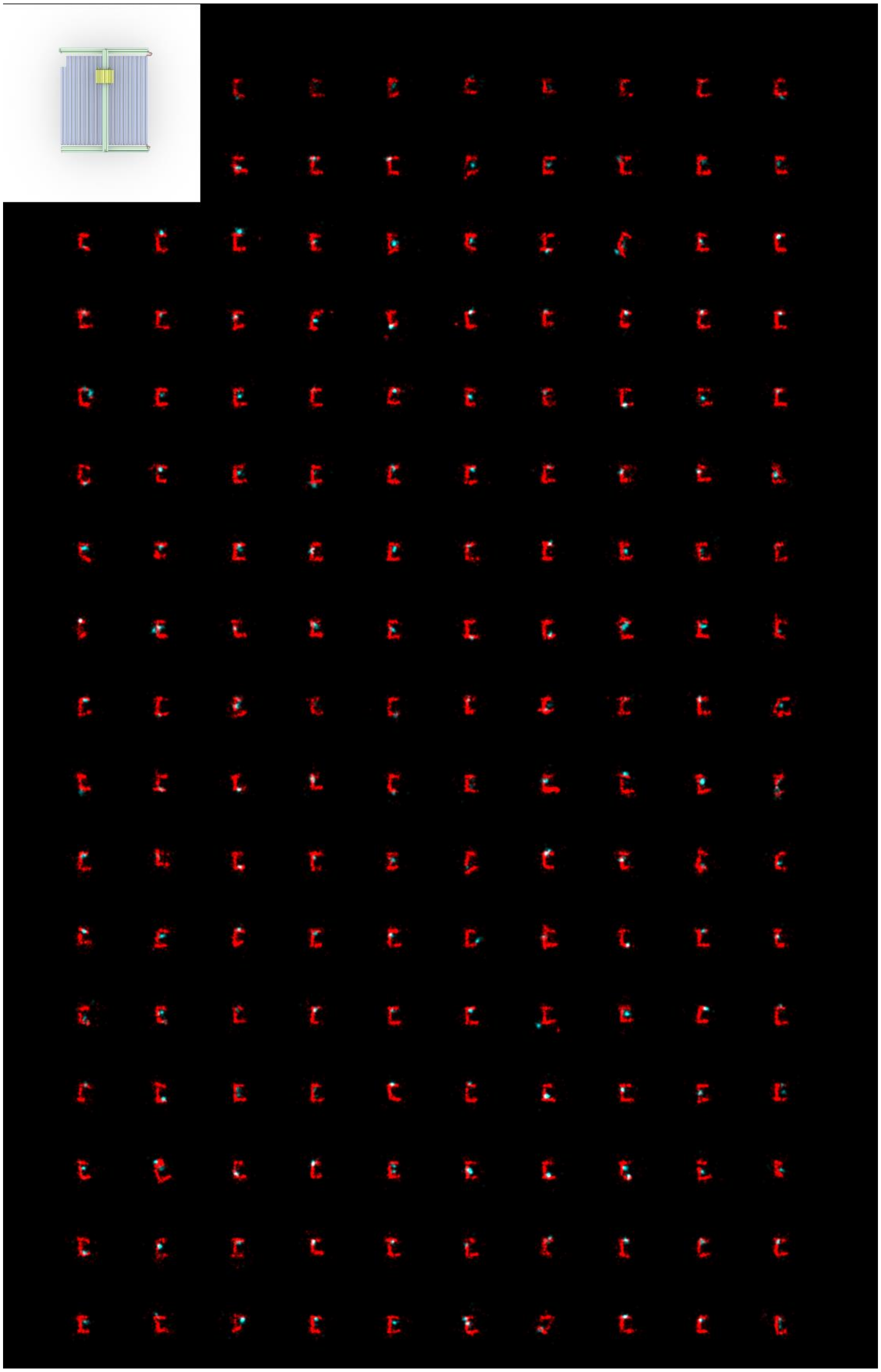
Supplementary figure 7. Alignment of DNA-PAINT data. Devices bound to the glass surface are oriented randomly. (A) For each candidate structure, PAINT localizations within a 2.5-pixel diameter circle (corresponding to 292.5 nm) are analyzed. The P1 fluorescence channel (red) corresponds to two lines of identical anchorages on the frame base beams and a single line on the canvas, forming a 'C'-shape. The sleeve carries a different anchorage sequence corresponding to the R1 fluorescence channel (blue). B) Two parallel and one orthogonal lines are fitted to P1 localizations using a Python script. C,D) The orientation and intersections of the lines are used to align data from all device images to enable averaging (as in Figures 2, 3), or for presentation in structure galleries (as in Supplementary Figures 9-17).



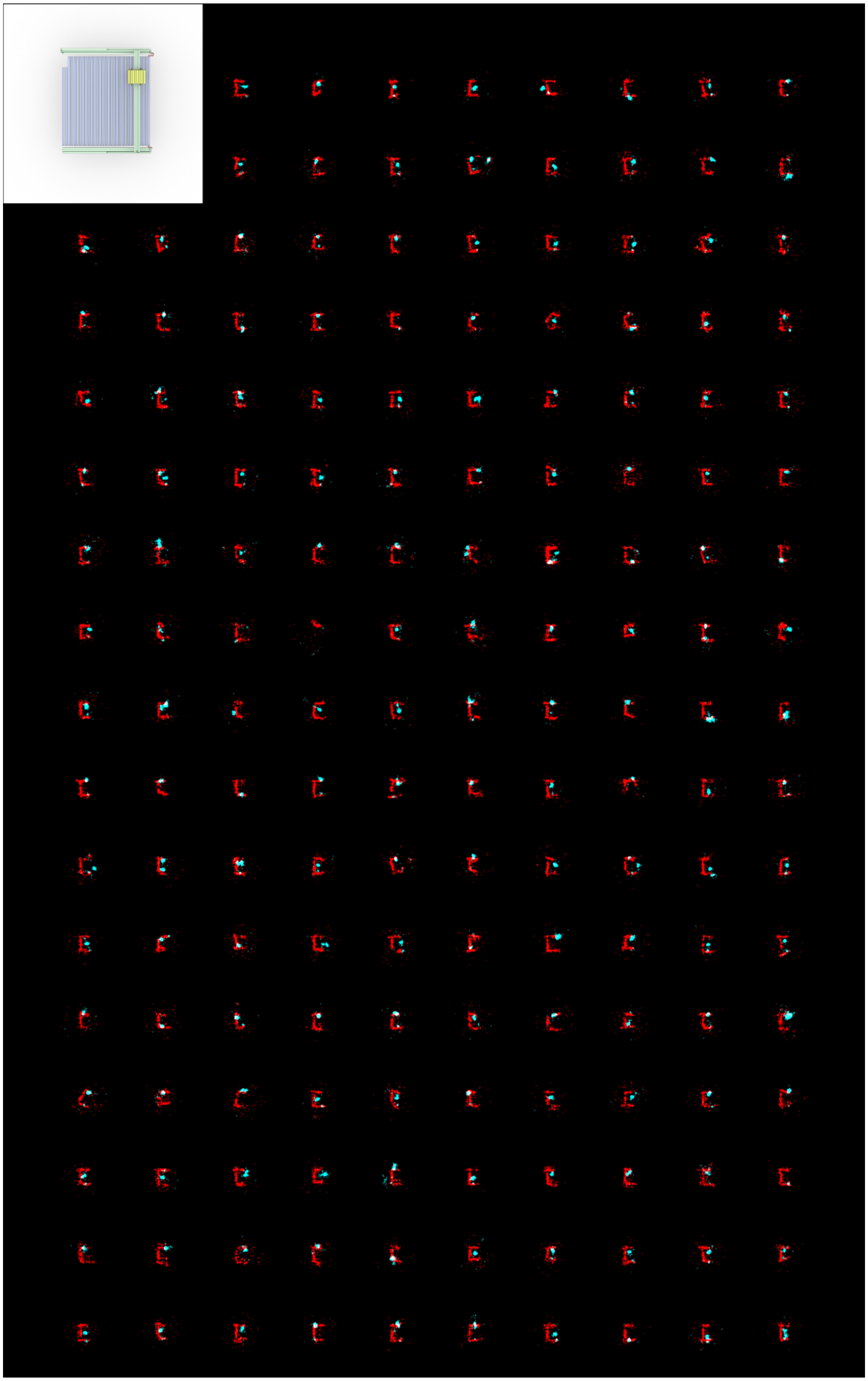
Supplementary figure 8. Placement yield of devices. The aligned DNA-PAINT data was used to estimate the placement yield. From each imaged device, the position of the sleeve was calculated as the average of the microscope localizations in the sleeve channel. Sleeves localized within 30 nm of their expected position were counted as successfully placed, this cutoff was chosen as a compromise between the precision of the alignment of the imaged channels, and the spacing of the tested positions. Data shown in 200 × 200 nm plot windows.



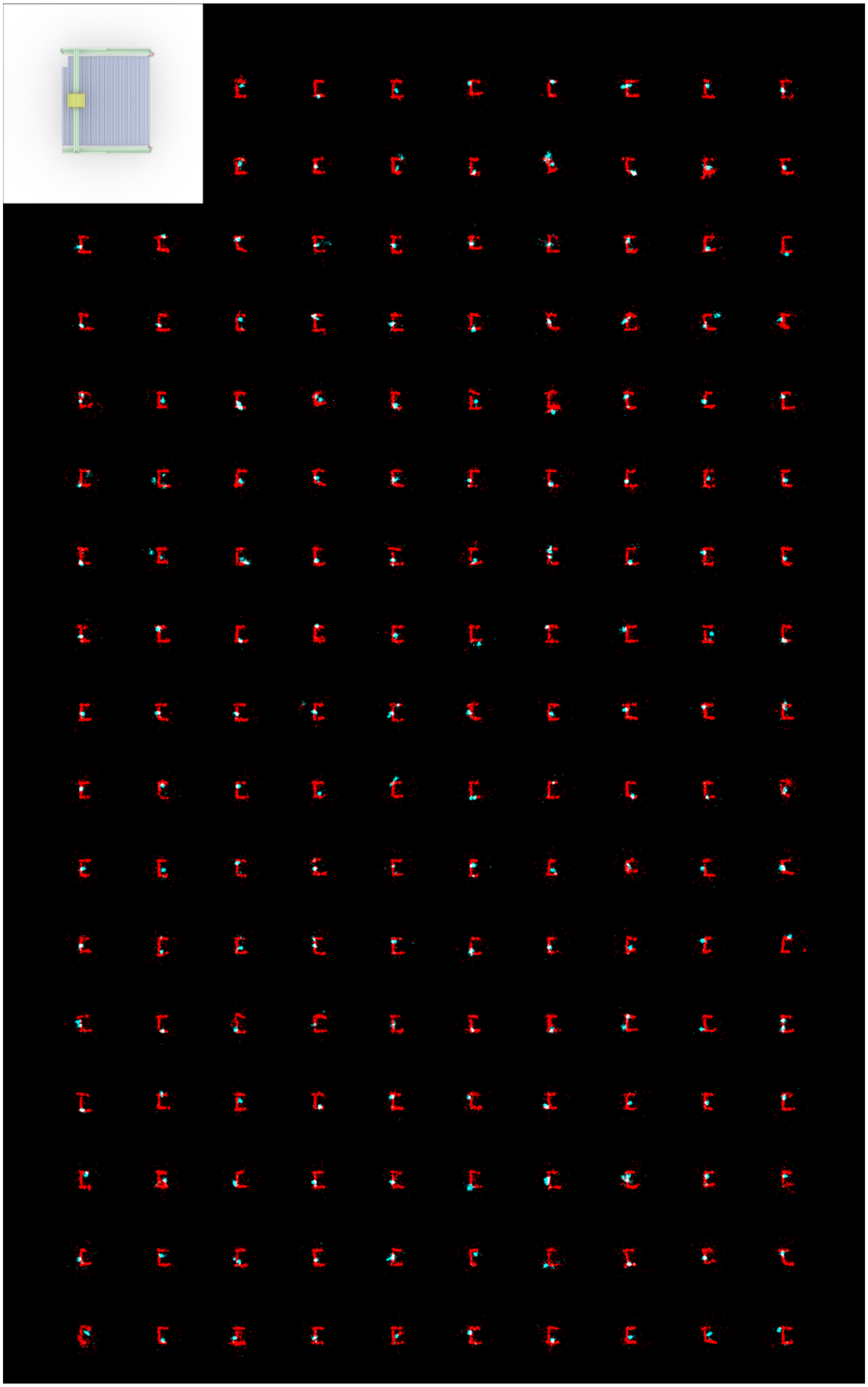
Supplementary figure 9. DNA-PAINT gallery of device with sleeve and rail nominally positioned at (top, left). Insert shows device in expected position.



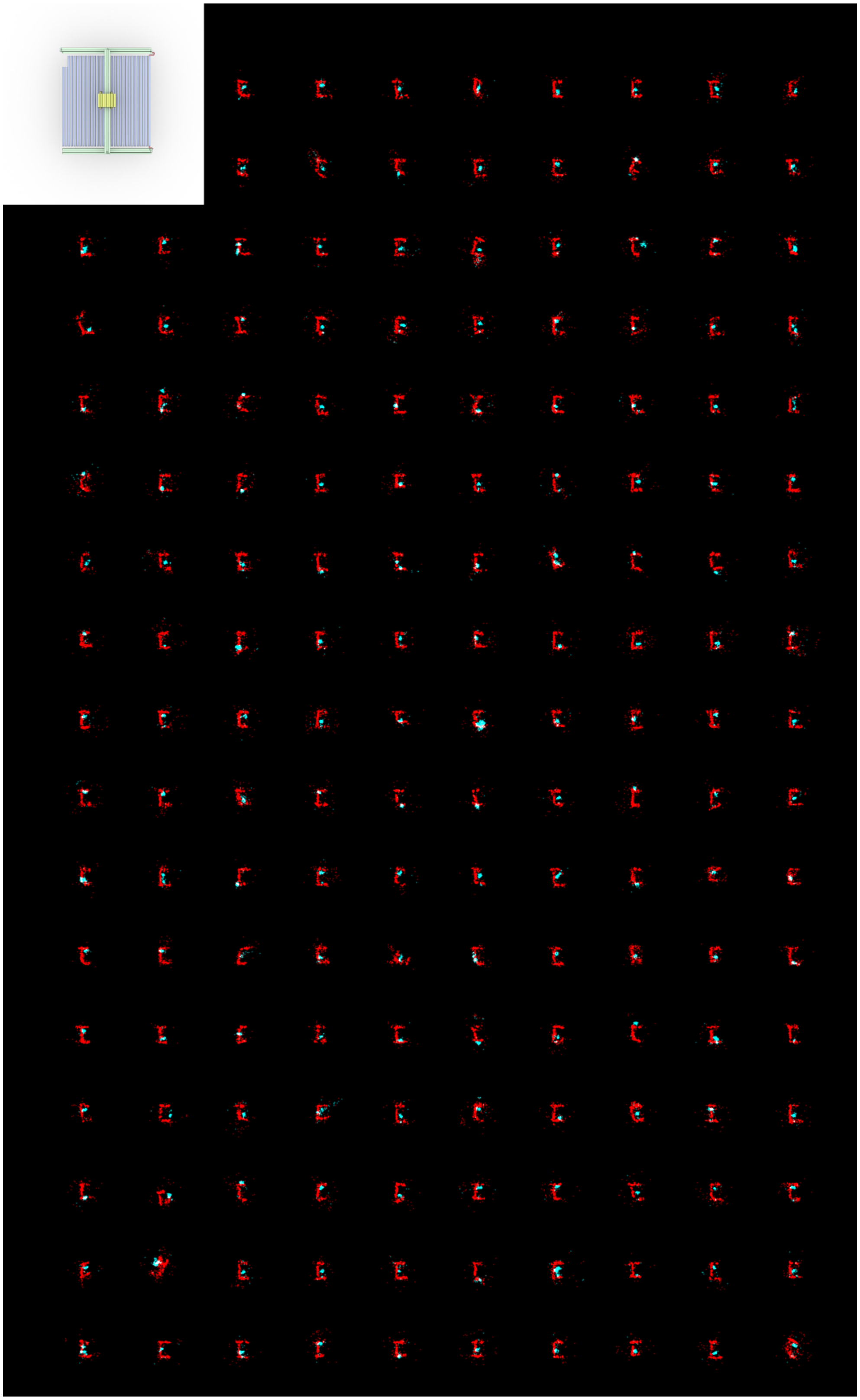
Supplementary figure 10. DNA-PAINT gallery of device with sleeve and rail nominally positioned at (top, centre). Insert shows device in expected position.



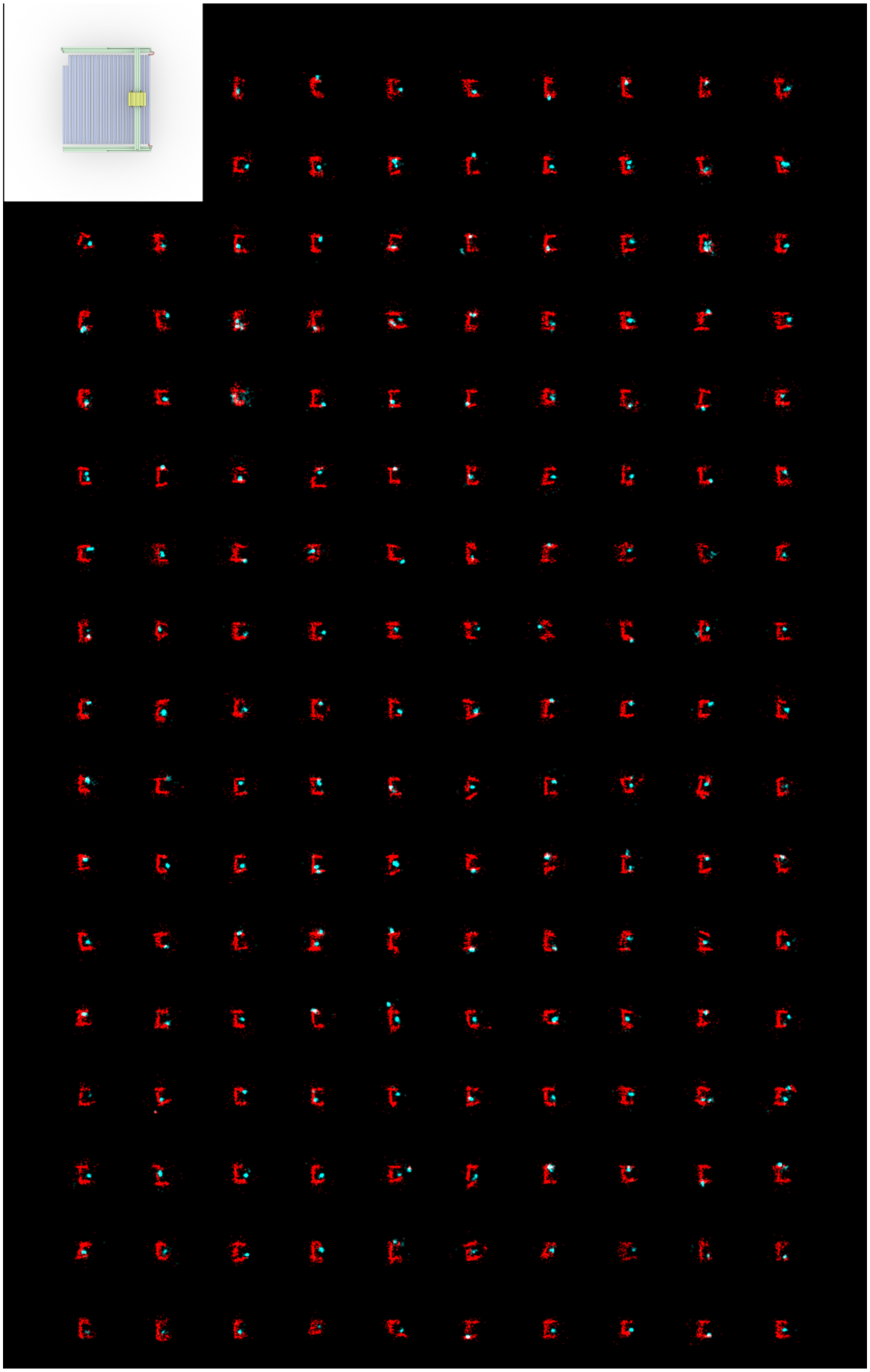
Supplementary figure 11. DNA-PAINT gallery of device with sleeve and rail nominally positioned at (top,right). Insert shows device in expected position.



