Electronic Supplementary Information for

Assembling Gold Nanobipyramids into Chiral Plasmonic Nanostructures by DNA Origami

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Experimental section

1. Materials

Gold chloride trihydrate ($HAuCl_4 \cdot 3H_2O$, >99%) was purchased from Sinopharm Chemical Reagent Co, Ltd (Shanghai, China). Cetyltrimethylammonium bromide (CTAB, >99%), sodium dodecyl sulfate (SDS), citric acid (>99%), cetyltrimethylammonium chloride (CTAC, 97%) were obtained from Sigma Aldrich. Sodium borohydride ($NaBH_4$, 99%), 5-Bromosalicylic acid (5-BrSA), silver nitrate ($AgNO_3$), tris(2-carboxyethyl) phosphine (TCEP) was purchased from Alfa Aesar. Non-thiolated DNA sequences were bought from GENEWIZ Suzhou, China. Thiolated DNA sequences of HPLC grade were bought from Sangon Biotech (shanghai) Co.,ltd. The p8064 DNA scaffold DNA was purchased from tilibit nanosystems ® GmbH (Garching, Germany). All reagents were used as received without further purification. All solutions were prepared using ultrapure water (18.2 MΩ).

2. Synthesis of the AuNRs[1]

The seed solution for AuNRs was prepared firstly. A 50 µL amount of 50 mM $HAuCl_4$ was mixed with 10 mL of 0.1 M CTAB solution. A 0.6 mL portion of fresh cold 0.01 M $NaBH_4$ was diluted to 1 mL with water and was then injected into the Au(III) CTAB solution under vigorous stirring (1200 rpm). The solution color changed from yellow to brownish-yellow, and the stirring was stopped after 2 min. The seed solution was aged at 25 ºC for 30 min before use. To prepare the growth solution, 1.8g of CTAB together with 0.22g 5-BrSA were dissolved in 50 mL of warm water (50-70 ºC). The solution was allowed to cool to 30 ºC, when a 1.2 mL of 4 mM $AgNO_3$ solution was added. The mixture was kept undisturbed at 30 ºC for 15 min, after which 50 mL of 1 mM $HAuCl_4$ solution was added. After 15min of slow stirring (400 rpm), 0.4 mL of 64 mM ascorbic acid was added, and the solution was vigorously stirred for 30 s until it became colorless. Finally, specific volume of seed solution (adjusting the volume according to desirable LSPR wavelength) was injected into the growth solution. The resultant mixture was stirred for 30 s and left undisturbed at 30 ºC for 12 h for AuNR growth. The reaction products were isolated by centrifugation at 8000 g for 30min followed by removal of the supernatant and the precipitates were re-dispersed in water.

3. Functionalization of the AuNRs[2]

Thiolated DNA strands were incubated with TCEP [tris(2-carboxyethyl) phosphine] for at least 1 h to reduce the disulfide bonds. The ration of DNA:TCEP was 1:200. Before functionalization, the AuNRs were spun down and then resuspended with ultrapure water (18.2 MΩ.cm) to remove excess cetyl trimethylammonium bromide (CTAB). AuNRs (1 nM, 500 µL) were mixed with H2O (150 µL), 0.2% sodium dodecyl sulfate (SDS, 100 µL), 10×TBE (50 µL),1M HCl (50 µL, pH=3) and 250mM thiolated DNA strands (10 µL). NaCl (5 M, 10 µL) was added every 20 min for 9 times. Subsequently, 1M NaOH (50 µL) was added to adjust the pH value back to 8. Finally, the concentration of NaCl reached 500 mM. The AuNRs functionalized with DNA were purified to remove excess free DNA strands by centrifugation before use.

4. Synthesis of the AuNBPs[3]

Initial gold seeds were prepared in a scintillation vial (20 mL) by fast reduction of $HAuCl_4$ (10 mL, 0.25 mM) with freshly prepared $NaBH_4$ (0.25 mL, 25 mM) in an aqueous CTAC solution (50 mM), in the presence of citric acid (5 mM) under vigorous stirring at room temperature. The mixture turned from light yellow to brownish indicating the formation of gold seeds. After 2 minutes, the vial was closed and the seed solution was heated in an oil bath at 80 ºC for 90 minutes under gentle stirring, leading to a gradual color change from brown to red. Finally, the thermally treated seed solution was removed from the bath and stored at room temperature.

Synthesis of the AuNBPs can be done using Eppendorf tubes (1.5 mL) when the seeds have cooled to RT. For each tube, specific volume of seed solution is added, followed by 1 mL of growth solution. The growth solution (quantity for six simultaneous tests) is made by mixing 6 mL of 46.5 mM CTAB, 60 µL of 25 mM $HAuCl_4$, 55 µL of 5 mM $AgNO_3$, and finally 85 µL of 0.4 M ethanolic HQL. The Eppendorf tubes are then mixed and heated at 40 °C in an oven for 1 h. Upon UV spectrum analysis, good seed batches are characterized by an LSPR-to-TSPR ratio of at least 5, preferably 6 or 7, and an LSPR between 700 and 800 nm (the lower the better).

5. Design, Preparation, Purification, and Characterization of DNA Origami Template

The DNA origami templates are designed by CaDNAno. For preparing the DNA origami template structures, 15 nM of the p8064 scaffold and a staple mixture containing 150 nM of each staple type were used. All DNA strands were mixed in ultrapure water (18.2 MΩ·cm) together with 12 mM $MgCl_2$ and 5 mM NaCl in 0.5× TE buffer. The mixture was then annealed as follows: 85 °C for 5 min; from 65 to 61 °C, -1 °C/5 min; from 60 to 51 °C, -1 °C/60 min; from 51 to 38 °C, -1 °C/20 min; from 37 to 26 °C, -1 °C/10 min; held at 25 °C. The DNA origami was purified by gel electrophoresis (1% agarose) in an ice bath. The target bands were cut and extracted by Bio-Rad Freeze'N Squeeze spin columns.

6. Gel purification and recycle of the self-assembled plasmonic nanostructures

Under visible light, the target bands are cut down carefully, and placed it on a flat plate wrapped with parafilm, then the gels are cut into small pieces. With a glass slide wrapped with parafilm, the small gel pieces are carefully squeezed to generate solutions. At last the squeezed solution are collected (avoid collecting gel particles) as sample solution.

7. Effective radius[4]

$R_{eff} = (3V/4\pi)^{1/3}$. R_{eff} is the radius of a sphere having a volume, V, equal to that of the nanorod. In addition to cross section, it is also useful to consider the efficiencies of extinction, absorption, and scattering.

For 41 nm × 18 nm AuNBP, V=2900.61 nm^3, R_{eff} =8.848nm.

For 34 nm × 11 nm AuNR, V=2881.16 nm^3, R_{eff} =8.828nm.

8. Anisotropy factor

The g-factor, also known as the anisotropy factor, was calculated using：

$$g = \frac{CD\ (in\ mdeg)}{33000 * Absorbance}$$

Both the CD and the absorbance were measured simultaneously by the CD spectrometer.

9. Characterization

The absorption spectra of the DNA origami templates and the AuNBPs were measured by using Thermo Scientific UV–vis Spectrometer. The concentration of the DNA origami template structures after purification at 260 nm. The CD spectra were collected on an Applied Photophysics Chirascan-plus CD spectrometer. The measurement was carried out at the wavelength range of 400-900 nm at 25 ℃ in a 10 mm length cell. All the products were diluted to 100 μL in 0.5×TBE-Mg^{2+}. The scanning speed is 100 nm/min. For DNA input strands, to achieve rapid and complete reactions, the molar ratio of the origami and the input DNA strands was kept to be 1:500. The CD spectra were measured 2 min after additions of input DNA strands at 25 ℃. Tecnai G2 F20 S-Twin TEM (200 kV) and Hitachi HT7700 TEM (100 kV) were used for TEM imaging. The purified samples were dropped on Glow-discharge grid for 20 seconds upon staining the samples with 0.75% uranyl formate for 20 seconds. liquid was excessed from the edge of the grid by filter paper edge and left for 30mins to completely dry the grid before injecting into the TEM.

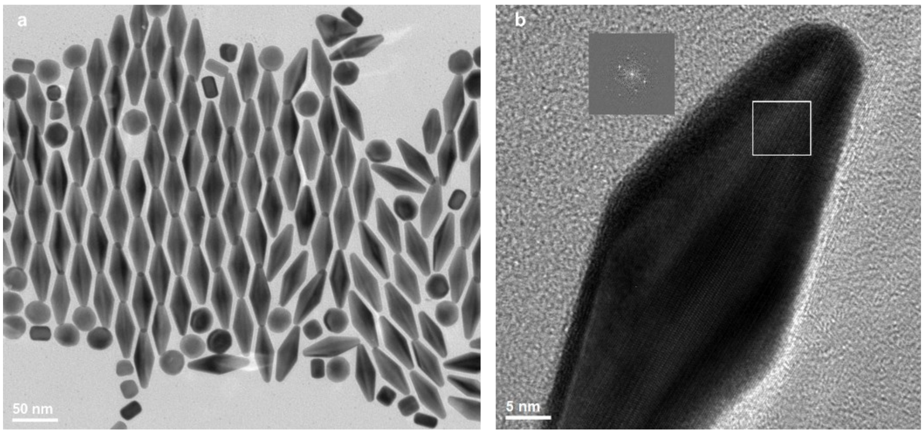

Fig. S1. (a) zoom out and (b) high-resolution TEM image of Au NBP.

