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Electronic Supplementary Information

Organic-inorganic hybrid self-pigmenting effect of anodic aluminium oxide membranes

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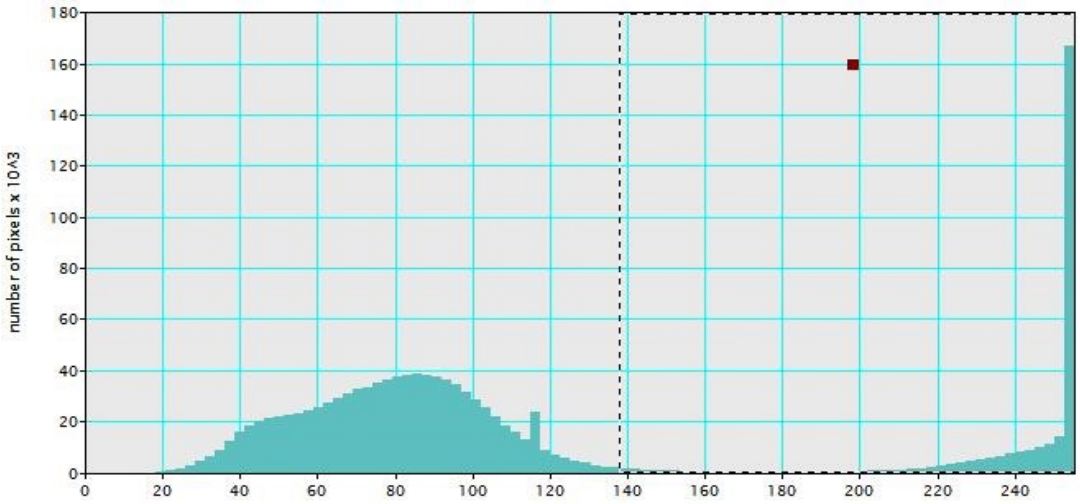
1. **Measurements of sizes of the top and bottom nanochannels of the AAO membranes by a Gatan DigitalMicrograph (DM) software**

a



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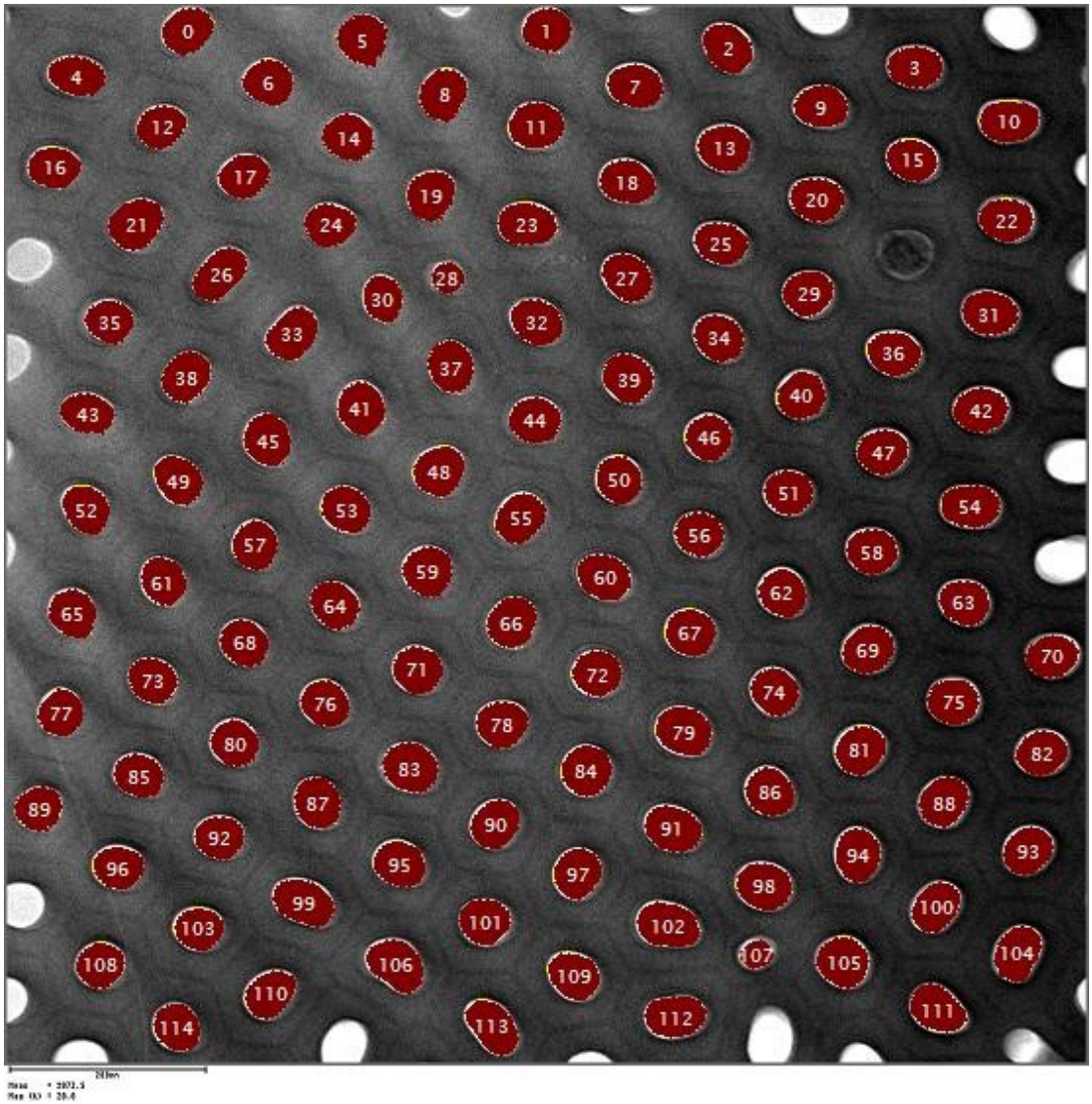