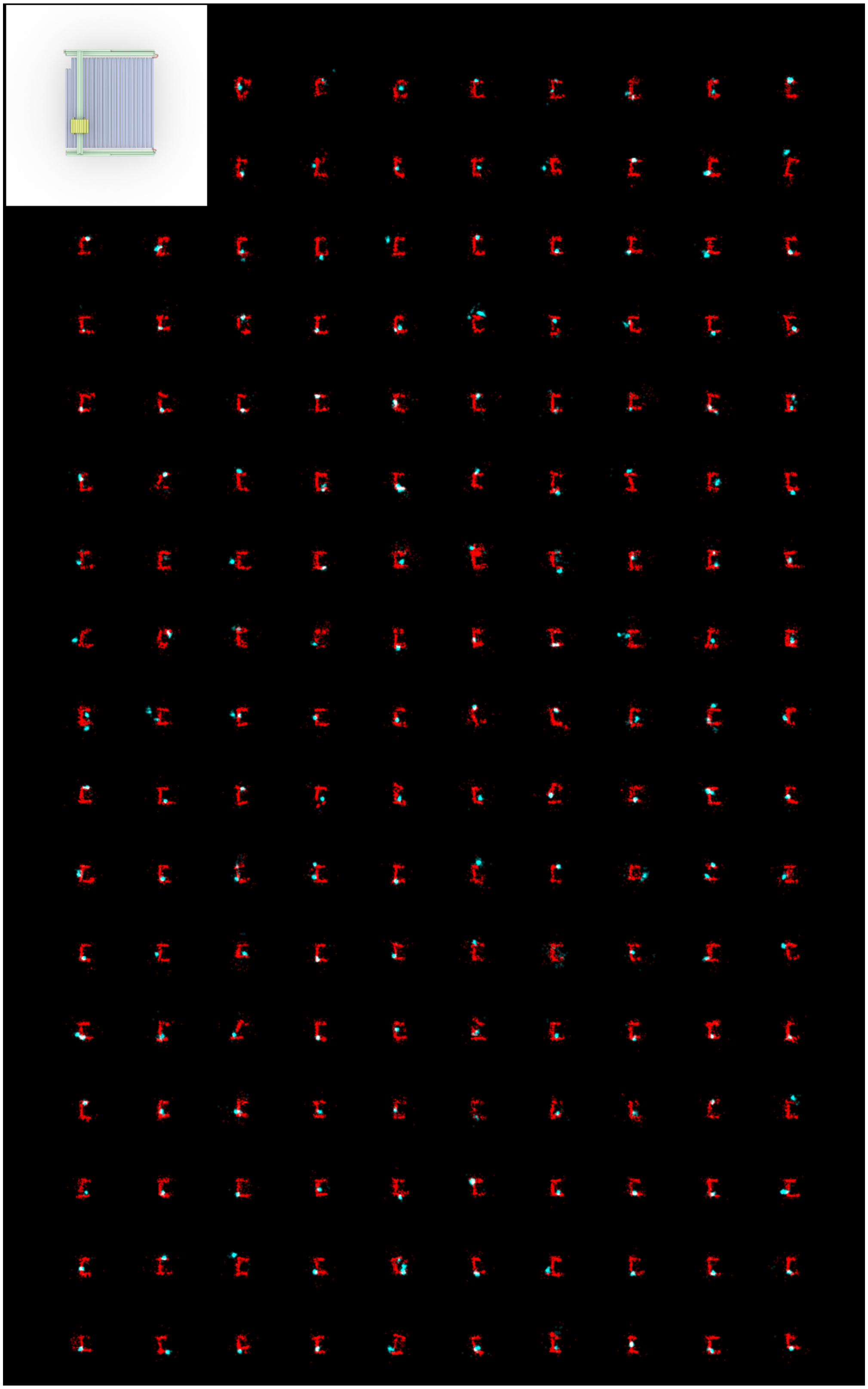
Supplementary figure 12. DNA-PAINT gallery of device with sleeve and rail nominally positioned at (centre, left). Insert shows device in expected position.



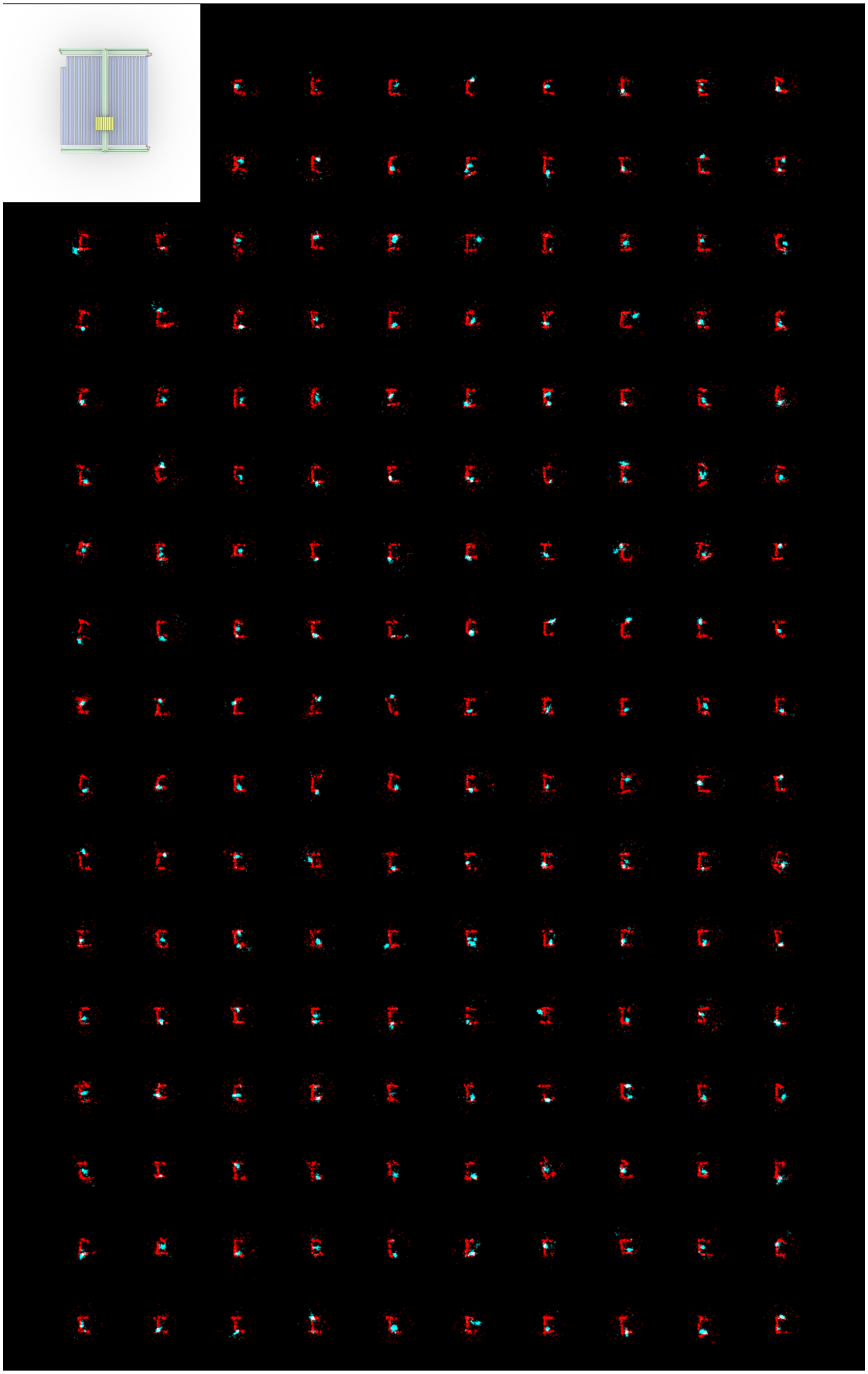
Supplementary figure 13. DNA-PAINT gallery of device with sleeve and rail nominally positioned at (centre, centre). Insert shows device in expected position.



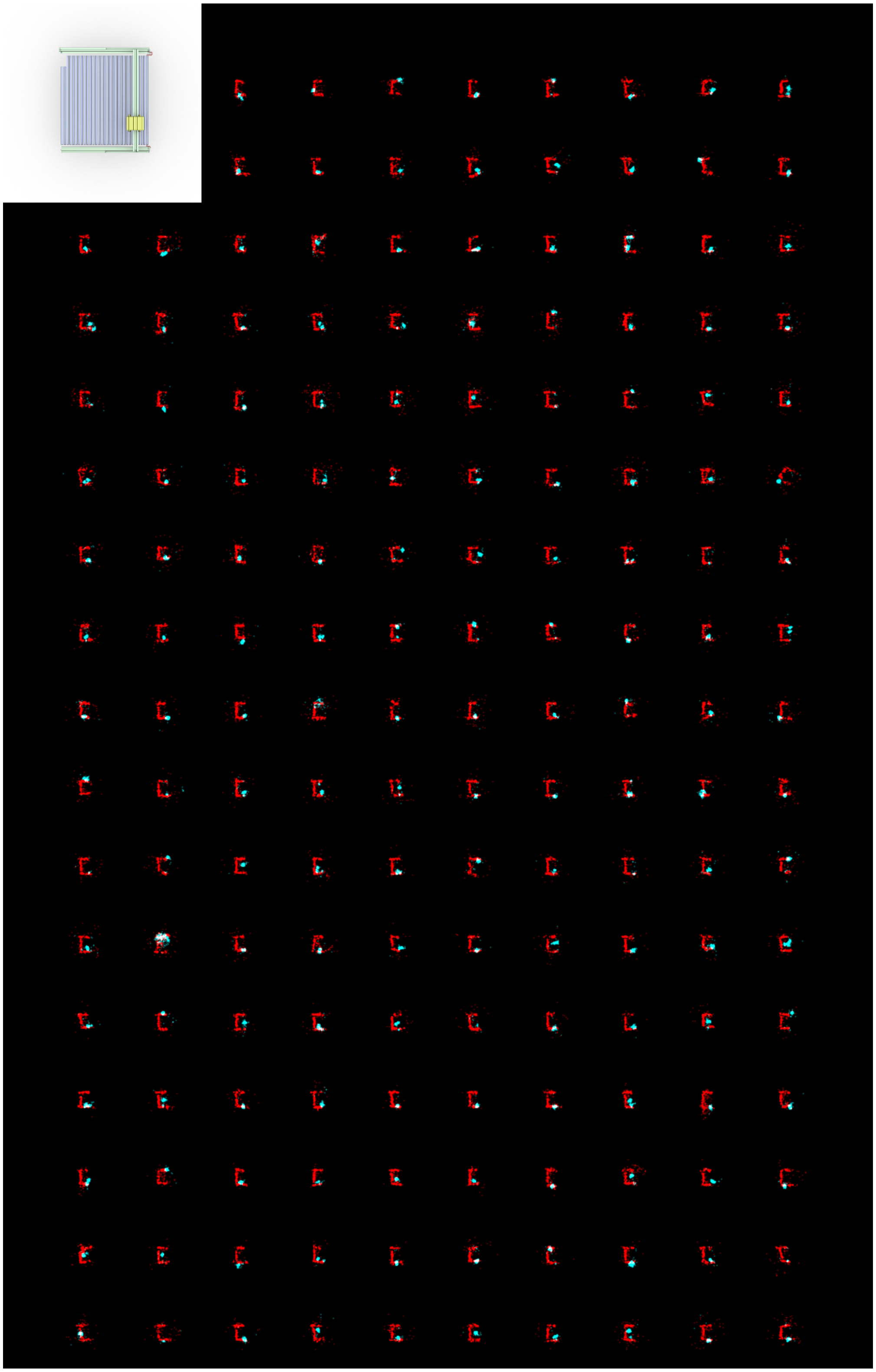
Supplementary figure 14. DNA-PAINT gallery of device with sleeve and rail nominally positioned at (centre, right). Insert shows device in expected position.



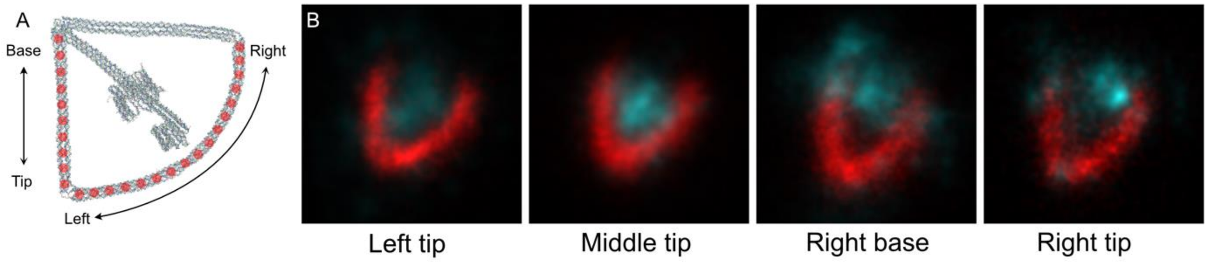
Supplementary figure 15. DNA-PAINT gallery of device with sleeve and rail nominally positioned at (bottom, left). Insert shows device in expected position.



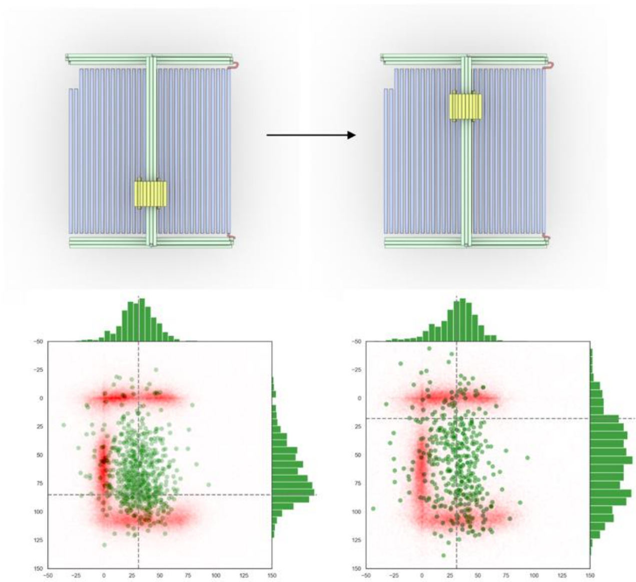
Supplementary figure 16. DNA-PAINT gallery of device with sleeve and rail nominally positioned at (bottom, centre). Insert shows device in expected position.



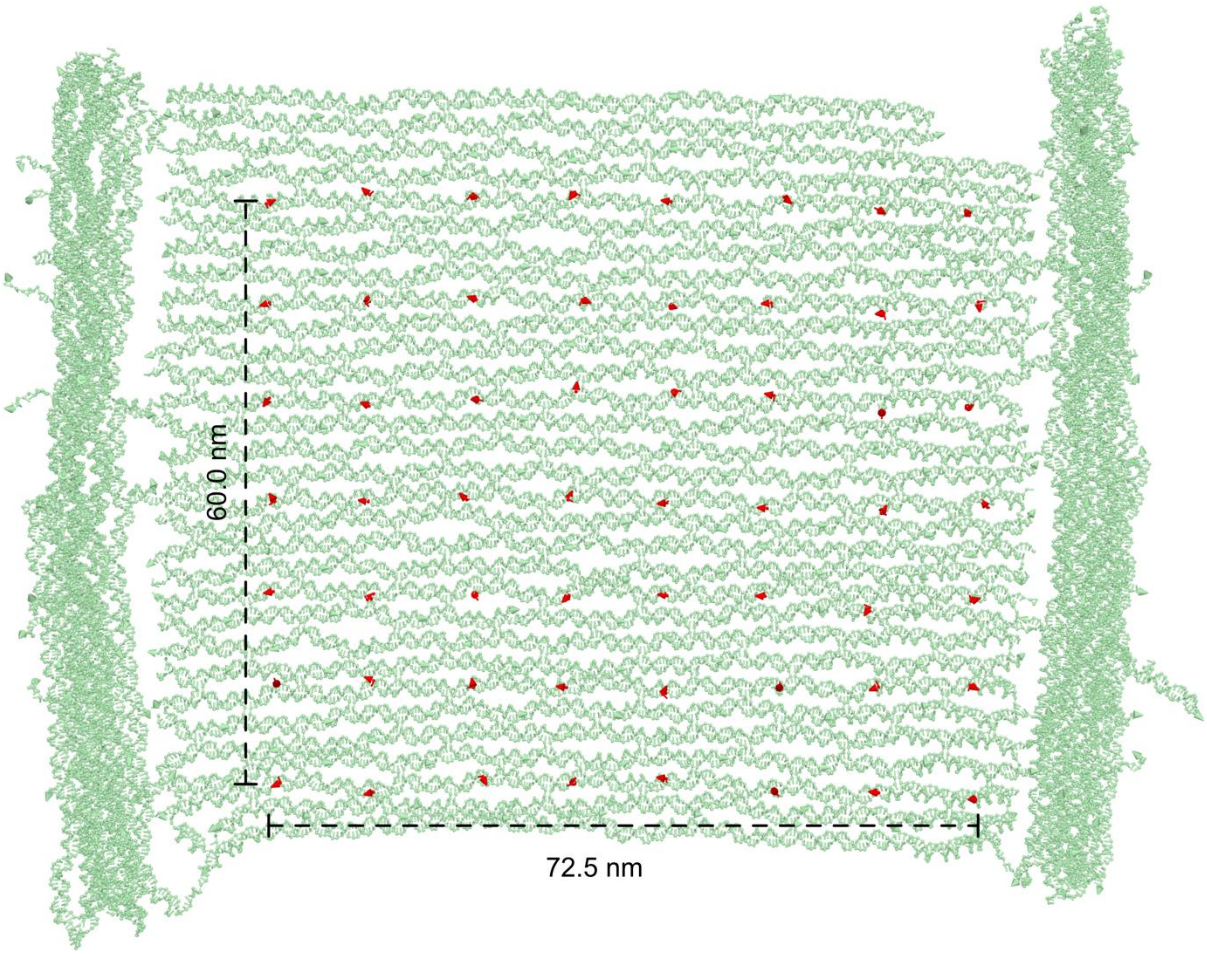
Supplementary figure 17. DNA-PAINT gallery of device with sleeve and rail nominally positioned at (bottom, right). Insert shows device in expected position.