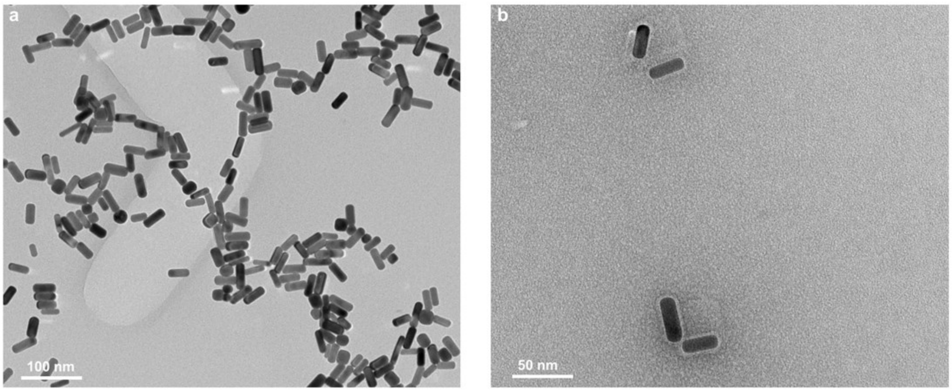

Fig. S2 TEM images of 672-nm AuNR (a) and "L" type AuNR dimer (b).

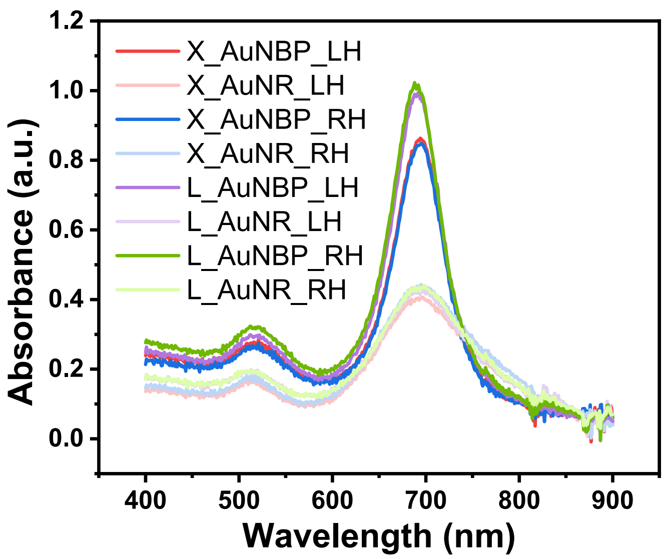

Fig. S3. UV-Vis absorption spectra of AuNBP and AuNR dimers.

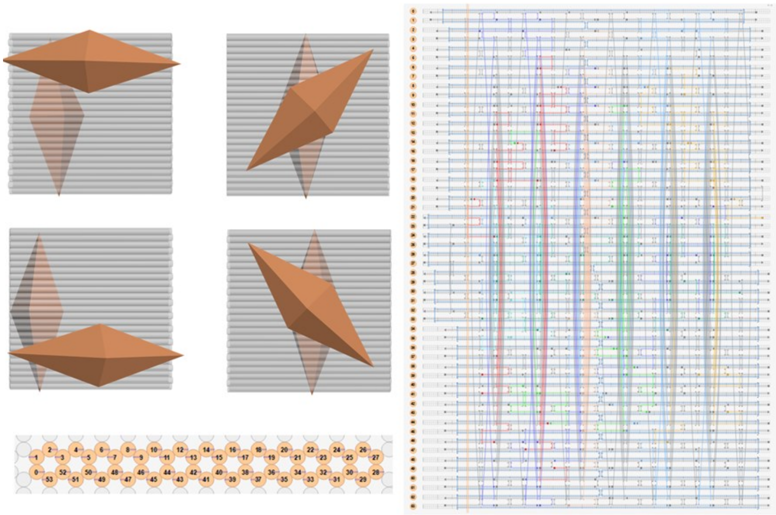

Fig. S4. Scheme of the DNA origami template for static chiral structures designed by caDNAno software.

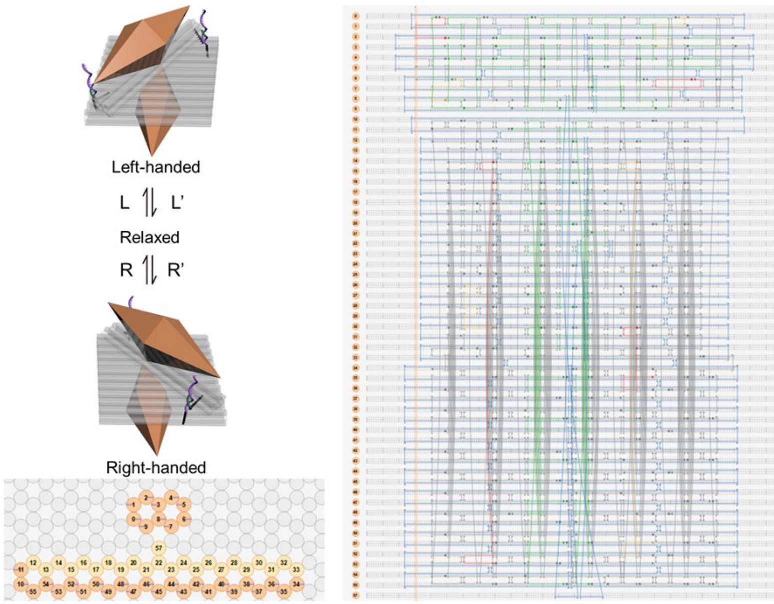

Fig. S5. Scheme of the DNA origami template for reconfigurable chiral plasmonic structure designed by caDNAno software.

Table S1. Staple strands of DNA origami for static structure

Start	End	Sequences 5'-3'	Length
0[161]	53[167]	TTTTTTGAGGAAGGGAATTTTTT	23
12[55]	10[42]	GCGAGAGGCTTTTGCATAGTATCAGTTG	28
29[119]	27[132]	CAGTATAGCATTTTCATGTTCAGCTAAT	28
26[139]	28[126]	AAAATAAGCAGAACTAATTTAGGCAGAG	28
49[119]	51[132]	CATCACGCAAATTAGATTTTACGAGCAC	28
24[55]	30[42]	AGACAGTTCATTGCGCCAGTTTGAGGGG	28
28[167]	29[153]	TTTTTTCCATATTTAACAACGCGCTTAAT	29
31[0]	30[14]	TTTTTTGCCAGCTTTCCGGCACGGAAGAT	29
33[0]	32[14]	TTTTTTCAGGGTTTTCCCAGTCTTAAGTT	29
30[167]	29[167]	TTTTTTTTTGAAATATGAGAATCGTTTTTT	30
32[167]	31[167]	TTTTTTAGGTCTGAGATTTAATGGTTTTTT	30
34[167]	33[167]	TTTTTTATGGAAACACAAAATCATTTTTTT	30
36[167]	35[167]	TTTTTTACGGATTCGCCTTTTTTATTTTTT	30
38[167]	37[167]	TTTTTTGTTTGGATTGAAACAATATTTTTT	30
40[167]	39[167]	TTTTTTCAACTCGTAATCCTGATTTTTTTT	30
42[167]	41[167]	TTTTTTATCAATATCACAATTCGATTTTTT	30
44[167]	43[167]	TTTTTTGCCATTAAAAAACCCTCATTTTTT	30
46[167]	45[167]	TTTTTTCAGATTCACTAAAACATCTTTTTT	30
48[167]	47[167]	TTTTTTATAACATCATTACATTGGTTTTTT	30
50[167]	49[167]	TTTTTTGCGGGAGCTTGATTAGTATTTTTT	30
52[167]	51[167]	TTTTTTGAAAGCGAAAGAATCAGATTTTTT	30
9[6]	10[6]	TTTTTTAGAACTGGCAACTAATGCTTTTTT	30
11[6]	12[6]	TTTTTTAGATACATAGGGTAATAGTTTTTT	30
13[6]	14[6]	TTTTTTTAAAATGTTCCCTGACTATTTTTT	30
15[6]	16[6]	TTTTTTTTATAGTCAATTAGAGAGTTTTTT	30
17[6]	18[6]	TTTTTTTACCTTTAACATTCCATATTTTTT	30
19[6]	20[6]	TTTTTTTAACAGTTGATTCTACTATTTTTT	30
3[6]	4[6]	TTTTTTCACTAAAACGAACGAGGCTTTTTT	30
5[6]	6[6]	TTTTTTGCAGACGGTTCATTACCCTTTTTT	30
7[6]	8[6]	TTTTTTAAATCAACGGCGATTTTATTTTTT	30
23[14]	24[0]	GGATAAAGTTCTAGCTGATAAATTAATTTTTT	32
25[14]	26[0]	TAGCTATATCAGAAAAGCCCCAAAAATTTTTT	32
27[0]	28[0]	TTTTTTCAGGAAGATTGTCATCAACATTTTTTT	33
25[0]	30[0]	TTTTTTTGCCGGAGAGGGCGCACTCCATTTTTT	33
23[0]	32[0]	TTTTTTATTTCAACGCAAGGGTAACGCTTTTTT	33
2[164]	1[161]	TTTTTTTTTTGCTAAACATTTCGAGGTTTTTTT	33
1[3]	2[6]	TTTTTTCATCGGAACGAGAAAAGAATATTTTTT	33
52[132]	1[125]	GGCAAGTGGGGAAACGATAGTTGCGCCGCTTTAAT	35
52[90]	1[83]	CGCGCCATAAATCGAACCGATATATTCGCATCACG	35
45[77]	10[84]	ATTCGTATGTGGTGCCACCGGAACCGCCCAAACAA	35