c

	FilledArea	CircDiamete
R0	2128.0	53.2284
R1	1937.0	50.1124
R2	2155.0	52.7879
R3	2048.0	51.4354
R4	2033.0	52.2904
R5	2356.0	58.6699
R6	2064.0	52.1644
R7	2226.0	53.7078
R8	2219.0	54.8496
R9	2049.0	51.3877
R10	2328.0	55.5584
R11	2324.0	54.6029
R12	1886.0	49.282
R13	2221.0	53.0534
R14	2181.0	54.7716
R15	1925.0	49.5724
R16	1965.0	50.8472
R17	1994.0	51.0859
R18	2207.0	53.4114
R19	2141.0	53.0623
R20	2106.0	51.9483
R21	2429.0	56.1346
R22	2115.0	52.3849
R23	2307.0	55.5219
R24	1942.0	50.3019
R25	2023.0	51.1779
R26	2256.0	55.8574
R27	2116.0	52.088
R28	960.0	35.5284
R29	2046.0	51.0324
R30	1682.0	47.3331
R31	2189.0	53.1052
R32	2114.0	52.233
R33	2319.0	55.5415
R34	2076.0	51.2596
R35	1886.0	49.7445
R36	2117.0	52.013
R37	2130.0	52.714
R38	2147.0	52.6976

	FilledArea	CircDiamete
R39	2246.0	53.4261
R40	2079.0	51.3833
R41	2293.0	54.7958
R42	2159.0	52.4611
R43	1998.0	52.3483
R44	2131.0	52.2543
R45	2221.0	54.2005
R46	1917.0	49.0661
R47	2056.0	51.0233
R48	2288.0	54.2834
R49	2069.0	52.3906
R50	1986.0	50.27
R51	1941.0	49.5797
R52	2031.0	51.4663
R53	2099.0	51.8175
R54	2291.0	54.8967
R55	2215.0	53.5671
R56	1953.0	49.6948
R57	1988.0	50.4777
R58	2029.0	50.7138
R59	2228.0	53.1587
R60	2214.0	53.5897
R61	1973.0	50.5407
R62	2052.0	51.0584
R63	2038.0	50.9632
R64	2063.0	51.3497
R65	2085.0	52.9374
R66	2240.0	53.8297
R67	2130.0	51.8331
R68	1991.0	50.3374
R69	2189.0	52.5862
R70	2011.0	50.8106
R71	2115.0	51.7899
R72	2060.0	51.0814
R73	1994.0	50.5272
R74	2034.0	50.8182
R75	2128.0	51.9206
R76	2019.0	50.6704
R77	1904.0	49.3283