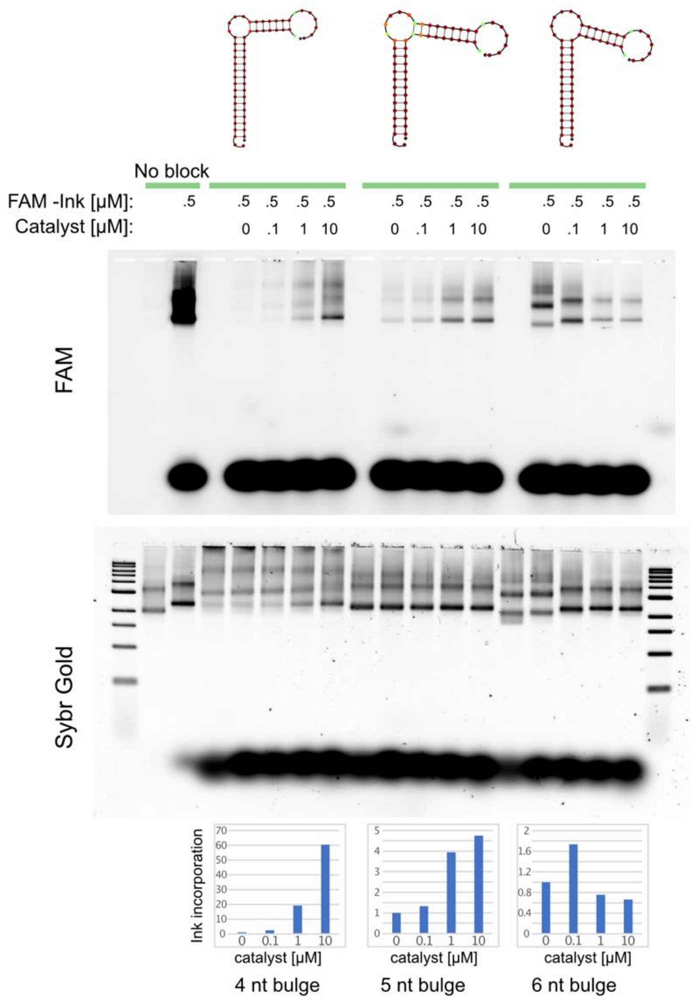
Supplementary figure 18. 2D placement in bow and arrow device. The base of the device was functionalized with an asymmetric pattern of DNA-PAINT docking sites, 10 on one of the straight members and 17 on the curved member (A). The device can be positioned in 2D in a polar coordinate system by locking the sleeve on the central rail and then locking the tip of the rail to the curved base member. B) Aligned and averaged DNA-PAINT images of the dial device with the arrow placed to the left, middle and right with the sleeve placed near the tip or close to the base. DNA-PAINT averages are cropped in 200 nm boxes.



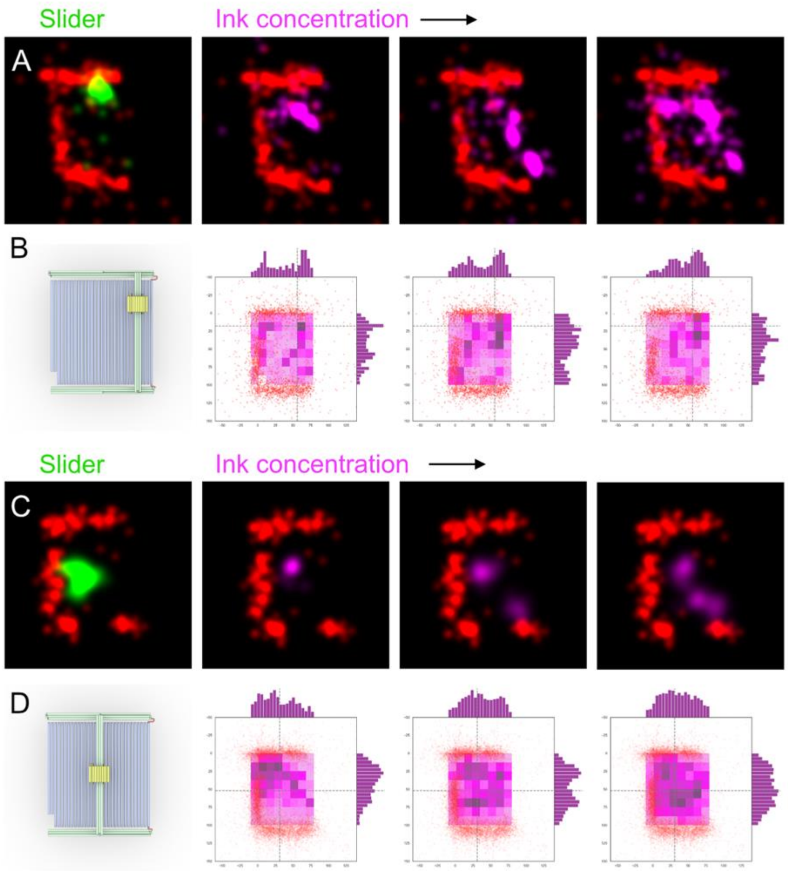
Supplementary figure 19. Unsuccessful repositioning of slider along locked-down rail. The slider was initially positioned in a bottom position with the rail in the middle (left). The slider was the released using toehold invaders, without releasing the rail, then repositioned in a higher position (right) through the addition of address strands. In subsequent experiments the rail was released from the printer base before repositioning the slider.



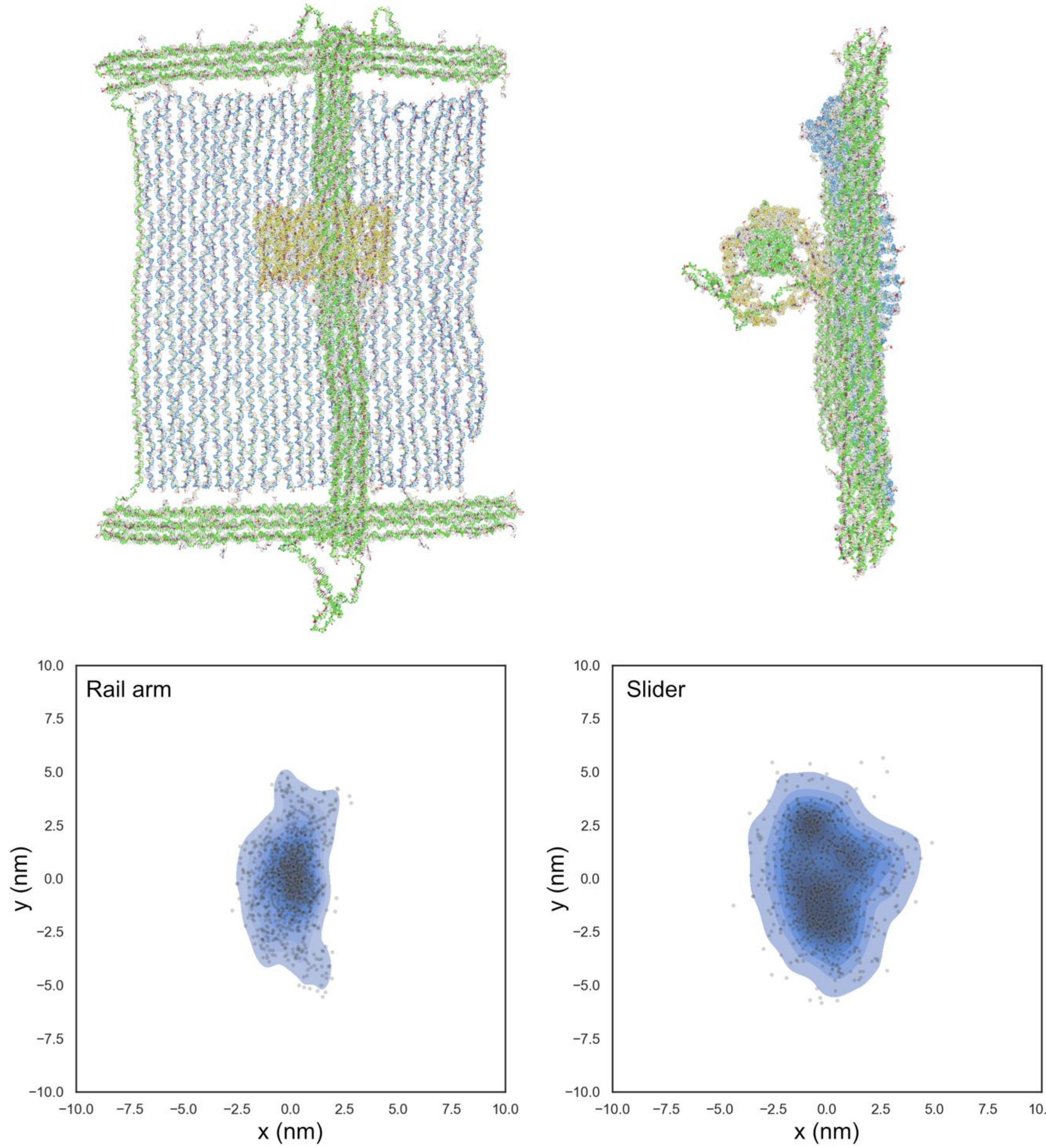
Supplementary figure 20. Layout of pixel grid. Rendering of oxDNA simulation snapshot with the position of the connection points for the 56 pixels highlighted in red. Illustration shows the measured distance from oxDNA of the extreme positions along the two axes. The average pixel pitch along the horizontal axis is 72.5 / 7 = 10.4 nm. The average pixel pitch along the vertical axis is 60.0 / 6 = 10.0 nm.



Supplementary figure 21. Patterning reaction: control experiments to compare reaction rates in solution with and without hybridization catalysis. Canvas with print pixels was assembled and PEG-purified. After staple removal, aliquots of the canvas were mixed with a 50× excess of blocker strands with 4- , 5- or 6-nt bulges (4-nt bulges are used for patterning in all subsequent experiments). A canvas without blocker strands was used as positive control for ink incorporation. Samples were mixed with 0.5 µM ink strands functionalized with FAM (FAM / TTTTGAATCGTGACCCGATATAATCTCTACG), and increasing concentrations of free catalyst strands (CGGTACTGAATC). Samples were incubated for 10 minutes at room temperature and then immediately loaded in the gel (2% agarose in 1× TAE with 10 mM $MgCl_2$, run at 85V for 135 minutes). The gel was first scanned in the FAM channel then post-stained with SYBR® Gold and re-scanned. Without catalyst, little ink is taken up in canvases with a 4-nt bulge in the pixel-blocker duplex; incorporation increases with increasing catalyst concentration. Blockers with larger bulges have significant leak reactions without the catalyst. Bottom row show quantification of brightness of the leading band in the FAM colour channel, corresponding to the uptake of FAM-ink; values are normalized to ink uptake with no catalyst present.



Supplementary figure 22. Patterning reaction: titration of ink concentration. Sleeves of devices immobilized in a flow chamber were locked in either the top right corner (A-B) or centre (C-D) of the canvas. The devices were then incubated with increasing concentrations of ink carrying DNA-PAINT docking site R3 (1, 5 and 10 nM) for 10 minutes each. Between patterning reactions, the incorporated ink was imaged with DNA-PAINT. A and C show consecutively imaged example devices. B and D show corresponding histograms of aligned devices with the sleeve locked in position.



Supplementary figure 23. Estimation of positioning precision from simulation. The device was simulated in oxDNA *(29)* with the address strands locking the rail arm and sleeve in central positions. Harmonic potential traps were applied to nucleotides on the bottom of the base-rail to lock them in space, emulating immobilization on glass. The structures were simulated for 10^8 time steps of 0.005 oxDNA time units with configurations saved every 10^5 time steps. For each saved configuration, the coordinates of the scaffold nucleotides of the rail arm and the sleeve were extracted and averaged to calculate the centre of mass of each component. Coordinates of the components are plotted relative to reference positions corresponding to their mean values in the time-series.

Supplementary table 1. Sequences of address strands.

Name	Sequence	Protrusion type
A	CGCGAGTCTATA	3'
B	CAACGGGTCTAT	3'
C	CCAATGTTCGAG	3'
D	GCCCTGAATGAT	3'
E	GCCTTATGACGA	3'
F	ACTGATGACCTG	3'
G	CACGGTTCATAG	3'
H	GTGCCGTAAATC	3'
I	AGTACTGTCCGA	3'
J	ATACCTGGGATC	3'
K	TGCTGAGATACC	3'
L	TTTACCAGGAGC	3'
M	AGGTACGCATTC	3'
N	AGGCCTGATATC	3'
O	CAGGTGCAATTC	3'
P	AGTTCCCGATAG	3'
Q	GCAGCATTTCAG	3'
R	GCGACGATTTAC	3'
S	GAGCTTACCGAT	5'
T	CCGTAGCTTAGA	5'
U	GCCTTTAGAACG	5'
V	ATGTAGCGATCC	5'
W	TCAATGGCCTAG	3'
X	CTCCGAATGTAG	3'
Y	TCAAAGTCTCGG	3'
Z	GGACTCTTGCAA	3'
ZA	GGCACCGTTATA	3'
ZB	AGCGATGTTACC	3'
ZC	AGGCTCTTGAAC	3'
ZD	TAAGGCTCCGTA	3'
ZE	GGCCTACGATTA	3'
ZF	TTCAAGCTCAGG	5'
ZG	CTTAGGCTAGCA	5'

Supplementary table 2. Staple sequences for frame structure.

Name	Sequence	Description
FrameCore1	ACCTACATTTTGACGCTCAATCGTCTGAAATCTG	Core staples for frame
FrameCore2	CCATTGCAACAGGAAAAACGCTCATGGAAATGAA	Core staples for frame
FrameCore3	GCTGGTAATATCCAGAACAATATTACCGCCAGATA	Core staples for frame
FrameCore4	CCTGAGTAGAAGAACTCAAACTATCGGCCTTCAA	Core staples for frame
FrameCore5	ATACTTCTTTGATTAGTAATAACATCACTTGTAA	Core staples for frame
FrameCore6	CTGTCCATCACGCAAATTAACCGTTGTAGCATCG	Core staples for frame
FrameCore7	TATAATCAGTGAGGCCACCGAGTAAAAGAGTTTT	Core staples for frame
FrameCore8	CGGTACGCCAGAATCCTGAGAAGTGTTTTTTC	Core staples for frame
FrameCore9	GTGTAGCCATAAAATGTCCAGGGATTGACGGTAATCGTAAAA	Core staples for frame
FrameCore10	CTAGCATGTCCAGAATGGGGTCATTAGATAGGGTGCGCGTAACCACCACTTT	Core staples for frame
FrameCore11	TGCTGCGGCAATCATAGGATTCTCCGTGGGAAGCCAGGGTCGGTTGTGT	Core staples for frame
FrameCore12	ACCCGCCGGCCGCCAGTTTCGCACAACCCGTCTGTACCCCGGTTGA	Core staples for frame
FrameCore13	CAGTGTCAAAGCCCCAAACATTAAATGTGAGCACGACGGCAATTTCTG	Core staples for frame
FrameCore14	GCGTACTACAGCGGATGTATGAGCCTTTCATCAAAACAGGAAGA	Core staples for frame
FrameCore15	GCCGGTGCAATATTTAGCGTCTGGCCTTCCTGCCGCCAAAAGAGA	Core staples for frame
FrameCore16	AACGTGCTGATAGCTCGGTAATGGAATAATTCAATTGTAAACGTT	Core staples for frame
FrameCore17	AATATTTTGTTGCCGGGTTTTCTTTGCGCGGTCCATAGAATCAGAGCGGGATTT	Core staples for frame
FrameCore18	TTTGGCCCTGAGAGAGTTTGCCCTTTAACGGCATCAGATAAAATTCGTTAACCA	Core staples for frame
FrameCore19	GCTAAACTGTGAGAAACATCCTCATTTTCATTAAATTTTTGTTTT	Core staples for frame
FrameCore20	TTCCGTAAAGCGGCCAGAATAACGGAGCACCGCTTTTTTTTCTGGTGCTTATACCTGGGATC	Core staples for frame
FrameCore21	CGGAAACCTTTCCGACGTGCCTAGCTGTAAATTGTTATCCGCT	Core staples for frame
FrameCore22	TCGCACTCCAGCCAGCAGGCAAAGTCGCTGGCAGCCTCCACTAAATTTGGGG	Core staples for frame
FrameCore23	AGCCCCCGTCCGTTTTAGCGTGGTTCAGGAAGA	Core staples for frame
FrameCore24	AGGCTGCGTATCGGCCGCTGGTCTGGGTACCGATACGAGCCGGAAGC	Core staples for frame
FrameCore25	GACGACGACAGCAACTGTTTCCGGCAAACGCGGATTTAGAGCCACTA	Core staples for frame
FrameCore26	CGGCGAACACGATGCTCAAGAATGCCAGTTTGAGGG	Core staples for frame
FrameCore27	TGCGGGCCTGCATCTGCCAACGGCTCCGTGAGGGGGTGCCTAATGAGT	Core staples for frame
FrameCore28	GCGCATCGTAACCGTCTTCGCTTGAAGGGT	Core staples for frame
FrameCore29	AGCGAAAGGGCGGCCTGCCATCCCTGTAGATGG	Core staples for frame
FrameCore30	GAAAGGGGCACGTTGGACGCAACCTTTCTGCCAATTGCGTTGCGCTCA	Core staples for frame
FrameCore31	CCGTAATGGGATAGGTGATGTGCTTAAAAAAAGCCGC	Core staples for frame
FrameCore32	TGGGTAACCAAACGGCCATCAGCGCGGCGGGCTCGGGAAACCTGTCGT	Core staples for frame
FrameCore33	TTGTAAAGAGTAACTCAATCCCTGTGCAAATCGGCCAACGCGC	Core staples for frame
FrameCore34	GAGGTGGAGTAGCCAGCGGGTCACATCAGACGCGTATTGGGCGCCAG	Core staples for frame
FrameCore35	CACCGGAACCATCAAAGTAAAGGTACCTGCAGACCAGTGAGACGGGCA	Core staples for frame
FrameCore36	ATAGGAACGACAATCGGTTCTCCGT	Core staples for frame
FrameCore37	CATGTTTAAAATCAGCCTTACACTGGTGTTT	Core staples for frame
FrameCore38	CACAATTCCACCCAAAAGAACGTCTTCGTCTCGCGCCATTCGCCATTCTTTGCTGAGATACC	Core staples for frame
FrameCore39	ATAAAGTGTATCAGGGAGCAACCGGATTGCCGTGGGAAGGGCGATCGGTTTTTACCAGGAGC	Core staples for frame
FrameCore40	GAGCTAAGGACTCCCGGTGGTTTAGTGAATTACGCCAGCTGGCTTAGGTACGCATTC	Core staples for frame
FrameCore41	CTGCCCGCGTTTGGAAGCTGGAGGAAATCCCGGCAAGGCGATTAAGTTTAGGCCTGATATC	Core staples for frame
FrameCore42	GCCAGCTGATAGCCCGGCAGGCGCCAGTTGGGTTTCCCAGTCACGACGTTCAGGTGCAATTC	Core staples for frame
FrameCore43	GGGGAGAGAAATCGGCCGGTTGCGCAAACTTACAGTGCCAAGCTTTCATTAGTTCCCGATAG	Core staples for frame
FrameCore44	GGTGGTTTCAGGCGAACTGCGGCTTCACGGAACGGGAACGGATAACCTTTGCAGCATTTCAG	Core staples for frame
FrameCore45	ACAGCTGATGCAGCAATCGTCATAGATAGACTCGAAACGTACAGCGCTTGCGACGATTTAC	Core staples for frame
FrameCore46	TTTTCCTCGCACATTT	Core staples for frame
FrameCore47	AAAGTTAAGTGGCGAGAGGGCGAA	Core staples for frame
FrameCore48	ACAGAGCGGGCCACTATTAAAGAACGTCTCACATTAGCACGCGTTATACATCTA	Core staples for frame
FrameCore49	ACATCGAGGTCACGCTTGAGTGTTGTTCCATTTCCAGCGTTTTCTTATACATCTA	Core staples for frame
FrameCore50	CTCATTTCGCTTAATTATAAA	Core staples for frame
FrameCore51	CGCAGAAATGGTTGCTTTTGATGGTGGTTCCGGCGGTTTGATCCAGCGTTATACATCTA	Core staples for frame
FrameCore52	GGTGAAGGTTCCTCGTCGCTGGTT	Core staples for frame
FrameCore53	TTGTCCCGGAATTAGGAGGCC	Core staples for frame
FrameCore54	TCGAGGTGTTTGTGTGTTCCTTTTTTATACATCTA	Core staples for frame
FrameCore55	TTCGTAATCATGGTCAGGACTTGTTCAAGTTTTCGGAACCCTAAAGGGTTT	Core staples for frame
FrameCore56	CGTGAACCATCACACAACAGCTCGAATTATACATCTA	Core staples for frame
FrameCore57	TTGTTCAGCAAATCGTCACCGCCTT	Core staples for frame
FrameCore58	TTTTATCAAAATTGAGTTATAAGAGCAAGAAA	Core staples for frame
FrameCore59	ATTAAGACAGCAATAGTATCAGAGAGATAACCCTGTCTTT	Core staples for frame
FrameCore60	GGCCAACAAACAAGAATTTTAACCAGCGCTAACTATCTTACCGAA	Core staples for frame
FrameCore61	GCCCTTTTTATTGAAAAAGGTTGGCCTTTGCACCCTTCTGACCTGATTT	Core staples for frame
FrameCore62	TAGAATCCAGAAAAGTTGAACAAAGTCAGAGTAAACCAAATAGATA	Core staples for frame
FrameCore63	AAGCGTAAGCGCCTGTACTATATGGAACACCCAAGCAGATAGCCG	Core staples for frame
FrameCore64	AACAAAGTTACCGTCGCTAGATGCAAACTTTACAAGGCACAGACAATATTTTT	Core staples for frame
FrameCore65	TGTAAATCAGAAGGCGCATTAGACGGGAGCAAGCCGTTCAGCTAA	Core staples for frame
FrameCore66	TTTGAATGCAATAAACGCAAGACACAGGGAAGAAACCGAGGAAA	Core staples for frame
FrameCore67	AATCAATAGGAATACCTTTACAG	Core staples for frame
FrameCore68	TAATCGGCACAAGAATCATAGGAGTCAAAAGGAGCGGAATTAT	Core staples for frame
FrameCore69	ACGGGTATGGTAATTGTCCGGCTTCATAGCGAATCAGATGATGGCAA	Core staples for frame
FrameCore70	AGAACAAGAATTAACTTAAATGCTTTAATTAATGATTGTTTGGATTAT	Core staples for frame
FrameCore71	AGGAATCACATAAAAAAAGAACGCTGAATAACAAGGGTTAGAACCTAC	Core staples for frame
FrameCore72	AGAGAATAATTACCGCGTCTGTCCA	Core staples for frame
FrameCore73	TGATAGCAAAAGGTATATATTAGCAGCC	Core staples for frame
FrameCore74	ATCAGATAATGAAAATTTAGTTAATGGAAACATGCACGTAAAACAGAA	Core staples for frame
FrameCore75	TTGTTTAACGTCAAAATAGAAGGCAATATAAA	Core staples for frame
FrameCore76	CCGAACGAGAGCCAGTAAATTTAAACGATTTT	Core staples for frame
FrameCore77	GAACGCGATAAGAATGGTTTGTTAACAAGATTTTCAGGTTTAA	Core staples for frame
FrameCore78	ATTTATCCCAATCCAAAGGCGTTTGGCAGAGG	Core staples for frame