47[91]	10[98]	CAACAGGAAAAACGACCCTTCGGAAAGCGGCCTTG	35
43[77]	12[84]	CCTGTGCTGCTCGTTCCAATGAAACCATACCAGAG	35
41[77]	14[84]	AAAGGTTCCACGCATCAAAGGGCGACATCGGAAAC	35
39[77]	16[84]	GTGGTGCTTCGTCTTACTGGCATGATTAGCGCCAA	35
37[77]	18[84]	CGGTCCGCTCATTTTGCCCACAAGAATTTACCCAA	35
38[125]	19[118]	CCTACCAAACGTAGCAGAAGGAAACCGAGCAAGAA	35
22[48]	19[55]	TACCAAATACAGGCTGGGGCGTAGATTTAGTTTGA	35
35[126]	20[119]	ATTACATGTTACAAAATCGCGACAATGACCTGAAC	35
37[98]	20[91]	GATTTTCTCATTTCGCCCAATATTGAGCGCTAATA	35
36[118]	21[125]	CAGAGGCAGAAAACAAAATTAAACCTTGAAAATAG	35
24[139]	21[132]	TAGCAAGCAAATCATTGCTATTTTCCAGCAGCCTT	35
36[62]	21[55]	GGCGGTTCCATTAGGCTATATTTTCATTAAGGCAA	35
33[105]	22[98]	TAGCGATAAATCGTCGCTATTTTTTGTTAATAAAC	35
26[34]	29[27]	TACCCCGAAATTGTGGCCTTCCTGTAGCACAACCC	35
26[97]	29[90]	TCAATAAATTCTGTTAAAGTACCGACAAGGGTTTA	35
6[55]	3[48]	CTTCATCAAGAGTAGACCAACCCGCGACATTATAC	35
22[83]	31[76]	TCCCAAAGCCTCAGAGGTAAATGCGGGCCGCAACT	35
24[97]	31[90]	GAACGCGAAGAACGTAGAAAAAGCCTTGAGATCGC	35
22[97]	33[90]	AGCCATATTGCGGGGATGCAAATCCAGGAACTTAG	35
31[119]	34[126]	AAATATATTTTAGTGCTTAGGCGCTGAGAGTGAAT	35
19[140]	34[133]	TCTTACCACGGGAGAATTAACTACAGAGATATGTG	35
20[132]	35[139]	TGAACACAATAGCAATAGCTAATACCAATTAACAA	35
18[83]	35[76]	AAGAATAATGCTGTTCGCAAAGCCGCCAATCAAAC	35
16[83]	37[76]	AGACAGCGTTTTAATGCTGAACGTCGCTGCAAACG	35
35[140]	38[147]	TTTCATTTGAATTACCTGATTATCGGGAATACTTC	35
14[118]	39[125]	CCAGTAGGGTAAATGTTTGAGATCATATTCCTGAT	35
36[55]	39[48]	GTGTACATCGACATAAGTTAAATCCTCACAGCAAC	35
14[83]	39[76]	GTCACAAATGCTTTTCAAATAACCAGCTACCGTCG	35
53[140]	4[133]	AACGTGGGGCGCTAATGAATTTAGGAACCCATGTA	35
12[83]	41[76]	CCACCAGACGACGAATCCCCCCATAAACAATGGGT	35
10[34]	43[41]	GGAATACAAGGAATGGGTTTCGGTGCCGGTGCCCC	35
10[83]	43[76]	ATAAAGAACAACATTCGTTTACTGCGGCCTGCGCG	35
10[55]	45[48]	AGATTCAAGAGCAACCGTTTTCACGGTCCCTCACA	35
8[83]	45[76]	CTGCCTAGTAAATTGAACTAAAGCTGTTAGCTCGA	35
7[133]	46[140]	CAAGAGAAGAACTCCAATCGTCTGAAATACGACCA	35
6[83]	47[76]	TACTCACCAGGCGCCAGAACGTCGGGAAGTTGCGC	35
8[97]	47[90]	ACAGTTACCAGAATTGACCTGAAAGCCACCCATTG	35
45[98]	48[105]	GGCACAGACAATATAGATAGACTCATGGATATCCA	35
5[133]	48[140]	AGAGCCATTAAAGGACCGTTGTAGCAATGAGTAGA	35
45[140]	48[147]	CGAACTGATAGCCCCAGTCACGGATTATCTTGCCT	35
9[42]	48[49]	TGGGAAGCAACTTTGAATAAGGCTTGCCCTGCATT	35

46[48]	49[55]	GCTCACAAATGAGTAATGAATTCTTTTCACCAGTG	35
6[97]	49[90]	TAGGTGTTATTATTATTACCGCCAGCGCCGAATCA	35
1[98]	52[91]	AAAAAAGTAAAGGAATTGCGATAGTTAGCACCCGC	35
51[140]	6[133]	GTGCTTTAGGCCGACCACCCTCCAGGCGGATAAGT	35
49[77]	6[84]	CCTTCACTTTCCAGAGTATTTCGGAACCATCACCG	35
51[91]	6[98]	GCGCCGCTACAGGGTCCTGAGCCCTCAGCCCGGAA	35
47[77]	8[84]	TCACTGCTGGTCATCGTCCTCATTAAAGATGCCCC	35
49[91]	8[98]	GTGAGGCCACCGAGGAACAATCTGAAACCGTATAA	35
18[34]	35[41]	GTGTCTGATTCTGCTCCCGTAGAAGGGATAGCTCT	35
35[42]	21[62]	CACGGAAAAAGAGACGCAGAAACGTACAAGAATTA	35
12[164]	11[164]	TTTTTTTCATCGGCATTTCGCCACCAGAACTTTTTT	36
14[164]	13[164]	TTTTTTACCGACTTGAGCTGTAGCGCGTTTTTTTTT	36
16[164]	15[164]	TTTTTTGAAACGCAAAGAATTATCACCGTCTTTTTT	36
18[164]	17[164]	TTTTTTAAGAAAAGTAAGCAACATATAAAATTTTTT	36
24[164]	23[164]	TTTTTTGAATCATTACCGCAATTTTATCCTTTTTTT	36
26[164]	25[164]	TTTTTTAGATAAGTCCTGTTTTCATCGTAGTTTTTT	36
4[164]	3[164]	TTTTTTTAGCAAGCCCAATTCTGTATGGGATTTTTT	36
35[10]	36[10]	TTTTTTTTTCTCCGTGGTAAAAAAGCCGCATTTTTT	36
37[10]	38[10]	TTTTTTCAGGCGGCCTTTGGACTTGTAGAATTTTTT	36
39[10]	40[10]	TTTTTTCGTCAGCGTGGTCTTTCGCACTCATTTTTT	36
41[10]	42[10]	TTTTTTATCCGCCGGGCGGATGCCGGGTTATTTTTT	36
43[10]	44[10]	TTTTTTCCTGCAGCCAGCTGCCAGCACGCGTTTTTT	36
45[10]	46[10]	TTTTTTTGCCTGTTCTTCACGAGCCGGAAGTTTTTT	36
47[10]	48[10]	TTTTTTCATAAAGTGTAAGGAGAGGCGGTTTTTTTT	36
6[164]	5[164]	TTTTTTTTTTGCTCAGTACATTTTCAGGGATTTTTT	36
49[10]	50[10]	TTTTTTTGCGTATTGGGCATCCTGTTTGATTTTTTT	36
51[10]	52[10]	TTTTTTGGTGGTTCCGAAAACCGTCTATCATTTTTT	36
8[164]	7[164]	TTTTTTAGGAGTGTACTGGGATTAGCGGGGTTTTTT	36
10[164]	9[164]	TTTTTTCACCACCAGAGCTTTTGATGATACTTTTTT	36
43[109]	14[119]	GCAAATGAAAAATCTAAGGAATTGAGAATCAAAAATCA	38
41[88]	16[98]	CAACTAATAGATTAGAGATCATTTATTGAGGCATATGG	38
29[140]	27[164]	CAGTAGGCAACATGGCGCCTGTTTATCAACAATTTTTTT	39
21[6]	22[0]	TTTTTTATAGTAGTATTTTGCGGGAGAAGCCTTTTTTTTT	40
44[102]	42[91]	ATTAAGAGCCGCTCAAAATCACCGGACGATAGCTTTAGGA	40
50[48]	0[35]	GGTTTGCTTATAAACTCCAACCACCCAACCGCTTTTGCGGGA	42
51[56]	0[56]	AATAGCCCGAGATATCCACTAGGTCGAGAGGCTTGCAGGGAG	42
4[69]	0[70]	CCTGATAAGTACAATAAAATACATGAGGAAGTTTCGTCGCTG	42
48[34]	10[35]	CGCGCGGAGCCTGGGGTGCCTATTCCACAGGACGTAGATTTA	42
42[90]	13[104]	GCACTTTACCAGTGCCACGCTGAGAGCCAAATATCAGCACCG	42
43[56]	15[55]	CCAGCGCACACTGGTAAATATTCAGAAAACGAGAATAAGAGG	42
41[112]	16[112]	TAGATAATACATTTTTTAAAAATTGACGTGTCACAATCAATA	42