FrameCore79	AGGTGAGGGCCAACATATAAATAAGCCATATT	Core staples for frame
FrameCore80	TTGCGGGAAATAAACAGGCGTTAAAACAAACAAGTAACAGTACCTTT	Core staples for frame
FrameCore81	GCCAGTTACAAGGTTTTGGCCATAT	Core staples for frame
FrameCore82	AACAGTGCGGCTTAATGGAATCATAGAGCCTAATTT	Core staples for frame
FrameCore83	TTAGTTGCGTCTTTCCAATTACTATTTCAATTATAACGGATTCGCCTG	Core staples for frame
FrameCore84	AACGCTAACGAGCTATTTTGCCAACGCT	Core staples for frame
FrameCore85	AAAAATCTTACCAGTATCATAGAATCTTACC	Core staples for frame
FrameCore86	TTCCTTGCGTTATTTTACAAAAAGTTTT	Core staples for frame
FrameCore87	CACCAGTCACACGCGAGCATGTAGTTTTTTAAACCAATCAATTAGTACTGTCCGA	Core staples for frame
FrameCore88	CATCATATTTAAAAGTGACTACCTAAATAATACCTTATCATTCCAAGATTGTGCCGTAAATC	Core staples for frame
FrameCore89	TTCATCAATATTAAATGTTATATATTATCAACAGTACCGCACTCATCGTTCACGGTTCATAG	Core staples for frame
FrameCore90	ACTTCTGTATTAGATCCAATCAACATGTTTTTATTTTCATCGTTTACTGATGACCTG	Core staples for frame
FrameCore91	CATATCAAGTCAATAGTTTTTCAAAAAGTAATCCCAATAGCAAGCAATTGCCTTATGACGA	Core staples for frame
FrameCore92	ATAAAGAATAGGAGCATCTGACCTAATAAGAGTTATCCGGTATTCTAATTGCCCTGAATGAT	Core staples for frame
FrameCore93	CGTCAGATAGGAATTGACCGTGTGGTAATTTATAGCGAACCTCCCGACTTCCAATGTTCGAG	Core staples for frame
FrameCore94	TACATCGGTATCTGGTTAAACACCTGAGAATCAAGCCTTAAATCAAGATTCAACGGGTCTAT	Core staples for frame
FrameCore95	ATTGCTTTTGCTGAACCTGTTTAGTATAAAGCACCCAGCTACAATTTTTCGCGAGTCTATA	Core staples for frame
FrameCore96	TCCCATCCTAATTTAACCAGTACATTATC	Core staples for frame
FrameCore97	AGTCCTGGAGATAGACCGAACGTTATTAATTTCCTGATTTAGCTTAGTTATACATCTA	Core staples for frame
FrameCore98	TGCAGAACGAATACGTACAATTCG	Core staples for frame
FrameCore99	GACGACGAGCTATTAGTTTGAGGATTTAGAAGAATAATGGCTTGCTTCTTATACATCTA	Core staples for frame
FrameCore100	GTACCGACCCTAAAACTAATAGATTAGAGCCAATTATTGTACATATTATACATCTA	Core staples for frame
FrameCore101	CATTTTCACCACCATATCTAA	Core staples for frame
FrameCore102	TTAACAACCGGTCAGTCAAATCAACAGTTGAAGAATATACTCAAGAAATTATACATCTA	Core staples for frame
FrameCore103	CAACAGTAGCACGCTGATCAAACCC	Core staples for frame
FrameCore104	TTACAAATTCTAATT	Core staples for frame
FrameCore105	ACAAAATTAATTACATAAATACCGAGGAAGGTGCAGAAGATAAAACAGTTT	Core staples for frame
FrameCore106	AAAAGAAGATGATGAATAAGAACAGTTGGATTAACACCGCCTGCTTT	Core staples for frame
FrameCore107	TTAGCATCACCTGAATACCATCGCGCTTATACATCTA	Core staples for frame
FrameCore108	TTAACGAGGCGCAGACGCCACCCTCAGAGCCACCTT	Core staples for frame
FrameCore109	GAACCACTCAGAACCGGTCAATCAT	Core staples for frame
FrameCore110	GAGCCGCCACCCCACCAGAGCGCGACCTGTTAGTAAGTAATACTTTTGCG	Core staples for frame
FrameCore111	CCAAAAACATTTCAGGTCTAAATTGTGCTGACCAACCGCCTCCCTCA	Core staples for frame
FrameCore112	CAGGAGGTCACCGGAACTTTGAAAGA	Core staples for frame
FrameCore113	ACCAGAGCCACTGAGGCAGTATCATCTAAACAAAATCGGTTGTA	Core staples for frame
FrameCore114	AAGCCTCAGAGCAGCAAAGCAGTACAACGTGTACAGAAAATCACCGGA	Core staples for frame
FrameCore115	TTGATATTTCATAATCACCAGGCGCAT	Core staples for frame
FrameCore116	GCCATCTTTCACAAACAACCAAGCGAGAATAGAAATTAAGCAATA	Core staples for frame
FrameCore117	GCAAGGCAAAGAAGGAAGCCCACCCCCAGCTTCATCACCTTATTAGCGTTT	Core staples for frame
FrameCore118	GCATTTTCGGTATGGAAAGAAAACACTAATAATAAAAATCATACAG	Core staples for frame
FrameCore119	TAGTAGCATTAAAATTCGAGCAAAAGTATTCATGCGTTTTCATCG	Core staples for frame
FrameCore120	GATGATAGCGACAGAGTGAATAAG	Core staples for frame
FrameCore121	CGTAATCAGTACAGGAGTGTAAAATACTATCGGTTTTGGGGCGCGAGCT	Core staples for frame
FrameCore122	CCTGTTTAGCTATCCTTTAATGTTTCCATAGAAACACTCGATAGCAGCAC	Core staples for frame
FrameCore123	TAACGGGGTGAAACCACAGAACGAGT	Core staples for frame
FrameCore124	AACGTCACCAATCAGTGCCTTTTTCTTCTTAATGGTCAATAA	Core staples for frame
FrameCore125	CATTAGATACATTTTTGCGGCTTTGAGGTGAGATGGAGCAAGGCCGGA	Core staples for frame
FrameCore126	CGTATAAATTACCATTTTTAATTTCAA	Core staples for frame
FrameCore127	CAGTAGCACCACAGTTAATGCAACGGCCGACAATGATTTAGTTTGAC	Core staples for frame
FrameCore128	TTCTGCGATATAATGATCGGAAGAATTACCAGCAAAATCAC	Core staples for frame
FrameCore129	CGGAACCTATTAGAGCCTTATGCGATT	Core staples for frame
FrameCore130	CCATTTGGGAATTATTCTGAAACATGAGGATTAGGATTA	Core staples for frame
FrameCore131	TTAAGGCCGCTTTTGCGGGATCGCATTATACGTCACCGACTTGAG	Core staples for frame
FrameCore132	AAGAGGCTTTATCACCCAGTCAGGACGTT	Core staples for frame
FrameCore133	TTACCCTCAGAGCAACGATCTTT	Core staples for frame
FrameCore134	CAATACTGCGGAAGAACCGAATCGAAATCCCGCCGCCGCATTCCACAGACA	Core staples for frame
FrameCore135	AGTAAAATGGATGAACGGGAGATTTGGTCAGACTTCGTCACCAGTAC	Core staples for frame
FrameCore136	CTTTTGCAAAAGGCTGACCGATTATAATAAATCAATAGGAACCCA	Core staples for frame
FrameCore137	ACGACGATAGAACCGGAAATACACTCGCAGTCTGCCACCACCCTCATT	Core staples for frame
FrameCore138	ATAACGCCAACCCTGACGTAAACGGGTACTGGTATACTCAGGAGGTT	Core staples for frame
FrameCore139	TTTAGGAATACCATTGGGCTACTAAAGACTTGAGTAATAAGTATAGCCCGG	Core staples for frame
FrameCore140	TACAGGTAATCATTGTCGAGGGTAGCCCCCTGCCAGGCGGATAAGT	Core staples for frame
FrameCore141	GCCCTCATATCCAGACGCTCCATCGAGAATAATATTC	Core staples for frame
FrameCore142	AAACTACAAGGATTTTGCGCCTGATTTACCCTGTGGATAGCGTC	Core staples for frame
FrameCore143	TGTACCGTAAGCGGAGTGCGAAACAAGGATTGCAGCCAGAGGGGGTAAT	Core staples for frame
FrameCore144	TTCAGGGATGAATTGCGCATCTTTGGAAAGACTAATAGCGAGAGG	Core staples for frame
FrameCore145	TAGTACCGCCTTAATTGGTAATGCCAACAGGACGAGGCATAGT	Core staples for frame
FrameCore146	AATAGGTGAGGTGAATATGAGGAATGCTCCTTACTAATGCAGATAC	Core staples for frame
FrameCore147	GCCGTCGAGAAGTTGCGCTACAGAGGATGGCTTACATCAGTTGAGA	Core staples for frame
FrameCore148	GCGGGGTTTTGCACGCATAAAGACAGCCTGTAGCTACGGAACAACATTAT	Core staples for frame
FrameCore149	TTGAGACTCCTTGCAGGGAGTTATTT	Core staples for frame
FrameCore150	AAGGTCGTCATAGACCATAAATCAAAAAATGACCCTATGAATTTTTGGCCTACGATTA	Core staples for frame
FrameCore151	GGACATTTAGACACTATTATAGTCAGAATAAAGCTACTTTCAATTTAAGGCTCCGTA	Core staples for frame
FrameCore152	AGGCTGAAGTTTTTCAAAAAGATTAAGATTAGCAAAAGGAACTTAGGCTCTTGAAC	Core staples for frame
FrameCore153	CTTGACAAAAAACCAATCAAATATCGCGTTTTCATCCAATTTTTTTCATTAGCGATGTTACC	Core staples for frame
FrameCore154	GCTTGAAGGAATTTCAGGATTAGAGAGTAATTTTCATTATCAGCTTTGGACTCTTGCAA	Core staples for frame
FrameCore155	AGTAAACATTCATTGATAAGAGGTCATTTCGCAAAACAGCTTGTTTCAAAGTCTCGG	Core staples for frame
FrameCore156	CTTTAGAAAGATTGAGCTTAATTGCTGAAACGAGTAGACAACAACTTCTCCGAATGTAG	Core staples for frame
FrameCore157	TTAAGACGAACTACAACATGTTTTAAATATCCATATAATTCGGTCTTTCAATGGCCTAG	Core staples for frame
FrameCore158	CCGTAGCTTAGATTTATCTACGTTAATAAAAACTGGCTTCACCCTC	Core staples for frame
FrameCore159	GCCTTTAGAACGTTTAGAAGCCTCAGAAAAGTTACTTAGCCGGTT	Core staples for frame
FrameCore160	AGCAGCGAACCGATATACAGTTGATTCCCAA	Core staples for frame

FrameCore161	ATGTAGCGATCCTTTTTGAATCCCCCTCAAATGTT	Core staples for frame
FrameCore162	GAGCTTACCGATTTTGTTTCATTGCAACTAAAGTACGGGGAAGAAA	Core staples for frame
FrameCore163	AGCGTCAGCAGTAAGCACCTAAAAAAAAAAAAGTCTACTAATAG	Core staples for frame
FrameCore164	ACCCTCAGAACCGCCACAATCTCCACGAAAGAGGCTTCAAACCCTCGTTTACCAG	Core staples for frame
FrameCore165	CCGGAAGCATCAATGCTCCAAATTGGCACCGTTATA	Core staples for frame
FrameCore166	AAGCCAGACATAGCCCAGAGTAAT	Core staples for frame
FrameCore167	TACCGTTCACTGTAGCTACCCAAA	Core staples for frame
FrameBio1	/5Biosg/TTTAAACCGTCTAAAGCCTCCTCCTCATTATACATCTA	Biotin strands for imobilization
FrameBio2	/5Biosg/TTTACGGTCATACCGGGGGAGCTTACGCAAGAGTCGCTAGGGCGCTGGCAATTT	Biotin strands for imobilization
FrameBio3	/5Biosg/TTTTCAAAAGACATTAATGCTCTGTGGTTATACATCTA	Biotin strands for imobilization
FrameBio4	/5Biosg/TTTTGCCCCAGTTCTTTTCCCAGCGGTTTATACATCTA	Biotin strands for imobilization
FrameBio5	/5Biosg/TTTATTTTGCGACCACCAGTAGTGAATTTATACATCTA	Biotin strands for imobilization
FrameBio6	/5Biosg/TTTACAACTCGTATAATCCTTTTCCCTTTATACATCTA	Biotin strands for imobilization
FrameBio7	/5Biosg/TTTAATATCTTATTGCGTATTTCATTTTTATACATCTA	Biotin strands for imobilization
FrameBio8	/5Biosg/TTTTCAATCAAGAGAAACAACCTGAGCTTATACATCTA	Biotin strands for imobilization
ARM_paint1	TTCTTTAAACAGTTTTATTTCAAAGTTTTGTCGTCTTGTTAGCGTCGCCACCATTATACATCTA	Paint strands from arm
ARM_paint2	TCTGTATGCGCCTGTAAGCATTGATTATACATCTA	Paint strands from arm
ARM_paint3	AGTTTCACACTGAGTGATTGGCCTTATACATCTA	Paint strands from arm
ARM_paint4	AACTAAAGAGCAAGCCCCTCATTATTATACATCTA	Paint strands from arm
ARM_paint5	CGTTGAACCTCAGACTGAATTTTATACATCTA	Paint strands from arm
ARM_paint6	AGGAGCCTACCCTCAGTGGCTTTTTTATACATCTA	Paint strands from arm
ARM_paint7	TGCTTTCGTATCACCGATAAGTTTTTATACATCTA	Paint strands from arm
ARM_paint8	ATACCGATGGGTTGATACAGTGCCTTATACATCTA	Paint strands from arm
ARM_paint9	CATCGCCCTCAGTACCTATTTTTATACATCTA	Paint strands from arm
ARM_paint10	GCTGAGGCTCAAGAGAAAAGTATTTTATACATCTA	Paint strands from arm
ARM_paint1_E	TTCTTTAAACAGTTTTATTTCAAAGTTTTGTCGTCTTGTTAGCGTCGCCACCA	Empty paint strands from arm
ARM_paint2_E	TCTGTATGCGCCTGTAAGCATTGA	Empty paint strands from arm
ARM_paint3_E	AGTTTCACACTGAGTGATTGGCC	Empty paint strands from arm
ARM_paint4_E	AACTAAAGAGCAAGCCCCTCATTA	Empty paint strands from arm
ARM_paint5_E	CGTTGAACCTCAGACTGAATT	Empty paint strands from arm
ARM_paint6_E	AGGAGCCTACCCTCAGTGGCTTTT	Empty paint strands from arm
ARM_paint7_E	TGCTTTCGTATCACCGATAAGTTT	Empty paint strands from arm
ARM_paint8_E	ATACCGATGGGTTGATACAGTGCC	Empty paint strands from arm
ARM_paint9_E	CATCGCCCTCAGTACCTATTT	Empty paint strands from arm
ARM_paint10_E	GCTGAGGCTCAAGAGAAAAGTATT	Empty paint strands from arm
Sleeve_link1	AAGAGCAACACACAAAGCTAGGCACCAGTCATACAAACCGCCCGTAGGGTGAGGATTGCGTGGAGGTA	Binding sites for sleeve
Sleeve_link2	TCAACGTATATCATAAGCGAACCAGACGACATCGACGCATCCCGTAGGTGAT	Binding sites for sleeve
Sleeve_link3	GAAAAGGTGGCAAACTCCACTACGAGCTCATTCAATCAAGTTTGCCTTTGCAGCGCGTGGCTTCCGCGTGAGTGG	Binding sites for sleeve
Canvas_linker1	CAATGAAATGCTGAGAAGTCTGAGATTGAGTAAATAAAAGGGACATTCTTTAGCATTCG	Binding sites for canvas
Canvas_linker2	CGCAATAATAACTATGTGAGGAGAAAACATAATACATCTTTAATGCGCGAACTTCGCAGTAT	Binding sites for canvas
Canvas_linker3	GAATTACCTTTTTTAATTTCATCTCTAACAACATCGCCATTAAAAATATTTGACATCG	Binding sites for canvas
Canvas_linker4	GAGCCAGCAGCAAATGTTTGACGTTC	Binding sites for canvas
Canvas_linker5	CAGTTGAGGATCCCCGGTCAGCCGATGGCCTTGACGGGGAAAGCTTACTAGCGT	Binding sites for canvas
Canvas_linker6	TGCCTGTTCTTCGCGAGCACCGTAACGTCAAAAAGGAAGGGAAGAATTAGTTCACG	Binding sites for canvas
Canvas_linker7	TAATCAGAACTGCGCGCGCCGGGCGAAAATCCCTGCGCCGCTACAGGGCTTTCGTGAAC	Binding sites for canvas
Canvas_linker8	TTGTATAAGCACCCCTGCTGTTGCCAATCCTGTTGACGAGCACGTATTTACATGTGC	Binding sites for canvas

Supplementary table 3. Staple sequences for canvas structure.

Name	Sequence	Description
Canvas_core_1	TTCAGGTCATTGCGGAT	Core staples for canvas
Canvas_core_2	CCGTCGGACTGTAGCCAGCTTTCAGAA	Core staples for canvas
Canvas_core_3	ACAGTCAACATTAATT	Core staples for canvas
Canvas_core_4	AGAGTCTGGAGCATTTTTGAGAGATCTTCGGTTGT	Core staples for canvas
Canvas_core_5	GGGTAGCTAAACAAGAGAATCGAT	Core staples for canvas
Canvas_core_6	CGGTAATCGTAAATAGCTGATAAATTAATATACTTTT	Core staples for canvas
Canvas_core_7	ACCGTTCACTAGCATGTCAATC	Core staples for canvas
Canvas_core_8	TGTACCCCGGTTGAAATCACCATCAATATGCAAGGAT	Core staples for canvas
Canvas_core_9	AGACAGTCATAATCAGAAAAGCCC	Core staples for canvas
Canvas_core_10	AAACAGGAAGATTTCAAAAGGGTGAGATTTTAAA	Core staples for canvas
Canvas_core_11	GGTAAAGATGTATAAGCAAATATT	Core staples for canvas
Canvas_core_12	ATTGTAAACGTTGGACGACGACAGTATCGGCCGTA	Core staples for canvas
Canvas_core_13	GTTTGAGGAATATTTTGTTAAAAT	Core staples for canvas
Canvas_core_14	CATTAAATTTTTGCGCATCGTAACCGTGCGCTTCTGG	Core staples for canvas
Canvas_core_15	AGATGGGTTAAATCAGCTCATT	Core staples for canvas
Canvas_core_16	TAACCAATAGGAATAATGGGATAGGTCACATTCGCCA	Core staples for canvas
Canvas_core_17	ATTGACCGCGCCATCAAAAATAA	Core staples for canvas
Canvas_core_18	GCGTCTGGCCTTCTTCTCCGTGGGAACAAAGGGCGAT	Core staples for canvas
Canvas_core_19	TTATAAAGCTAAAACAAAGGCTATTT	Core staples for canvas
Canvas_core_20	TTATGTGAGCGAGCCAGCTGGCTT	Core staples for canvas
Canvas_core_21	ACCAAAAAAAATTAAGCAATAACAAACTCC	Core staples for canvas
Canvas_core_22	GCGGGAGAAATAAATCATACAGGCCTTTAATT	Core staples for canvas
Canvas_core_23	AAAAATTTAATTCTACTAATAGTATTTGCGGA	Core staples for canvas
Canvas_core_24	TGCAATGCCATTTGGGGCGCGAGATAATGC	Core staples for canvas
Canvas_core_25	TATATTTTCTGAGTAATGTTCAGGAAGATCGC	Core staples for canvas
Canvas_core_26	ACTCCAGAAATGGTCAATAACCGCAACTAA	Core staples for canvas
Canvas_core_27	TGCCGGAATAGATTTAGTTTGACCTCCATATA	Core staples for canvas
Canvas_core_28	TTCAGGCTACGACGTTGTAAAACGACGGCTGC	Core staples for canvas
Canvas_core_29	CGGTGCGGTAAGTTGGGTAACGCCACGGATAA	Core staples for canvas
Canvas_core_30	AATATCGCCAGGATTAGAGAGTACAAGGCAAA	Core staples for canvas
Canvas_core_31	AAAAGATTGATAAGAGGTCATTGTAGCATT	Core staples for canvas
Canvas_core_32	TATTATAGAGCTTAATTGCTGAATCTGAAAAG	Core staples for canvas
Canvas_core_33	CATAAATCAACATGTTTTAAATATTGTTTAGC	Core staples for canvas
Canvas_core_34	TTTGCCGCTGTCTGGAAGTTTCATATTAGATA	Core staples for canvas
Canvas_core_35	AAGGGATAGGAGCCGCCACGGGAAGGGTTT	Core staples for canvas
Canvas_core_36	AATTTGTGGAAACAATCGGCGAAATGTGCTGC	Core staples for canvas
Canvas_core_37	AACAGGTGTTTTAATTCGAGCTGTTTTGCC	Core staples for canvas
Canvas_core_38	GCTCCTTTTAAGAGGAAGCCCGAATAGACTGG	Core staples for canvas
Canvas_core_39	TGGCTTAGTCAGAAGCAAAGCGGAGTCATAAA	Core staples for canvas
Canvas_core_40	TGTAGCTCAAAAATCAGGTCTTTCTTTAAA	Core staples for canvas
Canvas_core_41	AGTACGGCAGCAGTTGGGCGGTTGTGTGAC	Core staples for canvas
Canvas_core_42	ACAGTTGAGGATCAAACTTAAATTCAGGCGGC	Core staples for canvas
Canvas_core_43	AAACAGCTTCCCAATTCCAGTGCCAAGCTT	Core staples for canvas
Canvas_core_44	TCAGAGGTGCTCTCACGGAAAAAGAAACGATG	Core staples for canvas
Canvas_core_45	CCTCACCGAGAGATAGACTTTCTCGGTCCGTT	Core staples for canvas
Canvas_core_46	TTTTGCAAAAGAATCAAAGCGAACTT	Core staples for canvas
Canvas_core_47	AGACGACGGTAATAGTAAAATGTTAGACTTCA	Core staples for canvas
Canvas_core_48	AAGAGCACAATACTGCGGAATCTTGCATCA	Core staples for canvas
Canvas_core_49	ACATAACGGAATCCCCCTCAAATGACCCTGAC	Core staples for canvas
Canvas_core_50	TATTACAGCGTAAAAAAAGCCGCATCTGCTCA	Core staples for canvas
Canvas_core_51	ACGTTAAATGAAGGGTAAAGTTAGACGCAG	Core staples for canvas
Canvas_core_52	CTGGTCTGCGTTCCGGCAAACGCCGTGGTG	Core staples for canvas
Canvas_core_53	CGTGCCGGTCGTCGCTGGCAGCCTAGTCCCGG	Core staples for canvas
Canvas_core_54	TTCATGTTTACCCCGGCCAGAGTT	Core staples for canvas
Canvas_core_55	AGAGGGGATAAAAACCAAAATATTACCCAA	Core staples for canvas
Canvas_core_56	ATAGCGTCACACTATCATAACCCTTCAGTGAA	Core staples for canvas
Canvas_core_57	TATTCATTCCAAAAGGAATTACGAACCAGAAC	Core staples for canvas
Canvas_core_58	CAGTTCAGTACCACATTCAACTAGTTTAAT	Core staples for canvas
Canvas_core_59	TTTAGGAAAAAACGAGAATACATCGACATAAA	Core staples for canvas
Canvas_core_60	AAAATCCGTAGAAAGATTCATCCCTTATGC	Core staples for canvas
Canvas_core_61	CTTTAGTGTAAAACGAACTAACGGACCAGTCA	Core staples for canvas
Canvas_core_62	CTGATTGCGTCAGCAGCAACCGCAAGAATTCT	Core staples for canvas
Canvas_core_63	TTTTCGTCACTTGTAGAACGTCAGAACCAGCT	Core staples for canvas
Canvas_core_64	TTCCGGATATTCAGCGAGAGGCTTTT	Core staples for canvas
Canvas_core_65	GGCTGACCTAACAAAGCTGCTCATCGTTTACC	Core staples for canvas
Canvas_core_66	ATGAACGGCCCTGACGAGAAACGGCATAGT	Core staples for canvas
Canvas_core_67	GAACCGAAAATTGGGCTTGAGATGATGCAGAT	Core staples for canvas
Canvas_core_68	CGGAACGATAATCATTGTGAATTAAGTTGAGA	Core staples for canvas
Canvas_core_69	TACACTGGAGAACTGGCTCATTATAACAACAT	Core staples for canvas
Canvas_core_70	GGGTCACTGGTGCCATCCCACGCCGTGGTG	Core staples for canvas
Canvas_core_71	CAATCCGCGAGGTGTCCAGCATCATAACGGAA	Core staples for canvas
Canvas_core_72	ATCAACGTTCATCAAGAGTAATCACTAAAA	Core staples for canvas
Canvas_core_73	TAAGGCTTGTGTACAGACCAGGCGTTATACCA	Core staples for canvas
Canvas_core_74	GAGTAGTACTGACCAACTTTGAAAGATTTGTA	Core staples for canvas
Canvas_core_75	TTCAACTTGGCGCAGACGGTCAAAATCCGC	Core staples for canvas
Canvas_core_76	GATTTTATGTGTTCAGCAAATCGTTAAAGC	Core staples for canvas
Canvas_core_77	GGACGTTGTCTTTGCTCGTCATAACCGGTGCC	Core staples for canvas
Canvas_core_78	AAAGGTTGGAAGAAAAAGCCAACGGCAGCA	Core staples for canvas

Canvas_core_79	CCGTCGGTGTTGCCCTGCGGCTGGAGTGTCAC	Core staples for canvas
Canvas_core_80	TACGGCTGCGGGCGCGGTTGCGGTGCTGCGGC	Core staples for canvas
Canvas_core_81	TTGCAAAAGAATACTTGACAAGAATT	Core staples for canvas
Canvas_core_82	GCCACTACCTTTGACCCCCAGCGACATAGGCT	Core staples for canvas
Canvas_core_83	AAGTTTCACAAAGTACAACGGAGAGGACAG	Core staples for canvas
Canvas_core_84	AGGCTTTGTGATAAATTGTGTCGATCATAAGG	Core staples for canvas
Canvas_core_85	TGCGGGATCCTGCAGCCAGCGGTGACATCCCT	Core staples for canvas
Canvas_core_86	CTGAGGCCAGACGATCCAGCGCTAATGGGT	Core staples for canvas
Canvas_core_87	CACAGTTGTGTGCACTCTGTGGTATGAGCC	Core staples for canvas
Canvas_core_88	CGTGCCTGGGCGGGCCGTTTTCACTTCGCACT	Core staples for canvas
Canvas_core_89	TTTGCAGGCGCTGGTCATACCGTT	Core staples for canvas
Canvas_core_90	CACTCATGAAGGCACCAACCTAAAAGGAAT	Core staples for canvas
Canvas_core_91	AGCGCGAACATTAAACGGGTAAAATGAAAATC	Core staples for canvas
Canvas_core_92	TCATCGCCAGGACTAAAGACTTTTAGCCTTTA	Core staples for canvas
Canvas_core_93	GACCTGCTAACGAGGGTAGCAACTTCGAGG	Core staples for canvas
Canvas_core_94	AGCATCGGCCATGTTACTTCGGCATCAGATGC	Core staples for canvas
Canvas_core_95	CGGGTTACGTCACCCTCAGCAGCGATAGTT	Core staples for canvas
Canvas_core_96	CCCTGCATTTGCAGGGAGTTAAAGCGCCCACG	Core staples for canvas
Canvas_core_97	TGCGCGCCAGGATCCCCGGGTACCGAGCTTCG	Core staples for canvas
Canvas_core_98	CAGAATGCTTCTTCGCGTCCGTGAGAAATTGT	Core staples for canvas
Canvas_core_99	TTAAGGAACAACTAAACGAAAGAGTT	Core staples for canvas
Canvas_core_100	CAACTTTCAATAATTTTTTCACGTTACGTAAT	Core staples for canvas
Canvas_core_101	AAATGAAAAAGGCTCCAAAAGGTCATGAGG	Core staples for canvas
Canvas_core_102	TCTAAAGTGGTTTATCAGCTTGCTGGCTACAG	Core staples for canvas
Canvas_core_103	CCACAGACTTAAACAGCTTGATACCGAAAGAC	Core staples for canvas
Canvas_core_104	ATGAATCGCAATGACAACAACCATGCCGCTTT	Core staples for canvas
Canvas_core_105	ATTAATTGAGCTGTTTCCTGTGTGCCTCCT	Core staples for canvas
Canvas_core_106	CCTGGGGTCACAATTCCACACAACCCAGCACG	Core staples for canvas
Canvas_core_107	TTGGGGTTTCTGATACGAGCCGTT	Core staples for canvas
Canvas_core_108	TGCGAATAACAGTTTCAGCGGAACCCTCAG	Core staples for canvas
Canvas_core_109	TCCAAAAATTTTCTGTATGGGATTCCCTCATT	Core staples for canvas
Canvas_core_110	ATTGTATCTTTGTCGTCTTTCCAGGAACCCAT	Core staples for canvas
Canvas_core_111	TGAATTTCAGCCCTCATAGTTAGCCAGTAC	Core staples for canvas
Canvas_core_112	GCGCCGAGCCAACGCGCGGGGAGAGGCATT	Core staples for canvas
Canvas_core_113	CATAACCGAAACCTGTCGTGCCAGCACCAGTG	Core staples for canvas
Canvas_core_114	AGTCGGGATATATTCGGCGAATTCGTAATC	Core staples for canvas
Canvas_core_115	ATGGTCATCGTTGCGCTCACTGCCTTCACCGC	Core staples for canvas
Canvas_core_116	TATCCGCTGCCTAATGAGTGAGCTAGCGGTCC	Core staples for canvas
Canvas_core_117	ATCACCGTACCCTCAGAGCCACCATTGCTAAA	Core staples for canvas
Canvas_core_118	GGTTGATTAGCAAGCCCAATAGACGTTAGT	Core staples for canvas
Canvas_core_119	CTCAGTACACACTGAGTTTCGTCACGTAACGA	Core staples for canvas
Canvas_core_120	AACATGAAGGGTGGTTTTTCTTTTCTGCATTA	Core staples for canvas
Canvas_core_121	CCCCTGCAACAGCTGATTGCCCCGCTTTCC	Core staples for canvas
Canvas_core_122	CCCGAGATGAGAGAGTTGCAGCAAACTCAC	Core staples for canvas
Canvas_core_123	CGGCAAAATTGCCCCAGCAGGCGAGTGTAAAG	Core staples for canvas
Canvas_core_124	TTGAAGCATAAAAAATCCTGTTTT	Core staples for canvas
Canvas_core_125	AACCGCCACTCAGGAGGTTTAGGACGATTG	Core staples for canvas
Canvas_core_126	TTCAGGGAATAAGTATAGCCCGGAAATCCTCA	Core staples for canvas
Canvas_core_127	GTACCGTACAGGCGGATAAGTGCCGTCTCTGA	Core staples for canvas
Canvas_core_128	AAACTACAGGATTAGGATTAGCGACATGGC	Core staples for canvas
Canvas_core_129	CAAGAGAAACGCCTGTAGCGGTTTGCGTATTG	Core staples for canvas
Canvas_core_130	GGCGCCAAGTATTAAGAGGCTGGTAATAAG	Core staples for canvas
Canvas_core_131	AGACGGGCCTATTTCGGAACCTATGTAACAGT	Core staples for canvas
Canvas_core_132	CTGGCCCTAGGGTTGAGTGTTGTTCCAGTTGC	Core staples for canvas
Canvas_core_133	ACGCTGGTTCCCTTATAAATCAAACAACGTCA	Core staples for canvas
Canvas_core_134	TTGAGGCAGGTCATACCGCCACCCTT	Core staples for canvas
Canvas_core_135	CCACCAGATATTCACAAACAAATAATAGGTGT	Core staples for canvas
Canvas_core_136	GCCACCAAGAATGGAAAGCGCAGTCGAGAG	Core staples for canvas
Canvas_core_137	GAGCCGCCTTCCAGTAAGCGTCATGGGTTTTG	Core staples for canvas
Canvas_core_138	ACCAGAGCATACAGGAGTGTACTGAGACTCCT	Core staples for canvas
Canvas_core_139	AACGTGGCGGGGTCAGTGCCTTGATATTCTGA	Core staples for canvas
Canvas_core_140	AAAGCACTAAAGAACGTGGACTCAGAATAG	Core staples for canvas
Canvas_core_141	CAAATCAAAAAACCGTCTATCAGGTCCGAAAT	Core staples for canvas
Canvas_core_142	TTTGATGGTGGTGCGATGGCCCTT	Core staples for canvas
Canvas_core_143	GCCTTGAGCCGCCGCCAGCATTGTAATCAG	Core staples for canvas
Canvas_core_144	TTAAAGCCCCCTCAGAGCCGCCACTTAGCGTC	Core staples for canvas
Canvas_core_145	ATTTACCGACCCTCAGAACCGCCACATTTTCG	Core staples for canvas
Canvas_core_146	TTTTGATGCACCACCGGAACCGCGCCATCT	Core staples for canvas
Canvas_core_147	TTTTAACGAGAAAGGAAGGGAAGAAAGGGA	Core staples for canvas
Canvas_core_148	GCCCGTATAGAGCTTGACGGGGAACGGTCACG	Core staples for canvas
Canvas_core_149	CCGATTTAAACAGTTAATTGGAACAAGAGT	Core staples for canvas
Canvas_core_150	CCACTATTAAATCGGAACCCTAAACGCGCTTA	Core staples for canvas
Canvas_core_151	AAGGGCGAGTTTTTTGGGGTCGAGTATGGTTG	Core staples for canvas
Canvas_core_152	AGCAAGGCAGAATCAAGTTTGCCTCAGAACCA	Core staples for canvas
Canvas_core_153	CAGCAAAGCGCGTTTTCATCGGCCCTCAGA	Core staples for canvas
Canvas_core_154	GTCACCGACCCCTTATTAGCGTTTCTCCCTCA	Core staples for canvas
Canvas_core_155	ACCGATTGGCGCTGGCAAGTGTAGAGCCGGCG	Core staples for canvas
Canvas_core_156	ACCAGCGAACCACCACACCCGCGGGAGCCC	Core staples for canvas
Canvas_core_157	AGGAACGGCTACAGGGCGCGTACGTGCCGT	Core staples for canvas
Canvas_core_158	AAACAGGAAGCACGTATAACGTGCCCATCACC	Core staples for canvas
Canvas_core_159	TAGCGACCGGAAACGTCACCAAGAAACCGA	Core staples for canvas
Canvas_core_160	AGACTGTAATCACCAGTAGCACCACCCAAAAG	Core staples for canvas