20[76]	16[63]	CAATAACCTGTTTAATACATTAGCTCAAGCTTAATTTCGAGC	42
20[118]	17[118]	AAAGTCAGAGGGTAAATAAGAGGAAACGGCAGTATGTTAGCA	42
40[55]	18[56]	TCCAGCACGCAAGAATGCCAATCCGGCCGCTTAGACATGTTT	42
53[70]	2[84]	GTGCCGTAAAGCACGTTTGGATTAGACAGCCCTCAATAATAA	42
35[77]	20[77]	TTAAATTTCACCGGTAATCCAAATAAGATCAGAGAGATAAGT	42
25[105]	21[118]	AACCAAGATCCGGTGAAGCCTGTTACAATAACGTCAAAAATG	42
33[70]	22[84]	CCACGGGAACGGATCGATCGGGAGAACCTCCCGACTTATTTA	42
31[35]	23[48]	GAAACCAACGACGACAAAGGCTATCAGGCAAATCATTTTAAA	42
29[56]	25[69]	GATTGACGGAACGCATTCGCATTAAATTAACGGTATCTGGAG	42
29[91]	26[105]	GTATCATATGCGTTGAGAATACCAGACGACGACAACATGTAG	42
51[119]	3[132]	GCTTTGAGACAGGAGAACCGCCACCCTCCCGTAACCCAGACG	42
24[118]	32[105]	AAGGCTTTACCGCAAAACACCGGAATCAGAGAAAATATATGT	42
31[140]	34[140]	ATCTTCTGACCTAAAGACTACAATTTATGTACATAAATCAAT	42
24[69]	34[70]	GTGAGAAAATGTGTAGCATAAGCAAAATTAAGCAAAAACAAT	42
31[56]	35[69]	CGCCATTCAGGCTGCTCTTCGGGAGCCGCGGCGAAACAGCGG	42
16[139]	36[140]	GAATAAGATACATATGGAAGGACAGTACCTTTTACGCTTTGA	42
16[62]	37[62]	TTCAAAGCGAACCAGCGGATGAGAGCACACGATGCTGATTGC	42
16[97]	39[97]	TTTACCAAGACTCCAAACAGAAATAATTCAAAACCACCAGAA	42
53[119]	4[105]	GCTTGACGTAGCGGCGTCTTTACTGAGTTTCGTCACCAGTAC	42
50[83]	4[70]	TGGCCCTAGAGGAGGTTTAGTGTAGCATTCCACGTATCATCG	42
42[41]	40[28]	CGTTAACTCCAATAAAATCAAAAATCAGAGCGGATGCAGGCG	42
16[111]	42[112]	GAAAATTGAGGGAACACCATTTAATCAGTAGCGACAGGAAGG	42
9[140]	43[139]	ACATGGCCGCCGCCAGCATTGACCACCCCACCAGCCCTTGCT	42
41[126]	45[139]	GAGGATTGTTGAAAAGCATCAAGAAGATTAGTCTTTAATGCG	42
53[35]	5[34]	GAACCATGTCAAAGCCCAGCGCTGCTCCATGTTACAAGGGAA	42
2[83]	51[83]	TTTTTTTAAACGGGCGGAGATACAAGAGGGGTTGAGTGTTGT	42
1[84]	52[98]	TTGAAAATCTCCAACACGCATGAACCCTAAAGGGAACCACCA	42
51[35]	7[34]	AAATCCCCCCAGCACCGAACTATCTTGACAAGAACGCTGCTC	42
50[34]	8[35]	GGCGAAAGCCAGGGTGGTTTTCGGCCAAATTCAGTAATCATT	42
48[132]	9[118]	AAACTATCGGCCTTAGGCTGAAGTGCCTTGAGTAACTGAATT	42
12[34]	9[34]	AGTTTTGCCAGAGGACGCCAACACATTCTCATTATACCAGTC	42
49[56]	9[55]	AGACGGGGTGCCAGCTGACGAAGATGGTTTAATTTAAAAATC	42
31[42]	21[41]	GGCAAAGGGCGAAACAGTGCCGTTTACCAGTCCCGTAAATCA	42
29[0]	27[27]	TTTTTTTAAATGTGAGCGAGTACAGCTTTATAAGCAAATATTT	43
53[10]	0[3]	TTTTTGGGCGATGGCCCCCTCAGCAGCGAAAGACAGTTTTTT	43
20[149]	21[164]	TAGGAAGCCCTTTTTTTTTTTTTTTTTGAAGCACAGGTTTTTT	43
20[23]	37[34]	TCAATTCCCAGAAGTTTTTGCTCCTTTTGATACGTGCCAGTGATG	45
8[107]	49[118]	GCCATGAAAGAGTATAGAACCGCCACCCTCAACGGTACGTCTGTC	45
8[65]	49[76]	TTGGAAACACATAGGCTGATGAACGGTGTACGAGAGAGTGATTGC	45
30[27]	34[10]	GGCCTCACGCTTCTAAGGCGAACGACGTTGAGAGATAGACTTTTTT	46
49[147]	0[140]	ACTTCTTAAACAGGCCTCGTTAGGAGCGCGAGAAAATTTCTTAAACAGC	49

49[105]	0[98]	TAAAAGAGCCAGAACGCGTACGCGCGTAGCCCCCGCAACAACCATCGCC	49
36[69]	15[62]	GCAGTTGCGTTCCGGGCAGCCCGGCAGCTACGGCTGGAGGTGAAGCCCG	49
24[76]	28[70]	CAAAAGGCAAACAAGCGCATCGGATAGGTCACGTTAAGCTCATTTTTTA	49
8[34]	3[27]	GTGAATTACCTTATTAACAAACGGATATCAATCATTTAGCCGACTCATC	49
37[35]	34[28]	AAGGGTAAAAAAAAGAACGAGCGAGCTGAAAAGGTCATCCAAGAATTTG	49
38[118]	40[126]	TATCAAAACGTCAGATGAATATACAGTAGTTAGAATATCAGATATTAAT	49
43[140]	40[133]	GAACCTCTTGGCAAGTCAGACCATTTGGGAATTAGTTCATTACGAACGT	49
12[139]	42[147]	TAGCCCCCTTTAGCATCAACATAGAAGTATTAGACTTTACAATGGTCAG	49
16[34]	42[28]	TCCAACAGGTCAGGGAAGCAAGTCTTTATAGACTGGATAGCGGGCATCA	49
7[140]	47[132]	AGGATTAGTAATAAGTTTTAAGCGTCATGTAATAAAAGGGACTGACGCT	49
46[55]	48[63]	GTTATCCGTTGAGGATCCCCGGGTACCGTCCTGTGTAATTGCACCTGTC	49
53[56]	50[49]	TTTTTGGTTAAAGAGAAACAAAATTGTGTCGAAATTTTGAAACCACGCT	49
3[98]	51[90]	CGTAACGAAACTACAACGCCTACCGCCAAAGTGTTTTTATCCTCTTAAT	49
6[118]	9[125]	TGATATATATTAAGGCTGGTAAAATACCTACATTTATTCTGGTACCGTT	49
47[49]	10[56]	GAGCTAACTCACATTGAAATTTACGTTAGGTAGAA	35
15[63]	12[56]	AAAGACTAAACAGTTCATTGATAAAAACCAAAATA	35
41[28]	16[35]	CGGTTGCGGTATGAGGTCATTTGCATCAAGCAAAC	35
39[28]	18[35]	GCTGGTCTGGTCAGTAACGGAAAGAGGTAAGTACG	35
49[63]	6[56]	CAACAGCTTGCAGCAAGCGGTGAGGACAGGCTGAC	35
44[60]	8[66]	GCGGGCACTATCATAACCCTATTACAATAAAACGGGC	37
18[55]	14[45]	TAAATATGCAACTACATTTTTGACCGGAAAAAGATTGAC	39
24[34]	20[24]	TATGATATTCAACCAATTTTTGTAATACGCATTAAGGCA	39
46[34]	12[35]	ACAACATGCGTCCGTGAGCCTATACCGGTACGAGGCAAAAGA	42
22[164]	20[150]	TTTTTTGAATCTTACCAACATAAAAGCAT	29
43[147]	12[140]	AAATATCAATACCGAACGAACTCAGAGCTCGGTCA	35
39[147]	16[140]	CAATATATTAAATCCTTTGCCAAGGTGACACCACG	35
39[133]	18[140]	TGATGGCAATTCATTGAATAAAAGGTGGCAGATAG	35
9[126]	6[119]	CCAGTAACGGGGTCGACTCCTGCCGTCGAGAGGGT	35
14[128]	10[119]	AGCAGTTTGCCTTATTACAGAGCCACAGGAGGTTGAGG	38
18[139]	14[129]	CCGAACAAAGTTACAAAATACTTTATTTGAAATTAAGCC	39
12[118]	8[108]	CCATCTTTTCATAACACCCTCGACGATTGCAGTCTCAGT	39
46[118]	12[119]	CCAACAGTTTTGAATGGCTATAAAACAGCCACCCTGCGTTTG	42
26[55]	29[55]	AACTAGCTGTTAAACATCAAAAATAATTGGGAACAAACGGCG	42
26[118]	29[118]	TTACGAGTAAACAACGAGCCAGTAATAAATACAAATTCTTAC	42
22[41]	31[34]	AACATTATGACCCTAGAACCCGTGCTGCGGTGCCG	35
22[62]	31[55]	AGCTAAATCGGTTGTGCAATGGCCAGCTCGCCATT	35
22[125]	31[118]	AGCCTAATTTGCCATAAATCAATATAACCTTTTTC	35
21[140]	31[139]	AGAATAACGCTAACGAGCGTCTTTGCACACCTCCGTAATTTC	42
1[35]	51[34]	CAGAGGCCCAACCTAAAACGATTTGACCGGCGAAAATCGGCA	42
1[56]	51[55]	ACTTTTTCGTAATGCCACTACCAAGCGCACGTGGATCAAAAG	42
2[125]	51[118]	GTGAGAATAGAAAGGTTTTGTTCACGCTTATGGTT	35