Canvas_core_161	GTCATAGCCTTGAGCCATTTGGGAATTACGCA	Core staples for canvas
Canvas_core_162	TTTCATAATTCATTAAAGGTGAACATACAT	Core staples for canvas
Canvas_core_163	GGAAATTATCAAAATCACCCGAAAGGAGCGGG	Core staples for canvas
Canvas_core_164	CGCTAGGAGGGAGGGAAGGTAACGCAAAGA	Core staples for canvas
Canvas_core_165	CTGCGCGTCCAAAGACAAAAGGGCTCACAATC	Core staples for canvas
Canvas_core_166	ATGCGCCGTACGCCAGAATCCTGAGAAGTTTT	Core staples for canvas
Canvas_core_167	CTTTGACGGGCCGATTAAAGGGATCTGTCCAT	Core staples for canvas
Canvas_core_168	TTGTTACCAGAAGTGAAACCATCGTT	Core staples for canvas
Canvas_core_169	CTTTTTAACAATAATAACGGAATATTACCATT	Core staples for canvas
Canvas_core_170	ATGAAATTGATTAAGACTCCTTATTAGAGC	Core staples for canvas
Canvas_core_171	TGAGTTAAGCAAACGTAGAAAATATTATCACC	Core staples for canvas
Canvas_core_172	CGCTAATACAACATATAAAAGAAAATATTGAC	Core staples for canvas
Canvas_core_173	ATACCTACGAATAAGTTTATTTTGGACATTCA	Core staples for canvas
Canvas_core_174	TTGCTGGTACCGAGTAAAAGAGTTTTAGAC	Core staples for canvas
Canvas_core_175	TGCCTGAGTTAACCGTTGTAGCAACGGGAGCT	Core staples for canvas
Canvas_core_176	TTAGAATCAGAGTACTTCTTTGTT	Core staples for canvas
Canvas_core_177	GGAAACGGAAAAGTAAGCAGATTTTTTTGT	Core staples for canvas
Canvas_core_178	AACTGGCAAGCAATAGCTATCTTAAGCCTTTA	Core staples for canvas
Canvas_core_179	GTATGTTAGCCCAATAATAAGAGCGGAAGCGC	Core staples for canvas
Canvas_core_180	AAAGGTGGTCAGAGAGATAACCCACCCTGA	Core staples for canvas
Canvas_core_181	CACCACGATTTTGACGCTCAATCGTCTGAG	Core staples for canvas
Canvas_core_182	AATAGAAAGCAACAGGAAAAACGCCACGACCA	Core staples for canvas
Canvas_core_183	AGCCATTATTCATATGGGTTTTTATAATCA	Core staples for canvas
Canvas_core_184	GTGAGGCCAATATCCAGAACAATAAACAGAGA	Core staples for canvas
Canvas_core_185	CACGCAAATAGAAGAACTCAAACTGTAAGAAT	Core staples for canvas
Canvas_core_186	TTATAAGAAACGAAGCCGAACAAATT	Core staples for canvas
Canvas_core_187	AAAATAAACAAAAATGAAAATAGCCCGAAGCC	Core staples for canvas
Canvas_core_188	GCGTCTTATAACATAAAAACAGAAGAAACA	Core staples for canvas
Canvas_core_189	AATTTTATGGAGAATTAACTGAACACAAGAAT	Core staples for canvas
Canvas_core_190	CCGACTTGGCAGATTCACCAGTCATCATGGAA	Core staples for canvas
Canvas_core_191	TCTAAGAAGGGACATTCTGGCCTTACCGCC	Core staples for canvas
Canvas_core_192	CGAACGAATTCTGACCTGAAAGCATCGGCC	Core staples for canvas
Canvas_core_193	GATAGCCCCAGACAATATTTTTGAACATCACT	Core staples for canvas
Canvas_core_194	TTAACGTCAGCCATATTATTTACATCCTAA	Core staples for canvas
Canvas_core_195	CAGAGAGATCCAGAGCCTAATTTGCAATAATC	Core staples for canvas
Canvas_core_196	ATTAGACGCCTGAATCTTACCAACAGAACGGG	Core staples for canvas
Canvas_core_197	ACAAAGTCGTTGCTATTTTGCACCGAGAAC	Core staples for canvas
Canvas_core_198	CAAGATTAAGAGGGTAATTGAAATGGATTATT	Core staples for canvas
Canvas_core_199	TACATTGCGGGAGGTTTTGAAGGTAGGAAT	Core staples for canvas
Canvas_core_200	GTAATAAAACGCGAGGCGTTTTAGAAATCAGA	Core staples for canvas
Canvas_core_201	TAGAACCCCCACCAGCAGAAGATAAAACATAT	Core staples for canvas
Canvas_core_202	ACGTGGCATAAAACATCGCCATTAGTGCCACG	Core staples for canvas
Canvas_core_203	TTAAATAATATCCTCCCAATCCAATT	Core staples for canvas
Canvas_core_204	TGTTTATCGCATGTAGAAACCAATCCAGTTAC	Core staples for canvas
Canvas_core_205	AACAACATTCCTTATCATTCCAGCTAACGA	Core staples for canvas
Canvas_core_206	GGTAAAGTCAAGTACCGCACTCATCCAGCTAC	Core staples for canvas
Canvas_core_207	AGTAATAACGTTTTTATTTTCATCCCTTAAAT	Core staples for canvas
Canvas_core_208	CAACTAATGCGCCCAATAGCAAGCCGAACCTC	Core staples for canvas
Canvas_core_209	TTGGCAAAACACCGCCTGCAACAAAAATAC	Core staples for canvas
Canvas_core_210	AATATCAACAGCAGCAAATGAAAACGCGAACT	Core staples for canvas
Canvas_core_211	TTGTCTTTAATGATCTAAAGCATT	Core staples for canvas
Canvas_core_212	CATTACCAGATTAGAGCCGTCAATAGAGCC	Core staples for canvas
Canvas_core_213	AGGTTATGCTTATCCGGGAGGTGAGGCGGT	Core staples for canvas
Canvas_core_214	TTAAAGCCTGTTTCTGAACAAGAATT	Core staples for canvas
Canvas_core_215	ATAAGAATATACAAATTCTTACCAAACGCGCC	Core staples for canvas
Canvas_core_216	AATACCGCAACAGTAGGGCTTACGACAATA	Core staples for canvas
Canvas_core_217	TTTCATCTTTTAACAACGCCAACACGACAAAA	Core staples for canvas
Canvas_core_218	GATGCAAAAAGTATTAGACTTTACAGCACTAA	Core staples for canvas
Canvas_core_219	AGGTTGGCGTATTAAATCCTTTATTGAGGA	Core staples for canvas
Canvas_core_220	ATAATCCTTTTTAAAAGTTTGAGTGGTCAG	Core staples for canvas
Canvas_core_221	TTCGGAATTATCATCATATTCCTGATTACGGAACAAAGAAACCAGAACCTCA	Core staples for canvas
Canvas_core_222	TTTCACCTTGCTCCAGAAGGAGTT	Core staples for canvas
Canvas_core_223	ATGCGTTAAACACCGGAATCATGAAACAGT	Core staples for canvas
Canvas_core_224	CCAACGCTACCGTGTGATAAATAAAATAACCT	Core staples for canvas
Canvas_core_225	TCGCCATATCTGACCTAAATTTAAAATTAATT	Core staples for canvas
Canvas_core_226	TAGGCAGATTTTTCAAATATATTAGCGATA	Core staples for canvas
Canvas_core_227	GATTTAGTCCAATCGCAAGACAGTCAATAG	Core staples for canvas
Canvas_core_228	CGACAACTGTTATATAACTATATGTGAGAGAC	Core staples for canvas
Canvas_core_229	GTTATTAAGATTGTTTGGATTATACTTCTCTT	Core staples for canvas
Canvas_core_230	TCATTTTGTCAGATGATGGCAATTTATTTGCACTT	Core staples for canvas
Canvas_core_231	AATTAATTTCAATATATGTGAGTGGGCGTTAA	Core staples for canvas
Canvas_core_232	GAAGATGTAAATCGTCGCTATTTGGTTTGA	Core staples for canvas
Canvas_core_233	GCGAATTAGAATCCTTGAAAACATTTAGTTAA	Core staples for canvas
Canvas_core_234	TTTGAATATAAGACGCTGAGAAGAAAGAACGC	Core staples for canvas
Canvas_core_235	GGGAGAAAATCAAAATCATAGGTCTAAATGCT	Core staples for canvas
Canvas_core_236	TTGTAAAACAGAAATAAAGAAATTGCCTACCATATCAAAATCATCAAT	Core staples for canvas
Canvas_core_237	ACATAAAACATTTAACAATTTCATTTGAATTACTT	Core staples for canvas
Canvas_core_238	TGCTTCTGATGAAACAAACATCAAGAAAACAA	Core staples for canvas
Canvas_core_239	TTCCCTTATTCATTTCAATTACCTGAGCAAAA	Core staples for canvas
Canvas_core_240	GCTTAGATCCAAGTTACAAAATCGCGCAGAG	Core staples for canvas
Canvas_core_241	TGAATTTCAATAACGGATTCGCCTGATTGC	Core staples for canvas
Canvas_core_242	TACCTTTTTACAGTAACAGTACCTTTTACATC	Core staples for canvas

Canvas_core_243	ATGAATATAACCTCCGGGAATAATGGAAGG	Core staples for canvas
Canvas_core_244	GTTAGAACGTAGATTTTCAGGTTTAACGTCAG	Core staples for canvas
Frame_linker_1	TTCAGACCGGAAGAGCCTCAGAGCTCGAATGCT	Linkers from canvas to frame
Frame_linker_2	TTGAAAGGGGGACGTACAGCGCTGCACATGT	Linkers from canvas to frame
Frame_linker_3	TTCACATCCTCAGCGGGGTCATTGTTCACGA	Linkers from canvas to frame
Frame_linker_4	TTTCAGAACCGCCGTGAGAATAGATATACTGCG	Linkers from canvas to frame
Frame_linker_5	TTATAGCAGCACCGACAGGAGGTTTCGATGTCA	Linkers from canvas to frame
Frame_linker_6	TTACTACGTGAATTTCCTCGTTTCGTGAACT	Linkers from canvas to frame
Frame_linker_7	TTATTAGTAATAATGGCTATTATACGCTAGT	Linkers from canvas to frame
Frame_linker_8	TTCTTTTTTAATGAATTACTAGAATGAACGTCT	Linkers from canvas to frame
Line1Paint_E_1	GAATTAGCACATTATGACCCTGTAGCCGGAGA	Line 1 no paint docking
Line1Paint_E_2	AACATCCAGCCTTTATTTCAACGATATTCA	Line 1 no paint docking
Line1Paint_E_3	GTGGCATCTTAGAACCCTCATATAAAGGCCGG	Line 1 no paint docking
Line1Paint_E_4	CATTTCGCCCAGCTTTCCGGCACCATCTGCCA	Line 1 no paint docking
Line1Paint_E_5	GAACGAGACCAGGCAAAGCGCCGTTGGTGT	Line 1 no paint docking
Line1Paint_E_6	TCCCAGTCGCGCAACTGTTGGGAACGGCGG	Line 1 no paint docking
Line1Paint_E_7	AAGGCGATGCCTCTTCGCTATTACGTAACAAC	Line 1 no paint docking
Line1Paint_1_P1	GAATTAGCACATTATGACCCTGTAGCCGGAGATTATACATCTA	Line 1 Paint docking
Line1Paint_2_P1	AACATCCAGCCTTTATTTCAACGATATTCATTATACATCTA	Line 1 Paint docking
Line1Paint_3_P1	GTGGCATCTTAGAACCCTCATATAAAGGCCGGTTATACATCTA	Line 1 Paint docking
Line1Paint_4_P1	CATTTCGCCCAGCTTTCCGGCACCATCTGCCATTATACATCTA	Line 1 Paint docking
Line1Paint_5_P1	GAACGAGACCAGGCAAAGCGCCGTTGGTGTTTATACATCTA	Line 1 Paint docking
Line1Paint_6_P1	TCCCAGTCGCGCAACTGTTGGGAACGGCGGTTATACATCTA	Line 1 Paint docking
Line1Paint_7_P1	AAGGCGATGCCTCTTCGCTATTACGTAACAACTTATACATCTA	Line 1 Paint docking
Line2Paint_E_1	TTTACGAAACAATAGATAAGTCAGTATCAT	Line 2 no paint docking
Line2Paint_E_2	GGCTGTCTTGTTCAGCTAATGCAGGTATAAAG	Line 2 no paint docking
Line2Paint_E_3	TATTAAACAATTCTGTCCAGACGAATTGAGAA	Line 2 no paint docking
Line2Paint_E_4	AAGCAAGCGAGAATATAAAGTACTGTAATT	Line 2 no paint docking
Line2Paint_E_5	GAGAAAACGGCATTTTCGATAATACATTTGAG	Line 2 no paint docking
Line2Paint_E_6	TATAGAAGCTAAAATATCTTTAGGAAACAATT	Line 2 no paint docking
Line2Paint_E_7	CAGTATTATCAACAGTTGAAAGGAGCCCGAAC	Line 2 no paint docking
Line2Paint_E_8	CTGAGAGCACCCTCAATCAATATCTAACATTA	Line 2 no paint docking
Line2Paint_1_P1	TTTACGAAACAATAGATAAGTCAGTATCATTTATACATCTA	Line 2 Paint docking
Line2Paint_2_P1	GGCTGTCTTGTTCAGCTAATGCAGGTATAAAGTTATACATCTA	Line 2 Paint docking
Line2Paint_3_P1	TATTAAACAATTCTGTCCAGACGAATTGAGAATTATACATCTA	Line 2 Paint docking
Line2Paint_4_P1	AAGCAAGCGAGAATATAAAGTACTGTAATTTTATACATCTA	Line 2 Paint docking
Line2Paint_5_P1	GAGAAAACGGCATTTTCGATAATACATTTGAGTTATACATCTA	Line 2 Paint docking
Line2Paint_6_P1	TATAGAAGCTAAAATATCTTTAGGAAACAATTTTATACATCTA	Line 2 Paint docking
Line2Paint_7_P1	CAGTATTATCAACAGTTGAAAGGAGCCCGAACTTATACATCTA	Line 2 Paint docking
Line2Paint_8_P1	CTGAGAGCACCCTCAATCAATATCTAACATTATTATACATCTA	Line 2 Paint docking

Supplementary table 4. Staple sequences for canvas structure with 56 print pixels.

Name	Sequence	Description
Print_can_core1	AGAGTCTGGAGCATTTTTGAGAGATCTTCGGTTGT	Canvas core staple with pixels
Print_can_core2	CGGTAATCGTAAATAGCTGATAAATTAATATACTTTT	Canvas core staple with pixels
Print_can_core3	TGTACCCCGGTTGAAATCACCATCAATATGCAAGGAT	Canvas core staple with pixels
Print_can_core4	AAACAGGAAGATTTCAAAAGGGTGAGATTTTAAA	Canvas core staple with pixels
Print_can_core5	CATTAAATTTTTGCGCATCGTAACCGTGCGCTTCTGG	Canvas core staple with pixels
Print_can_core6	TAACCAATAGGAATAATGGGATAGGTCACATTCGCCA	Canvas core staple with pixels
Print_can_core7	GCGTCTGGCCTTCTTCTCCGTGGGAACAAAGGGCGAT	Canvas core staple with pixels
Print_can_core8	ACCAAAAAAAATTAAGCAATAACAAACTCC	Canvas core staple with pixels
Print_can_core9	GCGGGAGAAATAAATCATACAGGCCTTTAATT	Canvas core staple with pixels
Print_can_core10	AAAAATTTAATTCTACTAATAGTATTTGCGGA	Canvas core staple with pixels
Print_can_core11	TGCAATGCCATTTGGGGCGCGAGATAATGC	Canvas core staple with pixels
Print_can_core12	TATATTTTCTGAGTAATGTTCAGGAAGATCGC	Canvas core staple with pixels
Print_can_core13	ACTCCAGAAATGGTCAATAACCGCAACTAA	Canvas core staple with pixels
Print_can_core14	TGCCGGAATAGATTTAGTTTGACCTCCATATA	Canvas core staple with pixels
Print_can_core15	TTCAGGCTACGACGTTGTAAAACGACGGCTGC	Canvas core staple with pixels
Print_can_core16	CGGTGCGGTAAGTTGGGTAACGCCACGGATAA	Canvas core staple with pixels
Print_can_core17	AATATCGCCAGGATTAGAGAGTACAAGGCAAA	Canvas core staple with pixels
Print_can_core18	AAAAGATTGATAAGAGGTCATTGTAGCATT	Canvas core staple with pixels
Print_can_core19	TATTATAGAGCTTAATTGCTGAATCTGAAAAG	Canvas core staple with pixels
Print_can_core20	CATAAATCAACATGTTTTAAATATTGTTTAGC	Canvas core staple with pixels
Print_can_core21	TTTGCCGCTGTCTGGAAGTTTCATATTAGATA	Canvas core staple with pixels
Print_can_core22	AAGGGATAGGAGCCGCCACGGGAAGGGTTT	Canvas core staple with pixels
Print_can_core23	AATTTGTGGAAACAATCGGCGAAATGTGCTGC	Canvas core staple with pixels
Print_can_core24	AACAGGTGTTTTAATTCGAGCTGTTTTGCC	Canvas core staple with pixels
Print_can_core25	GCTCCTTTTAAGAGGAAGCCCGAATAGACTGG	Canvas core staple with pixels
Print_can_core26	TGGCTTAGTCAGAAGCAAAGCGGAGTCATAAA	Canvas core staple with pixels
Print_can_core27	TGTAGCTCAAAAATCAGGTCTTTCTTTAAA	Canvas core staple with pixels
Print_can_core28	ACAGTTGAGGATCAAACTTAAATTCAGGCGGC	Canvas core staple with pixels
Print_can_core29	AAACAGCTTCCCAATTCCAGTGCCAAGCTT	Canvas core staple with pixels
Print_can_core30	TCAGAGGTGCTCTCACGGAAAAAGAAACGATG	Canvas core staple with pixels
Print_can_core31	CCTCACCGAGAGATAGACTTTCTCGGTCCGTT	Canvas core staple with pixels
Print_can_core32	AGAGGGGATAAAAACCAAAATATTACCCAA	Canvas core staple with pixels
Print_can_core33	ATAGCGTCACACTATCATAACCCTTCAGTGAA	Canvas core staple with pixels
Print_can_core34	TATTCATTCCAAAAGGAATTACGAACCAGAAC	Canvas core staple with pixels
Print_can_core35	CAGTTCAGTACCACATTCAACTAGTTTAAT	Canvas core staple with pixels
Print_can_core36	TTTAGGAAAAAACGAGAATACATCGACATAAA	Canvas core staple with pixels
Print_can_core37	AAAATCCGTAGAAAGATTCATCCCTTATGC	Canvas core staple with pixels
Print_can_core38	CTTTAGTGTAAAACGAACTAACGGACCAGTCA	Canvas core staple with pixels
Print_can_core39	CTGATTGCGTCAGCAGCAACCGCAAGAATTCT	Canvas core staple with pixels
Print_can_core40	TTTTCGTCACTTGTAGAACGTCAGAACCAGCT	Canvas core staple with pixels
Print_can_core41	GGCTGACCTAACAAAGCTGCTCATCGTTTACC	Canvas core staple with pixels
Print_can_core42	ATGAACGGCCCTGACGAGAAACGGCATAGT	Canvas core staple with pixels
Print_can_core43	GAACCGAAAATTGGGCTTGAGATGATGCAGAT	Canvas core staple with pixels
Print_can_core44	CGGAACGATAATCATTGTGAATTAAGTTGAGA	Canvas core staple with pixels
Print_can_core45	TACACTGGAGAACTGGCTCATTATAACAACAT	Canvas core staple with pixels
Print_can_core46	GGGTCACTGGTGCCATCCCACGCCGTGGTG	Canvas core staple with pixels
Print_can_core47	CAATCCGCGAGGTGTCCAGCATCATAACGGAA	Canvas core staple with pixels
Print_can_core48	ATCAACGTTCATCAAGAGTAATCACTAAAA	Canvas core staple with pixels
Print_can_core49	TAAGGCTTGTGTACAGACCAGGCGTTATACCA	Canvas core staple with pixels
Print_can_core50	GAGTAGTACTGACCAACTTTGAAAGATTTGTA	Canvas core staple with pixels
Print_can_core51	TTCAACTTGGCGCAGACGGTCAAAATCCGC	Canvas core staple with pixels
Print_can_core52	GGACGTTGTCTTTGCTCGTCATAACCGGTGCC	Canvas core staple with pixels
Print_can_core53	AAAGGTTGGAAGAAAAAGCCAACGGCAGCA	Canvas core staple with pixels
Print_can_core54	CCGTCGGTGTTGCCCTGCGGCTGGAGTGTCAC	Canvas core staple with pixels
Print_can_core55	TACGGCTGCGGGCGCGGTTGCGGTGCTGCGGC	Canvas core staple with pixels
Print_can_core56	CACTCATGAAGGCACCAACCTAAAAGGAAT	Canvas core staple with pixels
Print_can_core57	AGCGCGAACATTAAACGGGTAAAATGAAAATC	Canvas core staple with pixels
Print_can_core58	TCATCGCCAGGACTAAAGACTTTTAGCCTTTA	Canvas core staple with pixels
Print_can_core59	GACCTGCTAACGAGGGTAGCAACTTCGAGG	Canvas core staple with pixels
Print_can_core60	AGCATCGGCCATGTTACTTCGGCATCAGATGC	Canvas core staple with pixels
Print_can_core61	CGGGTTACGTCACCCTCAGCAGCGATAGTT	Canvas core staple with pixels
Print_can_core62	CCCTGCATTTGCAGGGAGTTAAAGCGCCCACG	Canvas core staple with pixels
Print_can_core63	TGCGCGCCAGGATCCCCGGGTACCGAGCTTCG	Canvas core staple with pixels
Print_can_core64	CAGAATGCTTCTTCGCGTCCGTGAGAAATTGT	Canvas core staple with pixels
Print_can_core65	CAACTTTCAATAATTTTTTCACGTTACGTAAT	Canvas core staple with pixels
Print_can_core66	AAATGAAAAAGGCTCCAAAAGGTCATGAGG	Canvas core staple with pixels
Print_can_core67	TCTAAAGTGGTTTATCAGCTTGCTGGCTACAG	Canvas core staple with pixels
Print_can_core68	CCACAGACTTAAACAGCTTGATACCGAAAGAC	Canvas core staple with pixels
Print_can_core69	ATGAATCGCAATGACAACAACCATGCCGCTTT	Canvas core staple with pixels
Print_can_core70	ATTAATTGAGCTGTTTCCTGTGTGCCTCCT	Canvas core staple with pixels
Print_can_core71	CCTGGGGTCACAATTCCACACAACCCAGCACG	Canvas core staple with pixels
Print_can_core72	TGCGAATAACAGTTTCAGCGGAACCCTCAG	Canvas core staple with pixels
Print_can_core73	TCCAAAAATTTTCTGTATGGGATTCCCTCATT	Canvas core staple with pixels
Print_can_core74	ATTGTATCTTTGTCGTCTTTCCAGGAACCCAT	Canvas core staple with pixels
Print_can_core75	TGAATTTCAGCCCTCATAGTTAGCCAGTAC	Canvas core staple with pixels
Print_can_core76	CATAACCGAAACCTGTCGTGCCAGCACCAGTG	Canvas core staple with pixels
Print_can_core77	AGTCGGGATATATTCGGCGAATTCGTAATC	Canvas core staple with pixels
Print_can_core78	ATGGTCATCGTTGCGCTCACTGCCTTCACCGC	Canvas core staple with pixels

Print_can_core79	TATCCGCTGCCTAATGAGTGAGCTAGCGGTCC	Canvas core staple with pixels
Print_can_core80	AACCGCCACTCAGGAGGTTTAGGACGATTG	Canvas core staple with pixels
Print_can_core81	TTCAGGGAATAAGTATAGCCCGGAAATCCTCA	Canvas core staple with pixels
Print_can_core82	GTACCGTACAGGCGGATAAGTGCCGTCTCTGA	Canvas core staple with pixels
Print_can_core83	AAACTACAGGATTAGGATTAGCGACATGGC	Canvas core staple with pixels
Print_can_core84	CAAGAGAAACGCCTGTAGCGGTTTGCGTATTG	Canvas core staple with pixels
Print_can_core85	GGCGCCAAGTATTAAGAGGCTGGTAATAAG	Canvas core staple with pixels
Print_can_core86	AGACGGGCCTATTTCGGAACCTATGTAACAGT	Canvas core staple with pixels
Print_can_core87	CTGGCCCTAGGGTTGAGTGTTGTTCCAGTTGC	Canvas core staple with pixels
Print_can_core88	ACGCTGGTTCCCTTATAAATCAAACAACGTCA	Canvas core staple with pixels
Print_can_core89	CCACCAGATATTCACAAACAAATAATAGGTGT	Canvas core staple with pixels
Print_can_core90	GCCACCAAGAATGGAAAGCGCAGTCGAGAG	Canvas core staple with pixels
Print_can_core91	GAGCCGCCTTCCAGTAAGCGTCATGGGTTTTG	Canvas core staple with pixels
Print_can_core92	ACCAGAGCATACAGGAGTGTACTGAGACTCCT	Canvas core staple with pixels
Print_can_core93	AACGTGGCGGGGTCAGTGCCTTGATATTCTGA	Canvas core staple with pixels
Print_can_core94	AAAGCACTAAAGAACGTGGACTCAGAATAG	Canvas core staple with pixels
Print_can_core95	CAAATCAAAAAACCGTCTATCAGGTCCGAAAT	Canvas core staple with pixels
Print_can_core96	GCCTTGAGCCGCCGCCAGCATTGTAATCAG	Canvas core staple with pixels
Print_can_core97	TTAAAGCCCCCTCAGAGCCGCCACTTAGCGTC	Canvas core staple with pixels
Print_can_core98	ATTTACCGACCCTCAGAACCGCCACATTTTCG	Canvas core staple with pixels
Print_can_core99	TTTTGATGCACCACCGGAACCGCGCCATCT	Canvas core staple with pixels
Print_can_core100	GCCCGTATAGAGCTTGACGGGGAACGGTCACG	Canvas core staple with pixels
Print_can_core101	CCGATTTAAACAGTTAATTGGAACAAGAGT	Canvas core staple with pixels
Print_can_core102	CCACTATTAAATCGGAACCCTAAACGCGCTTA	Canvas core staple with pixels
Print_can_core103	AAGGGCGAGTTTTTTGGGGTCGAGTATGGTTG	Canvas core staple with pixels
Print_can_core104	TAGCGACCGGAAACGTCACCAAGAAACCGA	Canvas core staple with pixels
Print_can_core105	AGACTGTAATCACCAGTAGCACCACCCAAAAG	Canvas core staple with pixels
Print_can_core106	GTCATAGCCTTGAGCCATTTGGGAATTACGCA	Canvas core staple with pixels
Print_can_core107	TTTCATAATTCATTAAAGGTGAACATACAT	Canvas core staple with pixels
Print_can_core108	GGAAATTATCAAAATCACCCGAAAGGAGCGGG	Canvas core staple with pixels
Print_can_core109	CGCTAGGAGGGAGGGAAGGTAACGCAAAGA	Canvas core staple with pixels
Print_can_core110	CTGCGCGTCCAAAGACAAAAGGGCTCACAATC	Canvas core staple with pixels
Print_can_core111	ATGCGCCGTACGCCAGAATCCTGAGAAGTTTT	Canvas core staple with pixels
Print_can_core112	CTTTGACGGGCCGATTAAAGGGATCTGTCCAT	Canvas core staple with pixels
Print_can_core113	CTTTTTAACAATAATAACGGAATATTACCATT	Canvas core staple with pixels
Print_can_core114	ATGAAATTGATTAAGACTCCTTATTAGAGC	Canvas core staple with pixels
Print_can_core115	TGAGTTAAGCAAACGTAGAAAATATTATCACC	Canvas core staple with pixels
Print_can_core116	CGCTAATACAACATATAAAAGAAAATATTGAC	Canvas core staple with pixels
Print_can_core117	ATACCTACGAATAAGTTTATTTTGGACATTCA	Canvas core staple with pixels
Print_can_core118	TTGCTGGTACCGAGTAAAAGAGTTTTAGAC	Canvas core staple with pixels
Print_can_core119	TGCCTGAGTTAACCGTTGTAGCAACGGGAGCT	Canvas core staple with pixels
Print_can_core120	GGAAACGGAAAAGTAAGCAGATTTTTTTGT	Canvas core staple with pixels
Print_can_core121	AACTGGCAAGCAATAGCTATCTTAAGCCTTTA	Canvas core staple with pixels
Print_can_core122	GTATGTTAGCCCAATAATAAGAGCGGAAGCGC	Canvas core staple with pixels
Print_can_core123	AAAGGTGGTCAGAGAGATAACCCACCCTGA	Canvas core staple with pixels
Print_can_core124	AATAGAAAGCAACAGGAAAAACGCCACGACCA	Canvas core staple with pixels
Print_can_core125	AGCCATTATTCATATGGGTTTTTATAATCA	Canvas core staple with pixels
Print_can_core126	GTGAGGCCAATATCCAGAACAATAAACAGAGA	Canvas core staple with pixels
Print_can_core127	CACGCAAATAGAAGAACTCAAACTGTAAGAAT	Canvas core staple with pixels
Print_can_core128	TTAACGTCAGCCATATTATTTACATCCTAA	Canvas core staple with pixels
Print_can_core129	CAGAGAGATCCAGAGCCTAATTTGCAATAATC	Canvas core staple with pixels
Print_can_core130	ATTAGACGCCTGAATCTTACCAACAGAACGGG	Canvas core staple with pixels
Print_can_core131	ACAAAGTCGTTGCTATTTTGCACCGAGAAC	Canvas core staple with pixels
Print_can_core132	CAAGATTAAGAGGGTAATTGAAATGGATTATT	Canvas core staple with pixels
Print_can_core133	TACATTGCGGGAGGTTTTGAAGGTAGGAAT	Canvas core staple with pixels
Print_can_core134	GTAATAAAACGCGAGGCGTTTTAGAAATCAGA	Canvas core staple with pixels
Print_can_core135	TAGAACCCCCACCAGCAGAAGATAAAACATAT	Canvas core staple with pixels
Print_can_core136	ACGTGGCATAAAACATCGCCATTAGTGCCACG	Canvas core staple with pixels
Print_can_core137	TGTTTATCGCATGTAGAAACCAATCCAGTTAC	Canvas core staple with pixels
Print_can_core138	AACAACATTCCTTATCATTCCAGCTAACGA	Canvas core staple with pixels
Print_can_core139	GGTAAAGTCAAGTACCGCACTCATCCAGCTAC	Canvas core staple with pixels
Print_can_core140	AGTAATAACGTTTTTATTTTCATCCCTTAAAT	Canvas core staple with pixels
Print_can_core141	CAACTAATGCGCCCAATAGCAAGCCGAACCTC	Canvas core staple with pixels
Print_can_core142	TTGGCAAAACACCGCCTGCAACAAAAATAC	Canvas core staple with pixels
Print_can_core143	AATATCAACAGCAGCAAATGAAAACGCGAACT	Canvas core staple with pixels
Print_can_core144	AGGTTATGCTTATCCGGGAGGTGAGGCGGT	Canvas core staple with pixels
Print_can_core145	AAAATAAACAAAAATGAAAATAGCCCGAAGCCCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core146	AAACAGGAAGCACGTATAACGTGCCCATCACCCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core147	AACATCCAGCCTTTATTTCAACGATATTCACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core148	AACATGAAGGGTGGTTTTTCTTTTCTGCATTACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core149	AAGAGCACAATACTGCGGAATCTTGCATCACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core150	AAGGCGATGCCTCTTCGCTATTACGTAACAACCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core151	AAGTTTCACAAAGTACAACGGAGAGGACAGCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core152	AATACCGCAACAGTAGGGCTTACGACAATACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core153	AATTAATTTCAATATATGTGAGTGGGCGTTAA	Canvas core staple with pixels
Print_can_core154	AATTTTATGGAGAATTAACTGAACACAAGAATCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core155	ACAGTCAACATTAATT	Canvas core staple with pixels
Print_can_core156	ACATAAAACATTTAACAATTTCATTTGAATTACTT	Canvas core staple with pixels
Print_can_core157	ACATAACGGAATCCCCCTCAAATGACCCTGACCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core158	ACCAGCGAACCACCACACCCGCGGGAGCCCCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core159	ACCGATTGGCGCTGGCAAGTGTAGAGCCGGCGCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core160	ACCGTTCACTAGCATGTCAATC	Canvas core staple with pixels

Print_can_core161	ACGTTAAATGAAGGGTAAAGTTAGACGCAGCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core162	AGACAGTCATAATCAGAAAAGCCC	Canvas core staple with pixels
Print_can_core163	AGACGACGGTAATAGTAAAATGTTAGACTTCACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core164	AGATGGGTTAAATCAGCTCATT	Canvas core staple with pixels
Print_can_core165	AGCAAGGCAGAATCAAGTTTGCCTCAGAACCACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core166	AGGAACGGCTACAGGGCGCGTACGTGCCGTCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core167	AGGCTTTGTGATAAATTGTGTCGATCATAAGGCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core168	AGGTTGGCGTATTAAATCCTTTATTGAGGACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core169	AGTACGGCAGCAGTTGGGCGGTTGTGTGACCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core170	ATAAGAATATACAAATTCTTACCAAACGCGCCCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core171	ATAATCCTTTTTAAAAGTTTGAGTGGTCAGCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core172	ATCACCGTACCCTCAGAGCCACCATTGCTAAACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core173	ATGAATATAACCTCCGGGAATAATGGAAGG	Canvas core staple with pixels
Print_can_core174	ATGCGTTAAACACCGGAATCATGAAACAGTTTATACATCTA	Canvas core staple with pixels
Print_can_core175	ATTGACCGCGCCATCAAAAATAA	Canvas core staple with pixels
Print_can_core176	ATTGTAAACGTTGGACGACGACAGTATCGGCCGTACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core177	CACAGTTGTGTGCACTCTGTGGTATGAGCCCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core178	CACCACGATTTTGACGCTCAATCGTCTGAGCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core179	CAGCAAAGCGCGTTTTCATCGGCCCTCAGACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core180	CATTACCAGATTAGAGCCGTCAATAGAGCCCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core181	CATTTCGCCCAGCTTTCCGGCACCATCTGCCACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core182	CCAACGCTACCGTGTGATAAATAAAATAACCTTTATACATCTA	Canvas core staple with pixels
Print_can_core183	CCCCTGCAACAGCTGATTGCCCCGCTTTCCCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core184	CCCGAGATGAGAGAGTTGCAGCAAACTCACCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core185	CCGACTTGGCAGATTCACCAGTCATCATGGAACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core186	CCGTCGGACTGTAGCCAGCTTTCAGAA	Canvas core staple with pixels
Print_can_core187	CGAACGAATTCTGACCTGAAAGCATCGGCCCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core188	CGACAACTGTTATATAACTATATGTGAGAGACTTATACATCTA	Canvas core staple with pixels
Print_can_core189	CGGCAAAATTGCCCCAGCAGGCGAGTGTAAAGCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core190	CGTGCCGGTCGTCGCTGGCAGCCTAGTCCCGGCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core191	CGTGCCTGGGCGGGCCGTTTTCACTTCGCACTCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core192	CTCAGTACACACTGAGTTTCGTCACGTAACGACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core193	CTGAGGCCAGACGATCCAGCGCTAATGGGTCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core194	CTGGTCTGCGTTCCGGCAAACGCCGTGGTGCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core195	GAACGAGACCAGGCAAAGCGCCGTTGGTGTCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core196	GAAGATGTAAATCGTCGCTATTTGGTTTGA	Canvas core staple with pixels
Print_can_core197	GAATTAGCACATTATGACCCTGTAGCCGGAGACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core198	GATAGCCCCAGACAATATTTTTGAACATCACTCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core199	GATGCAAAAAGTATTAGACTTTACAGCACTAACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core200	GATTTAGTCCAATCGCAAGACAGTCAATAGTTATACATCTA	Canvas core staple with pixels
Print_can_core201	GATTTTATGTGTTCAGCAAATCGTTAAAGCCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core202	GCCACTACCTTTGACCCCCAGCGACATAGGCTCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core203	GCGAATTAGAATCCTTGAAAACATTTAGTTAA	Canvas core staple with pixels
Print_can_core204	GCGCCGAGCCAACGCGCGGGGAGAGGCATTCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core205	GCGTCTTATAACATAAAAACAGAAGAAACACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core206	GCTTAGATCCAAGTTACAAAATCGCGCAGAG	Canvas core staple with pixels
Print_can_core207	GGGAGAAAATCAAAATCATAGGTCTAAATGCT	Canvas core staple with pixels
Print_can_core208	GGGTAGCTAAACAAGAGAATCGAT	Canvas core staple with pixels
Print_can_core209	GGTAAAGATGTATAAGCAAATATT	Canvas core staple with pixels
Print_can_core210	GGTTGATTAGCAAGCCCAATAGACGTTAGTCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core211	GTCACCGACCCCTTATTAGCGTTTCTCCCTCACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core212	GTGGCATCTTAGAACCCTCATATAAAGGCCGGCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core213	GTTAGAACGTAGATTTTCAGGTTTAACGTCAG	Canvas core staple with pixels
Print_can_core214	GTTATTAAGATTGTTTGGATTATACTTCTCTT	Canvas core staple with pixels
Print_can_core215	GTTTGAGGAATATTTTGTTAAAAT	Canvas core staple with pixels
Print_can_core216	TACCTTTTTACAGTAACAGTACCTTTTACATC	Canvas core staple with pixels
Print_can_core217	TAGGCAGATTTTTCAAATATATTAGCGATATTATACATCTA	Canvas core staple with pixels
Print_can_core218	TATTACAGCGTAAAAAAAGCCGCATCTGCTCACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core219	TCATTTTGTCAGATGATGGCAATTTATTTGCACTT	Canvas core staple with pixels
Print_can_core220	TCCCAGTCGCGCAACTGTTGGGAACGGCGGCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core221	TCGCCATATCTGACCTAAATTTAAAATTAATTTTATACATCTA	Canvas core staple with pixels
Print_can_core222	TCTAAGAAGGGACATTCTGGCCTTACCGCCCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core223	TGAATTTCAATAACGGATTCGCCTGATTGC	Canvas core staple with pixels
Print_can_core224	TGCGGGATCCTGCAGCCAGCGGTGACATCCCTCGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core225	TGCTTCTGATGAAACAAACATCAAGAAAACAA	Canvas core staple with pixels
Print_can_core226	TTAAAGCCTGTTTCTGAACAAGAATT	Canvas core staple with pixels
Print_can_core227	TTAAATAATATCCTCCCAATCCAATT	Canvas core staple with pixels
Print_can_core228	TTAAGGAACAACTAAACGAAAGAGTT	Canvas core staple with pixels
Print_can_core229	TTAGAATCAGAGTACTTCTTTGTT	Canvas core staple with pixels
Print_can_core230	TTATAAAGCTAAAACAAAGGCTATTT	Canvas core staple with pixels
Print_can_core231	TTATAAGAAACGAAGCCGAACAAATT	Canvas core staple with pixels
Print_can_core232	TTATGTGAGCGAGCCAGCTGGCTT	Canvas core staple with pixels
Print_can_core233	TTCAGGTCATTGCGGAT	Canvas core staple with pixels
Print_can_core234	TTCATGTTTACCCCGGCCAGAGTT	Canvas core staple with pixels
Print_can_core235	TTCCCTTATTCATTTCAATTACCTGAGCAAAA	Canvas core staple with pixels
Print_can_core236	TTCCGGATATTCAGCGAGAGGCTTTT	Canvas core staple with pixels
Print_can_core237	TTGAAGCATAAAAAATCCTGTTTT	Canvas core staple with pixels
Print_can_core238	TTGAGGCAGGTCATACCGCCACCCTT	Canvas core staple with pixels
Print_can_core239	TTGCAAAAGAATACTTGACAAGAATT	Canvas core staple with pixels
Print_can_core240	TTGGGGTTTCTGATACGAGCCGTT	Canvas core staple with pixels
Print_can_core241	TTGTAAAACAGAAATAAAGAAATTGCCTACCATATCAAAATCATCAAT	Canvas core staple with pixels
Print_can_core242	TTGTCTTTAATGATCTAAAGCATT	Canvas core staple with pixels

Print_can_core243	TTGTTACCAGAAGTGAAACCATCGTT	Canvas core staple with pixels
Print_can_core244	TTTCACCTTGCTCCAGAAGGAGTT	Canvas core staple with pixels
Print_can_core245	TTTCATCTTTTAACAACGCCAACACGACAAAACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core246	TTTGAATATAAGACGCTGAGAAGAAAGAACGC	Canvas core staple with pixels
Print_can_core247	TTTGATGGTGGTGCGATGGCCCTT	Canvas core staple with pixels
Print_can_core248	TTTGCAGGCGCTGGTCATACCGTT	Canvas core staple with pixels
Print_can_core249	TTTTAACGAGAAAGGAAGGGAAGAAAGGGACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Print_can_core250	TTTTGCAAAAGAATCAAAGCGAACTT	Canvas core staple with pixels
Print_can_core251	TTCGGAATTATCATCATATTCCTGATTACGGAACAAAGAAACCAGAACCTCACGTAGAGATTATATCGGGTCACGATTCAGTACCG	Canvas core staple with pixels
Frame_linker1	TTATTAGTAATAATGGCTATTATACGCTAGTAA	Canvas linkers to frame
Frame_linker2	TTACTACGTGAATTTCCTCGTTTCGTGAACTAA	Canvas linkers to frame
Frame_linker3	TTCACATCCTCAGCGGGGTCATTGTTCACGAAA	Canvas linkers to frame
Frame_linker4	TTGAAAGGGGGACGTACAGCGCTGCACATGTAA	Canvas linkers to frame
Frame_linker5	TTCAGACCGGAAGAGCCTCAGAGCTCGAATGCTAA	Canvas linkers to frame
Frame_linker6	TTTCAGAACCGCCGTGAGAATAGATATACTGCGAA	Canvas linkers to frame
Frame_linker7	TTATAGCAGCACCGACAGGAGGTTTCGATGTCAAA	Canvas linkers to frame
Frame_linker8	TTCTTTTTTAATGAATTACTAGAATGAACGTCTAA	Canvas linkers to frame
R3_ink	CTCTCTCTCTCTGAATCGTGACCCGATATAATCTCTACG	Ink strand with R3 DNA-PAINT site
Pixel blocker	TGAATCGTCGATATAATCTCTACG	Blocking strand for pixels

Supplementary table 5. Staple sequences for sleeve.