1[140]	51[139]	AGCTTGCACTTTCAACAGTTTTTAGTAAGGGCGCTGTATAAC	42
2[48]	53[55]	GAAGGCATTTGAGGACTAAAGTTAAAGGATCAAGT	35
3[105]	53[118]	ATCTAAAGAACAACGCTCCAAAAGGAGCACAATGAATTTAGA	42
26[27]	29[34]	GTTGATATTTTGAGAGATCTACAGTATCGTCGGAT	35
26[132]	29[139]	TATCCCAAGAACAAGCAAGCCAATAAGGCGCTCAA	35
2[27]	53[34]	AAGAGGCGGTAGCAACGGCTATCGTCACACTACGT	35
2[132]	53[139]	CAGCGGATGTATCGGTTTATCTTGATACGCCGGCG	35
14[104]	41[87]	ACCATTAGCAAGGCTCAACCGTGCGGAACAAAGTCTCAA	39
14[44]	41[55]	CATCTGCGGAATCGTCATGTGTTCCACTGTT	31
40[48]	43[55]	TCAGCGGGCCGGGTAGCAAATCTGCATCAGACGAT	35
41[56]	44[61]	GCCCTGCGGCTGGTATCCCTTAGTGTCACAGAATGCG	37
21[91]	35[88]	AACGATTAATTAATTTTCCCCTCAAA	26
38[102]	36[93]	ACGTATTATTACCAATAATAACGGAAGAGTTAAAATTA	38
36[92]	37[97]	CCTGAGCTGTTAGAAATTGCGTA	23
35[89]	38[103]	AGAAGATGATGAAACAAACATCAGAATTATAGGTTTAATTATTTGC	46
39[98]	43[108]	GGAGCGGAATTATCTAACATTCCGTCAATTATCTAAGCA	39
10[118]	44[103]	CAGGTCAAGAACCGAGGTGAGGCGGTCAGT	30
10[97]	45[97]	ATATTCATCCCTCACACCGCCTGCAATCATGTAAGAATACGT	42

Table S2. Functional strands of DNA origami for "X" type structure

Start	End	Sequences 5'-3'	Length
X_TOP			
35[77]	20[77]	TTAAATTTCACCGGTAATCCAAATAAGATCAGAGAGATAAGTACTAACTCAA	42
43[77]	12[84]	CCTGTGCTGCTCGTTCCAATGAAACCATACCAGAGACTAACTCAA	35
45[77]	10[84]	ATTCGTATGTGGTGCCACCGGAACCGCCCAAACAAACTAACTCAA	35
41[77]	14[84]	AAAGGTTCCACGCATCAAAGGGCGACATCGGAAACACTAACTCAA	35
33[70]	22[84]	CCACGGGAACGGATCGATCGGGAGAACCTCCCGACTTATTTAACTAACTCAA	42
39[77]	16[84]	GTGGTGCTTCGTCTTACTGGCATGATTAGCGCCAAACTAACTCAA	35
49[77]	6[84]	CCTTCACTTTCCAGAGTATTTCGGAACCATCACCGACTAACTCAA	35
37[77]	18[84]	CGGTCCGCTCATTTTGCCCACAAGAATTTACCCAAACTAACTCAA	35
53[70]	2[84]	GTGCCGTAAAGCACGTTTGGATTAGACAGCCCTCAATAATAAACTAACTCAA	42
47[77]	8[84]	TCACTGCTGGTCATCGTCCTCATTAAAGATGCCCCACTAACTCAA	35
X_Left-handed			
44[102]	42[91]	ATTAAGAGCCGCTCAAAATCACCGGACGATAGCTTTAGGA ACTAACTC	40
26[55]	29[55]	AACTAGCTGTTAAACATCAAAAATAATTGGGAACAAACGGCG ACTAACTC	42
22[62]	31[55]	AGCTAAATCGGTTGTGCAATGGCCAGCTCGCCATT ACTAACTC	35
18[83]	35[76]	AAGAATAATGCTGTTCGCAAAGCCGCCAATCAAAC ACTAACTC	35
26[27]	29[34]	GTTGATATTTTGAGAGATCTACAGTATCGTCGGAT ACTAACTC	35
45[98]	48[105]	GGCACAGACAATATAGATAGACTCATGGATATCCA ACTAACTC	35
1[140]	51[139]	AGCTTGCACTTTCAACAGTTTTTAGTAAGGGCGCTGTATAAC ACTAACTC	42
2[125]	51[118]	GTGAGAATAGAAAGGTTTTGTTCACGCTTATGGTT ACTAACTC	35
16[83]	37[76]	AGACAGCGTTTTAATGCTGAACGTCGCTGCAAACG ACTAACTC	35
14[104]	41[87]	ACCATTAGCAAGGCTCAACCGTGCGGAACAAAGTCTCAA ACTAACTC	39
22[41]	31[34]	AACATTATGACCCTAGAACCCGTGCTGCGGTGCCG ACTAACTC	35
10[118]	44[103]	CAGGTCAAGAACCGAGGTGAGGCGGTCAGT ACTAACTC	30
3[105]	53[118]	ATCTAAAGAACAACGCTCCAAAAGGAGCACAATGAATTTAGA ACTAACTC	42
2[132]	53[139]	CAGCGGATGTATCGGTTTATCTTGATACGCCGGCG ACTAACTC	35
8[107]	49[118]	GCCATGAAAGAGTATAGAACCGCCACCCTCAACGGTACGTCTGTC ACTAACTC	45
14[83]	39[76]	GTCACAAATGCTTTTCAAATAACCAGCTACCGTCG ACTAACTC	35
X_right-handed			
35[89]	38[103]	AGAAGATGATGAAACAAACATCAGAATTATAGGTTTAATTATTTGC ACTAACTC	46
10[83]	43[76]	ATAAAGAACAACATTCGTTTACTGCGGCCTGCGCG ACTAACTC	35
6[83]	47[76]	TACTCACCAGGCGCCAGAACGTCGGGAAGTTGCGC ACTAACTC	35
46[55]	48[63]	GTTATCCGTTGAGGATCCCCGGGTACCGTCCTGTGTAATTGCACCTGTC ACTAACTC	49
1[35]	51[34]	CAGAGGCCCAACCTAAAACGATTTGACCGGCGAAAATCGGCA ACTAACTC	42
1[56]	51[55]	ACTTTTTCGTAATGCCACTACCAAGCGCACGTGGATCAAAAG ACTAACTC	42
46[48]	49[55]	GCTCACAAATGAGTAATGAATTCTTTTCACCAGTG ACTAACTC	35
26[132]	29[139]	TATCCCAAGAACAAGCAAGCCAATAAGGCGCTCAA ACTAACTC	35
2[27]	53[34]	AAGAGGCGGTAGCAACGGCTATCGTCACACTACGT ACTAACTC	35
16[97]	39[97]	TTTACCAAGACTCCAAACAGAAATAATTCAAAACCACCAGAA ACTAACTC	42

22[125]	31[118]	AGCCTAATTTGCCATAAATCAATATAACCTTTTTC ACTAACTC	35
8[83]	45[76]	CTGCCTAGTAAATTGAACTAAAGCTGTTAGCTCGA ACTAACTC	35
21[140]	31[139]	AGAATAACGCTAACGAGCGTCTTTGCACACCTCCGTAATTTC ACTAACTC	42
26[118]	29[118]	TTACGAGTAAACAACGAGCCAGTAATAAATACAAATTCTTAC ACTAACTC	42
2[48]	53[55]	GAAGGCATTTGAGGACTAAAGTTAAAGGATCAAGT ACTAACTC	35
53[56]	50[49]	TTTTTGGTTAAAGAGAAACAAAATTGTGTCGAAATTTTGAAACCACGCT ACTAACTC	49

Table S3. Functional strands of DNA origami for "L" type structure

Start	End	Sequences 5'-3'	Length
L_Left-handed			
26[118]	29[118]	TTACGAGTAAACAACGAGCCAGTAATAAATACAAATTCTTAC ACTAACTC	50
26[132]	29[139]	TATCCCAAGAACAAGCAAGCCAATAAGGCGCTCAA ACTAACTC	43
22[125]	31[118]	AGCCTAATTTGCCATAAATCAATATAACCTTTTTC ACTAACTC	43
21[140]	31[139]	AGAATAACGCTAACGAGCGTCTTTGCACACCTCCGTAATTTC ACTAACTC	50
19[140]	34[133]	TCTTACCACGGGAGAATTAACTACAGAGATATGTG ACTAACTC	43
20[132]	35[139]	TGAACACAATAGCAATAGCTAATACCAATTAACAA ACTAACTC	43
16[139]	36[140]	GAATAAGATACATATGGAAGGACAGTACCTTTTACGCTTTGA ACTAACTC	50
14[118]	39[125]	CCAGTAGGGTAAATGTTTGAGATCATATTCCTGAT ACTAACTC	43
43[140]	40[133]	GAACCTCTTGGCAAGTCAGACCATTTGGGAATTAGTTCATTACGAACGT ACTAACTC	57
9[140]	43[139]	ACATGGCCGCCGCCAGCATTGACCACCCCACCAGCCCTTGCT ACTAACTC	50
41[126]	45[139]	GAGGATTGTTGAAAAGCATCAAGAAGATTAGTCTTTAATGCG ACTAACTC	50
7[133]	46[140]	CAAGAGAAGAACTCCAATCGTCTGAAATACGACCA ACTAACTC	43
7[140]	47[132]	AGGATTAGTAATAAGTTTTAAGCGTCATGTAATAAAAGGGACTGACGCT ACTAACTC	57
5[133]	48[140]	AGAGCCATTAAAGGACCGTTGTAGCAATGAGTAGA ACTAACTC	43
49[119]	51[132]	CATCACGCAAATTAGATTTTACGAGCAC ACTAACTC	36
2[125]	51[118]	GTGAGAATAGAAAGGTTTTGTTCACGCTTATGGTT ACTAACTC	43
1[140]	51[139]	AGCTTGCACTTTCAACAGTTTTTAGTAAGGGCGCTGTATAAC ACTAACTC	50
3[105]	53[118]	ATCTAAAGAACAACGCTCCAAAAGGAGCACAATGAATTTAGA ACTAACTC	50
2[132]	53[139]	CAGCGGATGTATCGGTTTATCTTGATACGCCGGCG ACTAACTC	43
L_Right-handed			
26[27]	29[34]	GTTGATATTTTGAGAGATCTACAGTATCGTCGGAT ACTAACTC	43
26[55]	29[55]	AACTAGCTGTTAAACATCAAAAATAATTGGGAACAAACGGCG ACTAACTC	50
22[41]	31[34]	AACATTATGACCCTAGAACCCGTGCTGCGGTGCCG ACTAACTC	43
22[62]	31[55]	AGCTAAATCGGTTGTGCAATGGCCAGCTCGCCATT ACTAACTC	43
37[35]	34[28]	AAGGGTAAAAAAAAGAACGAGCGAGCTGAAAAGGTCATCCAAGAATTTG ACTAACTC	57
20[23]	37[34]	TCAATTCCCAGAAGTTTTTGCTCCTTTTGATACGTGCCAGTGATG ACTAACTC	53
36[55]	39[48]	GTGTACATCGACATAAGTTAAATCCTCACAGCAAC ACTAACTC	43
42[41]	40[28]	CGTTAACTCCAATAAAATCAAAAATCAGAGCGGATGCAGGCG ACTAACTC	50
16[34]	42[28]	TCCAACAGGTCAGGGAAGCAAGTCTTTATAGACTGGATAGCGGGCATCA ACTAACTC	57
10[34]	43[41]	GGAATACAAGGAATGGGTTTCGGTGCCGGTGCCCC ACTAACTC	43
10[55]	45[48]	AGATTCAAGAGCAACCGTTTTCACGGTCCCTCACA ACTAACTC	43
9[42]	48[49]	TGGGAAGCAACTTTGAATAAGGCTTGCCCTGCATT ACTAACTC	43
46[48]	49[55]	GCTCACAAATGAGTAATGAATTCTTTTCACCAGTG ACTAACTC	43
53[56]	50[49]	TTTTTGGTTAAAGAGAAACAAAATTGTGTCGAAATTTTGAAACCACGCT ACTAACTC	57

1[35]	51[34]	CAGAGGCCCAACCTAAAACGATTTGACCGGCGAAAATCGGCA ACTAACTC	50
1[56]	51[55]	ACTTTTTCGTAATGCCACTACCAAGCGCACGTGGATCAAAAG ACTAACTC	50
2[27]	53[34]	AAGAGGCGGTAGCAACGGCTATCGTCACACTACGT ACTAACTC	43
2[48]	53[55]	GAAGGCATTTGAGGACTAAAGTTAAAGGATCAAGT ACTAACTC	43

Table S4. Staple strands of DNA origami Plate

Start	End	Sequences 5'-3'	Length
12[139]	10[126]	AGTTGAGAAACGAAATTAAGAGGCTGCACGTATAAAACACTA	42
12[55]	10[42]	CCTCAAATTACCCTGTGAATTTGTGAGAAAACAGCGGTAATA	42
54[69]	11[62]	CATAAAATTTCTGCAAAAGAAGTTTTGCTCAGCCA	35
55[119]	12[119]	CAGTGCCTACATGGGTCCAGACGACGTAATGCATTTTCGAGC	42
55[151]	12[140]	CTAATTACGAGGCATAGCCACATTATTCATC	31
10[41]	12[28]	GTAAAATTCGTCATAACAGTTCAGAAAA	28
55[56]	12[56]	ACTTAAAAAATCCCGAATAAACACCGGATTACCAGTATAACC	42
55[87]	12[77]	TTAAAAAATAGCGAGAGGGGCTTAACGTTATA	32
55[105]	12[91]	AGTGCCTTACCAGACGACGATATTTAACTATAAAGTATAGTA	42
16[118]	13[111]	CATCCTAATTTACGCAACAATGCTAATGGGTAAAG	35
16[55]	13[48]	GTTTTAATTCGAGCAAAGACTTCAGAAGCAGGTCT	35
52[125]	14[119]	TATTCACTCCTGAACAAGATTAAACAATAAACAAC	35
11[28]	14[35]	TGCGGAAGTTTAGAAAAAAGAGACGCAGGATAGACCAAAAATCAAAGCG	49
53[56]	14[56]	AAAAAGCGTTCCGGTCTAGTTAATTTCACGTTAAATAAGACT	42
53[84]	14[77]	TGAAGGGATGGGCGGTTGTGTTTACTAGTGTGATA	35
55[98]	14[91]	CGGGGTCGGAGTGTGACAAAACAGAACGCGAAATA	35
50[125]	16[119]	GAGCCGCTTTCCTTATCATTTATAAAATAATATCC	35
52[132]	16[140]	CGAGAGAGTAGACTCCTCAAGAGAAGGACGGATAATGGCTCAAATTACC	49
54[34]	16[35]	TTTCTCCGTACAGCGCCATGTCGGGAACAAGCCCGTTCAAAG	42
51[56]	16[56]	CGCGGTCGGAACGTACATATAACTATATTCAAATATATTTGC	42
51[87]	16[77]	GCCAATGGTAAAGTTAAAACCTAAAGCGAGAA	32
53[98]	16[91]	AGTCTCTTCATTAATGTTTATAGCATGTAGAAGAC	35
46[111]	17[104]	ATCGGCACATCTTTACCGGAAGCCACCCACCACCACCAGAGCACCAATC	49
52[34]	18[35]	GGATAACCGACGGCCAGTGCCGGTAACGAACAGGTTGATAAG	42
48[62]	18[56]	GGCAGCAGCAGAAGAGTCAATTTAGGTTGGGTTCT	35
49[84]	18[77]	TCTGGCGAGCTCCGGCCAGAGCTGATGCTTTTAAC	35
22[118]	19[111]	AACCTCCCGACTAAGCTTATCATAGCAAAGCAAGC	35
48[125]	19[118]	GAACCAGATTTTCATCGTATGAATCCAAGAACGGGTATTAAACGTTTTT	49
25[42]	19[48]	AATAGTAATTTTCAAATGGTCTCTGCGATTCCATAACATGTTTTGCTGA	49
48[118]	20[126]	AGCCACCTCATAATCAAAATCTGTAGCGCTAAGAACGCGACAGCGGAAT	49
48[132]	20[140]	ATAGGCGCTAACCGCCACCCTCAGAACCGGATAGCAGTGAATATCAACG	49
50[34]	20[35]	CCAGGGTCTGGCGAAAGGGGGAAGGGCGAGCTTAATTAAATA	42
47[56]	20[56]	CGGTGGTATTGCAGTGTCTGTAAATCGTATTAAGACGCTGTG	42
47[87]	20[77]	GCCCGCTCAGCAGCAACCTTATCAATAGCGAT	32
49[91]	20[91]	CCACCCTCAGAACCCCGCCTCGAGAACAGCAAATCAGTCCTT	42
44[125]	22[119]	GAAACGTTGAAGCCTTAAAGAATGGCGTTTTAGCG	35
48[34]	22[35]	ATCGGTGAAAGCGCCATTCGCCAGCTTTAGTTTCAACGAGTA	42
45[56]	22[56]	TTTCGCAGCTGGTATGGAACAAGAGTCCAATAACCTTGCTAT	42
45[84]	22[77]	GCGGTAACCTGGAGGTGTCCAAATTAATAATATAT	35
43[112]	24[126]	TTACCATTAGCAAGTCACCGTTAACGAGCGTCTTTTTTCAAG	42