Name	Sequence	Description
Sleeve_core1	TTTAAGTATAGCCCAGTACCGCCACTTT	Core staples of sleeve
Sleeve_core2	ATCACAGGATGGATTCGTACTCAGGAGGTTTGGAATAGGTGT	Core staples of sleeve
Sleeve_core3	TTTCCTCAAGAGAATAGCGGGGTTTTTT	Core staples of sleeve
Sleeve_core4	TTTCCTCAGAACCGGTTAGTAAATGTTT	Core staples of sleeve
Sleeve_core5	AGCAAGCCGCCACCACCCTCAATTCTGAACAGACCCTTCACATGAAAGTATTAAGAACCTATT	Core staples of sleeve
Sleeve_core6	TTTCAGACAGCCCTCATAGTTTTTTGCCTATTTCGGAGGCTGAGGCGTAACGATCTA	Core staples of sleeve
Sleeve_core7	TTTCCACCCTCAGACAATAGGAACCTTTTTTAATTTTCTGTAAGCGGAGTGAGAATAGAAAGGATTT	Core staples of sleeve
Sleeve_core8	CTTAGGCTAGCATTTCATGTACCGTAACACTGAGTTTCGTTTCAACAGTTTCTGGGATTTTGCTA	Core staples of sleeve
Sleeve_core9	GCGGAAGCCACGCGCTGCTTTAACACAGTTATAAAACTCACCAGTACAAACTACAATTT	Core staples of sleeve
Sleeve_core10	TTTAACAGTGCCCGTAATGCCCCCTTTCCTCCTCCTCCTCCT	Core staples of sleeve
Sleeve_core11	TTTACAACTAAAGGAATTGCGAATACACGTTGAAAATTT	Core staples of sleeve
Sleeve_core12	ACGGGGTCAGAGTGTACTGGTAATATTTTTATAATAGTTTTA	Core staples of sleeve
Sleeve_core13	TTTTGATGATACAGGTGCCTTGAGTTTCCTCCTCCTCCTCCT	Core staples of sleeve
Sleeve_core14	TTTTCTCCAAAAAACGGAACGAGGGTTT	Core staples of sleeve
Sleeve_core15	TTTCGAGGTGAATTATCGGTTTATCACGAAAGACAGCATAAATCGTCACCCT	Core staples of sleeve
Sleeve_core16	CAGCGTCAGTAAGCAG	Core staples of sleeve
Sleeve_core17	GCTATTCGGTCGCTGAGGCTTTTTTTTACCGTTCCATACATGGCCAGGGAGTTAAAGG	Core staples of sleeve
Sleeve_core18	TTTGCCTTTAATTGTTCTTAAACAGTTTTTTTAGCAACGGCTTGAGGACTAAATTT	Core staples of sleeve
Sleeve_core19	TTTCTTGATACCGATAGTTGCGCCGACCATTAAAGGGCTTACAGACCAGAATG	Core staples of sleeve
Sleeve_core20	CGGGATGCGTCGATGTCGTTTGAAAGCGCTAAATCCTAATGACAACAACCATCGCCTTT	Core staples of sleeve
Sleeve_core21	TTTTCACAAACAAAAGTCTCTGAATTTCCTCCTCCTCCTCCT	Core staples of sleeve
Sleeve_core22	TTTGACTTTTTCATAATGCCACTACTTT	Core staples of sleeve
Sleeve_core23	TTACGATTTCAGAAACGGGTAAAATACGTGAGGAAGTTTCCA	Core staples of sleeve
Sleeve_core24	TTTGTTGAGGCAGGGGCCTTGATATTTCCTCCTCCTCCTCCT	Core staples of sleeve
Sleeve_core25	TTTGAAGGCACCAAACGTCACCAATTTT	Core staples of sleeve
Sleeve_core26	CCAAGCGCCATCTTTGACCCCACCACCACCGGAACCGGCCAGAGCCG	Core staples of sleeve
Sleeve_core27	CCGCCAGCCCACCAGA	Core staples of sleeve
Sleeve_core28	CAGGAATTAGAGCCAGCAATTTTTTCCTCAGAGCCGATTGACAGCACCAGTAGCACC	Core staples of sleeve
Sleeve_core29	TACACTAAAACACTGAAACAAAGTATTTTTTGAAACCATCGAAGTTTGCCTTTTTT	Core staples of sleeve
Sleeve_core30	TTTCAACGGAGATTTTATTCATTAAAGAGCGACAGAATCATAGCAGCACCGTA	Core staples of sleeve
Sleeve_core31	CGCAATCCTCACCCTACGTTTATCCCCTCCGCCAAGTGTGAATTATCACCGTCACCTTT	Core staples of sleeve
Sleeve_core32	TTTACCCTCAGAACAGAGCCACCACTTCCTCCTCCTCCTCCT	Core staples of sleeve
Sleeve_core33	TTTAGCGTCAGACTTTCATCGGCATTTT	Core staples of sleeve
Sleeve_core34	GCCTCCCCGGAACCAGAGCCACCGCGTTGTAGCACCGGAACC	Core staples of sleeve
Sleeve_core35	TTATCAAAATCACTCAGAGCCGCCTT	Core staples of sleeve
Sleeve_core36	CCGCTTTTGCGGGGGCTCCAAAAGGATTGCACCAAAAAAAAAAAAAAAAAAAAA	Core staples of sleeve
Sleeve_core37	AAGTTTTGTCGTCTACCCTCAGAACCGTTGCACCAAAAAAAAAAAAAAAAAAAAA	Core staples of sleeve
Sleeve_core38	TTCAAGCTCAGGTTTCGCCTGTAGCATTCCATCAGGGAT	Core staples of sleeve
Sleeve_core39	ATTACCATTAGCAATAAAACGAAAGAG	Core staples of sleeve
Sleeve_core40	TTTGACTTGAGCCATTTGGCGATTATA	Core staples of sleeve
Seam_1	GCCCCCTTATTGCCGTCGAGAGGGTTGATATTTTCGGTCATA	Seam staples to close sleeve
Seam_2	AGGCGGATAAGTAGCGTTTGCCATCTTTTCATATGCTCAGTACC	Seam staples to close sleeve
p1496_dig1	GTACAACGGAGATTTGTATCATCGCCTGAT	Enzyme digestion region strands
p1496_dig2	TGACGGAAATTATTCATTAA	Enzyme digestion region strands
WH_staple	ATTTCACGCATAACCGATATTGCTTTCGGTACTGAATC	Strand to add write-head functionality
Bead_invader	TTTTTTTTTTTTTTTTTTTTTGGTGCAA	Invader to release sleeve from magnetic beads
Invader_1	TACCTCCACGCAATCCTCACCCTACG	Invader to release closed sleeve on rail
Invader_2	ATCACCTACGGGATGCGTCGATGTCG	Invader to release closed sleeve on rail
Invader_3	CCACTCACGCGGAAGCCACGCGCTGC	Invader to release closed sleeve on rail
		Invader to release closed sleeve on rail

Supplementary table 6. Sequence of linker and invader strands.

Name	Sequence	Description
Linker ZF-W	TGCTGCCCTGAGCTTGAACTAGGCCATTGA	Link sleeve site 1
Linker ZF-X	TGCTGCCCTGAGCTTGAACTACATTCGGAG	Link sleeve site 2
Linker ZF-Y	TGCTGCCCTGAGCTTGAACCGAGACTTTGA	Link sleeve site 3
Linker ZF-Z	TGCTGCCCTGAGCTTGAATTGCAAGAGTCC	Link sleeve site 4
Linker ZF-ZA	TGCTGCCCTGAGCTTGAATATAACGGTGCC	Link sleeve site 5
Linker ZF-ZB	TGCTGCCCTGAGCTTGAAGGTAACATCGCT	Link sleeve site 6
Linker ZF-ZC	TGCTGCCCTGAGCTTGAAGTTCAAGAGCCT	Link sleeve site 7
Linker ZG-Y	GCAGCATGCTAGCCTAAGCCGAGACTTTGA	Link sleeve site 1
Linker ZG-Z	GCAGCATGCTAGCCTAAGTTGCAAGAGTCC	Link sleeve site 2
Linker ZG-ZA	GCAGCATGCTAGCCTAAGTATAACGGTGCC	Link sleeve site 3
Linker ZG-ZB	GCAGCATGCTAGCCTAAGGGTAACATCGCT	Link sleeve site 4
Linker ZG-ZC	GCAGCATGCTAGCCTAAGGTTCAAGAGCCT	Link sleeve site 5
Linker ZG-ZD	GCAGCATGCTAGCCTAAGTACGGAGCCTTA	Link sleeve site 6
Linker ZG-ZE	GCAGCATGCTAGCCTAAGTAATCGTAGGCC	Link sleeve site 7
Invader ZF-W	TCAATGGCCTAGTTCAAGCTCAGGGCAGCA	Release sleeve site 1
Invader ZF-X	CTCCGAATGTAGTTCAAGCTCAGGGCAGCA	Release sleeve site 2
Invader ZF-Y	TCAAAGTCTCGGTTCAAGCTCAGGGCAGCA	Release sleeve site 3
Invader ZF-Z	GGACTCTTGCAATTCAAGCTCAGGGCAGCA	Release sleeve site 4
Invader ZF-ZA	GGCACCGTTATATTCAAGCTCAGGGCAGCA	Release sleeve site 5
Invader ZF-ZB	AGCGATGTTACCTTCAAGCTCAGGGCAGCA	Release sleeve site 6
Invader ZF-ZC	AGGCTCTTGAACTTCAAGCTCAGGGCAGCA	Release sleeve site 7
Invader ZG-Y	TCAAAGTCTCGGCTTAGGCTAGCATGCTGC	Release sleeve site 1
Invader ZG-Z	GGACTCTTGCAACTTAGGCTAGCATGCTGC	Release sleeve site 2
Invader ZG-ZA	GGCACCGTTATACTTAGGCTAGCATGCTGC	Release sleeve site 3
Invader ZG-ZB	AGCGATGTTACCCTTAGGCTAGCATGCTGC	Release sleeve site 4
Invader ZG-ZC	AGGCTCTTGAACCTTAGGCTAGCATGCTGC	Release sleeve site 5
Invader ZG-ZD	TAAGGCTCCGTACTTAGGCTAGCATGCTGC	Release sleeve site 6
Invader ZG-ZE	GGCCTACGATTACTTAGGCTAGCATGCTGC	Release sleeve site 7
Linker A-S	TGCTGCATCGGTAAGCTCTATAGACTCGCG	Arm site A Linker
Linker B-T	TGCTGCTCTAAGCTACGGATAGACCCGTTG	Arm site A Linker
Linker J-U	TGCTGCCGTTCTAAAGGCGATCCCAGGTAT	Arm site A Linker
Linker K-V	TGCTGCGGATCGCTACATGGTATCTCAGCA	Arm site A Linker
Linker B-S	TGCTGCATCGGTAAGCTCATAGACCCGTTG	Arm site B Linker
Linker C-T	TGCTGCTCTAAGCTACGGCTCGAACATTGG	Arm site B Linker
Linker K-U	TGCTGCCGTTCTAAAGGCGGTATCTCAGCA	Arm site B Linker
Linker L-V	TGCTGCGGATCGCTACATGCTCCTGGTAAA	Arm site B Linker
Linker C-S	TGCTGCATCGGTAAGCTCCTCGAACATTGG	Arm site C Linker
Linker D-T	TGCTGCTCTAAGCTACGGATCATTCAGGGC	Arm site C Linker
Linker L-U	TGCTGCCGTTCTAAAGGCGCTCCTGGTAAA	Arm site C Linker
Linker M-V	TGCTGCGGATCGCTACATGAATGCGTACCT	Arm site C Linker
Linker D-S	TGCTGCATCGGTAAGCTCATCATTCAGGGC	Arm site D Linker
Linker E-T	TGCTGCTCTAAGCTACGGTCGTCATAAGGC	Arm site D Linker
Linker M-U	TGCTGCCGTTCTAAAGGCGAATGCGTACCT	Arm site D Linker
Linker N-V	TGCTGCGGATCGCTACATGATATCAGGCCT	Arm site D Linker
Linker E-S	TGCTGCATCGGTAAGCTCTCGTCATAAGGC	Arm site E Linker
Linker F-T	TGCTGCTCTAAGCTACGGCAGGTCATCAGT	Arm site E Linker
Linker N-U	TGCTGCCGTTCTAAAGGCGATATCAGGCCT	Arm site E Linker
Linker O-V	TGCTGCGGATCGCTACATGAATTGCACCTG	Arm site E Linker
Linker F-S	TGCTGCATCGGTAAGCTCCAGGTCATCAGT	Arm site F Linker
Linker G-T	TGCTGCTCTAAGCTACGGCTATGAACCGTG	Arm site F Linker
Linker O-U	TGCTGCCGTTCTAAAGGCGAATTGCACCTG	Arm site F Linker
Linker P-V	TGCTGCGGATCGCTACATCTATCGGGAACT	Arm site F Linker
Linker G-S	TGCTGCATCGGTAAGCTCCTATGAACCGTG	Arm site G Linker
Linker H-T	TGCTGCTCTAAGCTACGGGATTTACGGCAC	Arm site G Linker
Linker P-U	TGCTGCCGTTCTAAAGGCCTATCGGGAACT	Arm site G Linker
Linker Q-V	TGCTGCGGATCGCTACATCTGAAATGCTGC	Arm site G Linker
Linker H-S	TGCTGCATCGGTAAGCTCGATTTACGGCAC	Arm site H Linker
Linker I-T	TGCTGCTCTAAGCTACGGTCGGACAGTACT	Arm site H Linker
Linker Q-U	TGCTGCCGTTCTAAAGGCCTGAAATGCTGC	Arm site H Linker
Linker R-V	TGCTGCGGATCGCTACATGTAAATCGTCGC	Arm site H Linker
Invader A-S	CGCGAGTCTATAGAGCTTACCGATGCAGCA	Arm site A invader
Invader B-T	CAACGGGTCTATCCGTAGCTTAGAGCAGCA	Arm site A invader
Invader J-U	ATACCTGGGATCGCCTTTAGAACGGCAGCA	Arm site A invader
Invader K-V	TGCTGAGATACCATGTAGCGATCCGCAGCA	Arm site A invader

Invader B-S	CAACGGGTCTATGAGCTTACCGATGCAGCA	Arm site B invader
Invader C-T	CCAATGTTCGAGCCGTAGCTTAGAGCAGCA	Arm site B invader
Invader K-U	TGCTGAGATACCGCCTTTAGAACGGCAGCA	Arm site B invader
Invader L-V	TTTACCAGGAGCATGTAGCGATCCGCAGCA	Arm site B invader
Invader C-S	CCAATGTTCGAGGAGCTTACCGATGCAGCA	Arm site C invader
Invader D-T	GCCCTGAATGATCCGTAGCTTAGAGCAGCA	Arm site C invader
Invader L-U	TTTACCAGGAGCGCCTTTAGAACGGCAGCA	Arm site C invader
Invader M-V	AGGTACGCATTCATGTAGCGATCCGCAGCA	Arm site C invader
Invader D-S	GCCCTGAATGATGAGCTTACCGATGCAGCA	Arm site D invader
Invader E-T	GCCTTATGACGACCGTAGCTTAGAGCAGCA	Arm site D invader
Invader M-U	AGGTACGCATTCGCCTTTAGAACGGCAGCA	Arm site D invader
Invader N-V	AGGCCTGATATCATGTAGCGATCCGCAGCA	Arm site D invader
Invader E-S	GCCTTATGACGAGAGCTTACCGATGCAGCA	Arm site E invader
Invader F-T	ACTGATGACCTGCCGTAGCTTAGAGCAGCA	Arm site E invader
Invader N-U	AGGCCTGATATCGCCTTTAGAACGGCAGCA	Arm site E invader
Invader O-V	CAGGTGCAATTCATGTAGCGATCCGCAGCA	Arm site E invader
Invader F-S	ACTGATGACCTGGAGCTTACCGATGCAGCA	Arm site F invader
Invader G-T	CACGGTTCATAGCCGTAGCTTAGAGCAGCA	Arm site F invader
Invader O-U	CAGGTGCAATTCGCCTTTAGAACGGCAGCA	Arm site F invader
Invader P-V	AGTTCCCGATAGATGTAGCGATCCGCAGCA	Arm site F invader
Invader G-S	CACGGTTCATAGGAGCTTACCGATGCAGCA	Arm site G invader
Invader H-T	GTGCCGTAAATCCCGTAGCTTAGAGCAGCA	Arm site G invader
Invader P-U	AGTTCCCGATAGGCCTTTAGAACGGCAGCA	Arm site G invader
Invader Q-V	GCAGCATTTCAGATGTAGCGATCCGCAGCA	Arm site G invader
Invader H-S	GTGCCGTAAATCGAGCTTACCGATGCAGCA	Arm site H invader
Invader I-T	AGTACTGTCCGACCGTAGCTTAGAGCAGCA	Arm site H invader
Invader Q-U	GCAGCATTTCAGGCCTTTAGAACGGCAGCA	Arm site H invader
Invader R-V	GCGACGATTTACATGTAGCGATCCGCAGCA	Arm site H invader