44[132]	24[140]	TGTATCGAGCCCTCATAGTTAGCGTAACGTAAATGCAGATGACGAACTG	49
46[34]	24[35]	CCGGCACCGACGACAGTATCGGGGCGCATTTCGCATTTGGGG	42
25[56]	24[49]	TAGTGGTTCCGAAATGTTCCAGTTTGTTTAGCTAT	35
43[87]	24[77]	CTCAGTATGAGCCGGGTCAAGAACGATAGGGT	32
45[91]	24[91]	TCAGTAGCGACAGATCGATAGAAAGGGCAGCTACAATGAATA	42
41[119]	26[126]	AAGGTGAAAGACAAAATAAGAAACGAGAACTTCCA	35
44[34]	26[35]	TCGTAACGGATTGACCGTAATAGTAACATTCTACTACAGGCA	42
41[56]	26[56]	ATGCCGGGTGTCACAGCACCGCCTGGCCTCCTGTTTGATGAC	42
42[83]	26[70]	TGGTGTGAATCCCTCCAGCAGGCGAAAA	28
43[98]	26[91]	CACCAGTATTTGGGTATCCTGAAATAAACACGCTG	35
38[111]	27[111]	GACACCAAAATTCAACATTCAACCGATTCATATTATTTATCC	42
39[119]	28[119]	TACCAGCAAAAGAAACAGGGAAGCGCAAGATTTTTTGTTTAA	42
40[132]	28[140]	TCGGTCAATGAATAATAATTTTTTCACGAGCCTTTCATCGCCAACAAAG	49
42[34]	28[35]	ACCCGTCTTCCTGTAGCCAGCCCAATAGCAATAAAAAAAACA	42
39[56]	28[56]	CGCCTGTCGGGGGTCAGAGAGGCGGTTTCTGATTGCCCTTCT	42
39[87]	28[77]	ATTGGGCCCCCTGCATCAAGTTGCAGAGACGG	32
30[111]	28[91]	TGAACACAGAATAAAATGAAAATAGCAGCCCTTTT	35
36[125]	30[119]	AACTGGCATATCAGAGAGAGTAAATTAGACGGGAG	35
40[34]	30[35]	GAACGCCTTCGCATTAAATTTCAAATATGGAGAAGGAACCCT	42
37[56]	30[56]	GCCAGCAGTACCGACACGTTGCGCTCACCCAACGCGCGGGAG	42
37[84]	30[77]	CGTGATATTGCGGCGGGCCGTGGGCGCCCATTAAT	35
39[98]	30[91]	CAATAGACGGAATATACAGAGCCTGAACAATCGTG	35
35[98]	31[111]	AGGAAACGAACAAACAAGAAACAATGAATAAGCCCGTAATTG	42
38[34]	31[41]	TTAAATTTAATCAGAAAAGCCCGTAAAAAGTAATG	35
34[125]	32[119]	AAGAAAATAGCTATCTTACCGACTAACCCACAAGA	35
32[55]	32[56]	AGGGTGACTGATAAATTAACACAACATATCACATTAATTGAA	42
35[87]	32[70]	GTAGGTGCCTCCTCACAGTTTCCAGATGAGTGAGCTAAC	39
37[98]	32[91]	TAGAAAATTATTACTCAGAGGAATAATAAGCTGGG	35
31[140]	33[146]	CTACGAATAAACGGGTAAAATAATGAGGACTAAAG	35
36[34]	33[48]	CTAGCATAGAGTCTGGAGCAATTTTGAGTTCAACCGTTCTAG	42
32[41]	34[28]	CGGAGACAGTCAAATATGATAAGATCTA	28
34[90]	34[91]	GAGTGAAATTGTTAGAAGCATAAAGTGTAAAGCAGGTTACCA	42
35[140]	35[139]	CAGCAGCCTACAGAGGCTTGCCCTTTTTAAGATCGTCACCCT	42
33[147]	35[150]	ACTTTTTCATGA??GAGGGTAGCAACGGGAAA	32
35[56]	35[55]	GAATTCGCATGCCGGAGAGGGTAGCTATACAAGAGAATCGTC	42
39[140]	36[133]	TTTCGAGTGCGCCGCTTTGACCAAAAGAATACACTAATGCCACCGCTTT	49
36[132]	36[140]	TGCGGAGATACCATCGCCCACGCATAACTTAAAGG	35
32[118]	37[111]	ATTGAGTATAGCAAGTAAGCAGATAGCCGCAATAAAGACTCCTACATAC	49
28[118]	37[125]	CGTCAAACATAAAAACGCAAAATAAAGGTGGCAAC	35
32[48]	37[55]	GAAAGGCTGTAGGTAAAGATTGCATGAACGGTAATCCAAAAACAGGACT	49
33[70]	37[69]	CGAGCCGTCCGCTCACAATTCTAATCATTCCCCGGCGCGTGC	42

28[76]	37[83]	GCAACAGGCGTATTTTTCACGCTGTTCTTCGCGTC	35
30[90]	37[97]	CCAGCTGAGGGTGGTTTTTTTAGTTTATGCAAACG	35
26[125]	39[118]	GAGCCTAATTTGCCCAATCCAAAGGGCGTATGGTT	35
28[139]	39[139]	TACAACGCACTCATACAATGACAACAATGCTTATCAGCTTGC	42
35[151]	39[150]	GACCAGGGAGCGATATACGATAGTGTGA	28
28[55]	39[55]	AAATCGGTTCAACGTTAGATTGTATAAGTTGTTAAATCAGCG	42
43[140]	40[133]	AACAACTGAACAACACGAGGCACCTGCTCCATGTTTTTGTATAATTGTA	49
24[125]	41[118]	ATTAGTTGCTATTTCCAACGCCACCGACTTCATTA	35
26[55]	41[55]	ATCCAATAGCATAATGCTCATTTTTAATTTCATCAACATAG	42
26[90]	41[97]	GTTTGCCTATAAATCAAAATTAATTAGAGGTAAAT	35
38[69]	42[56]	GTCATACGCACTCTCAGCGCAGTTACCTAATCGTTAACGGCA	42
24[76]	42[84]	TGAGTGTTCGGCAATTCAGCAGCAGCCAGCGGTGCCGGTGAAGCTACAC	49
24[139]	43[139]	ACCAACTAGCCGGATAAAGGAATTGCTAGCGGGATTTTGCTA	42
39[151]	43[150]	ATTCAAAAGGTTGAAAATAGAAAGTTCA	28
25[49]	43[55]	GTAGCATTCTAAATGTGAGCGGGGATAGGTCACGG	35
26[111]	44[112]	AGTTACAAATCTTATGCACCCGATGCGGGAGGTTTCACCAAT	42
47[140]	44[133]	GTAACACTGTAGCATCTTGACGCTGGCTGACCTTCAAGAGGAAATTTTC	49
41[98]	45[111]	ATTGACGGAAATTATTGAGCCAGCACCAGAAACCAATCAAGT	42
20[125]	45[125]	CATTACCGCGCCCACGGTATTCGTTTTCTTGCCTTTAGCGTC	42
22[55]	45[55]	TCCCAATAATAACCATGTTGGTGTAGATGCCTCAGGAAGAGC	42
20[76]	45[83]	AGCTTAGCGCTATTGCATCAGCGCCGGGCGCGGTT	35
24[90]	46[91]	GCCCGAGTGGACTCATAAATCTTTCCCTTAGAAATTCATAGC	42
47[98]	46[98]	CGTTTGCTTTTCGG	14
20[139]	47[139]	TAACAAAAGAGTAATTCCACAGACAGACACAACCCATGTACC	42
43[151]	47[150]	ACAGACGTTAGATCTAACAACGCCTGAG	28
20[55]	47[55]	TAGCTCATAACAGTGCTCGCACTCCAGCCATTCAGGCTGCGT	42
51[140]	48[133]	GTATAGCTTAGTACAGATGGTCAGAACGAGTAGTACTCATTCAAGCCCA	49
43[56]	48[63]	GTAAAGGTTTCTTTCCCTGCGCTCAATCCGGGGTCGCCATCCTGCCAAC	49
18[111]	49[125]	CCAAGTAAATAATCGGCTGTCCACCAGATCAGAGCCACCACC	42
18[55]	49[55]	TTAATTGATATAATCCGCAACTGTTGGGATGTGCTGCAAGCG	42
16[76]	49[83]	AACTTTTGTAAATGCACATCCCAGCGTGGTGCTGG	35
18[104]	50[91]	CCGCACTCAGAGAGACTACCTAAATCCAATCGCAACGCCGCC	42
16[139]	51[139]	TTATGCGGGGCTTGCGCCACCCTCAGCATTGGGTTGATATAA	42
47[151]	51[150]	TTTTTTTCAGGCCACCCAGGAGGTCCGG	28
18[48]	51[55]	CTCCTTTCAGGATTAGAGAGTGCGCGATTAAGTTGAAGCTTTCAGAGAA	49
55[140]	52[133]	ATGCCCCTGAAAGTCTAACGGGAAAAATCTACGTTTAAGAACGTGCCGT	49
12[118]	53[125]	CAGTAATTAATTCTCTTTTGACCGTTCCAGTAAGC	35
49[56]	53[69]	GACTTGTAGAACGTTCATAACCGTTTTTGATTGCCCGCACAG	42
12[76]	53[83]	CAAATTCATCATAAACATCGAGCGGCCTTTAGTGA	35
14[90]	53[97]	CCGACCGAAAAAGCCTGTTCCACTGGTAAAAGCGC	35
51[98]	54[105]	GAGGTTGAGGCAGGTAAATCCGAATTTATGATACA	35

12[111]	55[118]	AAGAGAAAACGCCAACATGTACCTCGTTTGAGTAA	35
10[125]	55[139]	TCATAACATTTAGGCAGAGTTAGGAATATAAGAGCACAGTTA	42
51[151]	55[150]	AATTACCAGGTTAGGATTGAAACACTGC	28
12[48]	55[55]	TGCTTTAAAATATTCATTGAACAGAGGGGGATCAA	35

Table S5. Staple strands of DNA origami Arm

Start	End	Sequences 5'-3'	Length
5[105]	0[112]	GCCATTGAATATCCTACTTCTTCACGCACGGTACGCCAGAATGAGCCGT	49
6[153]	0[140]	GTATTAACAGAAGATTAAAAACGCGAACAAATATCTTTAGGA	42
3[42]	0[52]	GTTTGGAAAGGAGCTTTTGCGGAACAAAACTC	32
9[63]	0[73]	AAAACAACAAACAATTCGACAGAGAGCGGGAGCTAAACAGGAGACT	46
5[21]	3[34]	AAATAAATCAAAATTTCATCAATATAAT	28
6[121]	4[126]	GGAAAAAACGCTCATGGCAAACTA	24
6[37]	4[42]	ATACGTAGATTTTCAGGGAAGGGT	24
4[118]	5[104]	TGCTGGTCAACAGGTTATTTACATTGGCAGATTCCACCGCCA	42
2[118]	6[122]	CTGTCCATTGATTATCTGACCGACCAGTAATAAAAAAAT	39
3[161]	6[154]	AATATCACCAGCAGCAAATGAACAGTGCGCGGTCA	35
4[34]	6[21]	TACCATAGAAATTGTACAGTAACAGTAC	28
6[48]	6[49]	ACGTCAGGCCTGATTGCTTGGGGTCGAGTGGCGAGAAAGGTA	42
2[76]	6[77]	GCTTTCCCTACAGGCCATCACAAAGCACTAAATCGGACGGGG	42
2[160]	7[160]	AATATCTAACCTCAATCGCCATAAAACA	28
4[97]	7[97]	TATAGCGGTCACGCCTATGGTTGCTTTTACCTTTTAAAGGGA	42
2[139]	8[126]	GAGGCCATGCCTGACGCCAACAGAGATA	28
0[135]	8[140]	TAAATTAGTCTTTAATGTACCGAA	24
2[55]	8[42]	CCACCAGTTATACTTTTGAATACCAAGT	28
0[51]	8[56]	GTAAAACAAACATCAAGAAGTTTT	24
4[76]	8[63]	AACCACCAGCGGGCAAAGCCGGCGAACGGTGCCGTCCAAATC	42
5[77]	8[84]	GCTAGGGCGCTGGCAAGTGTTCCGATTTAGAGCTTGAACCCTTTACACT	49
1[140]	9[160]	CAAATCAACAGTTGAAAGGAATTATCTATGATAGC	35
2[97]	9[97]	CGTGACGAGCACGTTAAAGGGATTTTAGTTTGAGGTCATTTG	42

Table S6. Staple strands of AuNR captures (arm)

Start	End	Sequences 5'-3'	Length
9[126]	2[119]	AATGGCTCAACTAATAGATTACCTGAGAAAAGAGT ACT AAC TCA AAA	44
3[140]	2[140]	GTATCACCTTGCTGGGTCAGTTGGCAGT ACT AAC TCA AAA	37
9[42]	2[35]	GATGATGTTAAATCCTTTGCCATTATCAGGAATTA ACT AAC TCA AAA	44
3[56]	2[56]	TCCTTAATGCGCCGTCGTTAGAATCAAA ACT AAC TCA AAA	37
9[84]	2[77]	AACAATTATTTAGAAGTATTAGGCCGATATAACGT ACT AAC TCA AAA	44
9[98]	2[98]	AAAATACGTGGCACCAATAGATAATACAACAGGAAAATTAAC ACT AAC TCA AAA	51
9[112]	4[119]	AGACAATATTTTTGGAACCCTGTAATAATCGGCCT ACT AAC TCA AAA	44
4[139]	4[140]	AAGAACTAAATACCTACATCCGCCTGCAAAAATCTAAAGCAG ACT AAC TCA AAA	51
0[30]	4[35]	CGTCCTGAGCAAAAGAATACAAAACCTGATTTAGAACC ACT AAC TCA AAA	47
4[55]	4[56]	AATAATGTTAAGGGAAGAAAGCGAAAGGACACCCGCCGCGTG ACTAACTCAAAA	51
0[72]	4[77]	TTAAATTAATTACATTTACGTGAAGCGCGTATGCGCGT ACT AAC TCA AAA	47
7[98]	4[98]	GCCACCAGTCACACTGAAAGCGTAAGTTGTAGCAAAGAACAA ACTAACTCA AAA	51

Table S7. Staple strands of AuNR captures (plate)

Start	End	Sequences 5'-3'	Length
30[76]	35[86]	GAATCGGTGCCCGCTTGAGGAGGTCATAGCTGTTTCCT ACT AAC TCA AAA	47
32[90]	35[97]	GTGCCTATCGGGAAACCTGAGGCAGTATGAAACCG ACT AAC TCA AAA	44
27[70]	39[86]	CTGAGAGGACGATCGTGGTGCTGCGGCCAGA ACT AAC TCA AAA	40
28[90]	39[97]	CACCAGTGCAAGCGGTCCAGCGAGGGAGTCACAAT ACT AAC TCA AAA	44
22[76]	43[86]	GTGAGTGACTATTAACTGTTGGCTCGTCATAAACATCC ACT AAC TCA AAA	47
21[98]	43[97]	ATAGAAGAACCGTCTATCAACCAACGTCCAGCACCGCAAAAT ACT AAC TCA AAA	51
18[76]	47[86]	CTCCGGCAGTGAATGCAAGAACACGCAACCAGCTTACG ACT AAC TCA AAA	47
20[90]	47[97]	GAAAACAAATCATAGGTCTTCCCTCAGATTATTAG ACT AAC TCA AAA	44
14[76]	51[86]	AATAAGGTCTTCTGCGATGCTTCGTCTCGTCGCTGGCA ACT AAC TCA AAA	47
16[90]	51[97]	AAAGAACTTTAATGGTTTGCCAGCCAGATTGACAG ACT AAC TCA AAA	44
11[63]	55[86]	ACGCTCAACAGTAGCTTTTGCTCATTTGCCGCCAGCAG ACT AAC TCA AAA	47
12[90]	55[97]	TCATATGTTGAGAATCGCCATAAAAACCGTTTTAA ACT AAC TCA AAA	44

Table S8. Switching systems on DNA origami templates

Start	End	Sequences 5'-3'	Length
2[34]	0[31]	TCATCATATTCCTGAAAGTTTGAGTAACCGAA TTTTTT TGTAGTTG	1R-0
6[142]	6[143]	TGACGCTCAATCGTCTGGGGACATTCTGGAACCACCAGCATT TTTTTT TGTAGTTG	1R-6
14[55]	53[55]	CCAATACAACTACA TTTTTT ATTATAGTCAAATACAGTGGAGCCGCCATTACCAGTCCCGAA	1R-14
30[118]	35[125]	CCAATACAACTACA TTTTTT AATTAACAGCGCTAATGATTATAACGGAATACCCA	1R-30
		TGTAGTTGTATTGGTGAAGT	R'
		ACTTCACCAATACAACTACA	R
3[126]	0[136]	CATCACTCCGAGTAAGTGTTTTTATAATGCAC TTTTTT TACTACTC	1L-0
8[34]	6[38]	TCGCGCAACAATAACGGATTCATGA TTTTTT TACTACTC	1L-6
30[55]	26[42]	TCTTGTGAGTAGTA TTTTTT GATAAAAATTTTTACCTTTATTTGTACCGCCTCAGAAATCAT	1L-30
14[118]	51[125]	TCTTGTGAGTAGTA TTTTTT ATGTTCAAGATAAGAAACAAATCAGACGATTGGCC	1L-14
		TACTACTCACAAGATGAAGA	L'
		TCTTCATCTTGTGAGTAGTA	L

Table S9. Sequence of SH-DNA on AuNRs

Name	Sequences 5'-3'	Length
SH-DNA	HS-TTT TGA GTT AGT	12

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