	FilledArea	CircDiamete
R78	2153.0	52.391
R79	2471.0	56.3416
R80	2025.0	50.8826
R81	2194.0	52.7527
R82	2061.0	51.1954
R83	2501.0	56.7738
R84	2303.0	54.0352
R85	1935.0	49.9522
R86	2105.0	51.5902
R87	2133.0	52.4239
R88	2160.0	52.455
R89	1877.0	49.0091
R90	2096.0	51.8851
R91	2337.0	54.9409
R92	1914.0	49.4964
R93	2081.0	51.4171
R94	2188.0	52.893
R95	2159.0	52.5879
R96	1980.0	50.1963
R97	2168.0	52.5651
R98	2399.0	55.3463
R99	2496.0	57.7625
R100	2088.0	52.1093
R101	2101.0	51.7033
R102	2573.0	58.6696
R103	1895.0	49.1171
R104	2220.0	54.1359
R105	2388.0	55.1056
R106	2573.0	58.759
R107	906.0	34.1982
R108	1967.0	49.8647
R109	2207.0	53.3386
R110	2095.0	52.4452
R111	2260.0	54.8787
R112	2303.0	55.4867
R113	2334.0	56.6876
R114	1957.0	49.9397

Fig. S1 a1. (a) Histogram of thresholding the TEM imageof the top surface of the AAO membrane withoutthe chemical etching, the thresholding is the process of separating the top surfaces of the nanochannels from the rest of the image, ideally, the histogram contains two major peaks: one for the background, the other for the nanochannels. (b) The TEM image with analyzed nanochannels after the thresholding. (c) Measurements of the sizes (diameter, unit: nm) of the analyzed nanochannels on the top surface.

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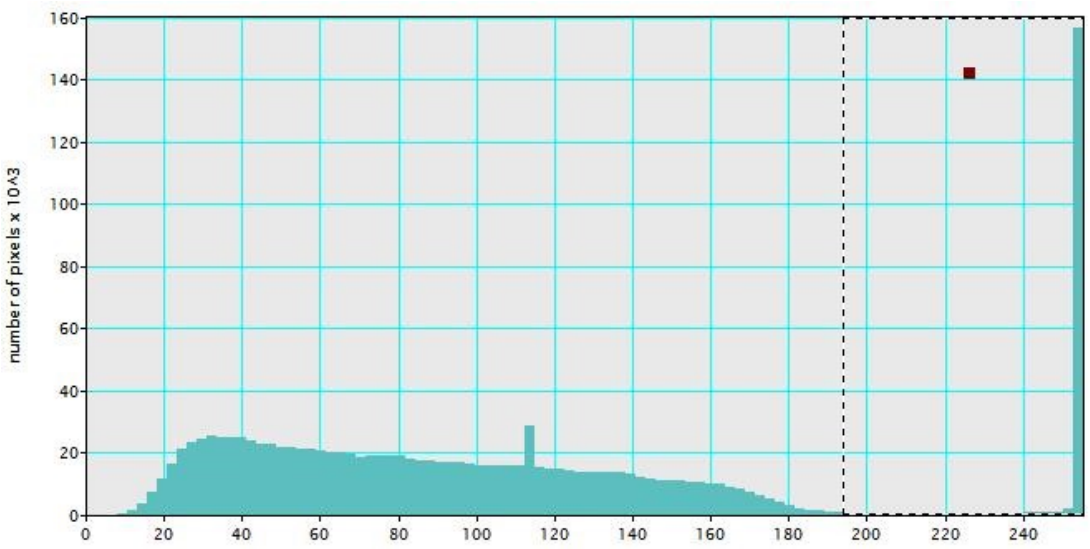
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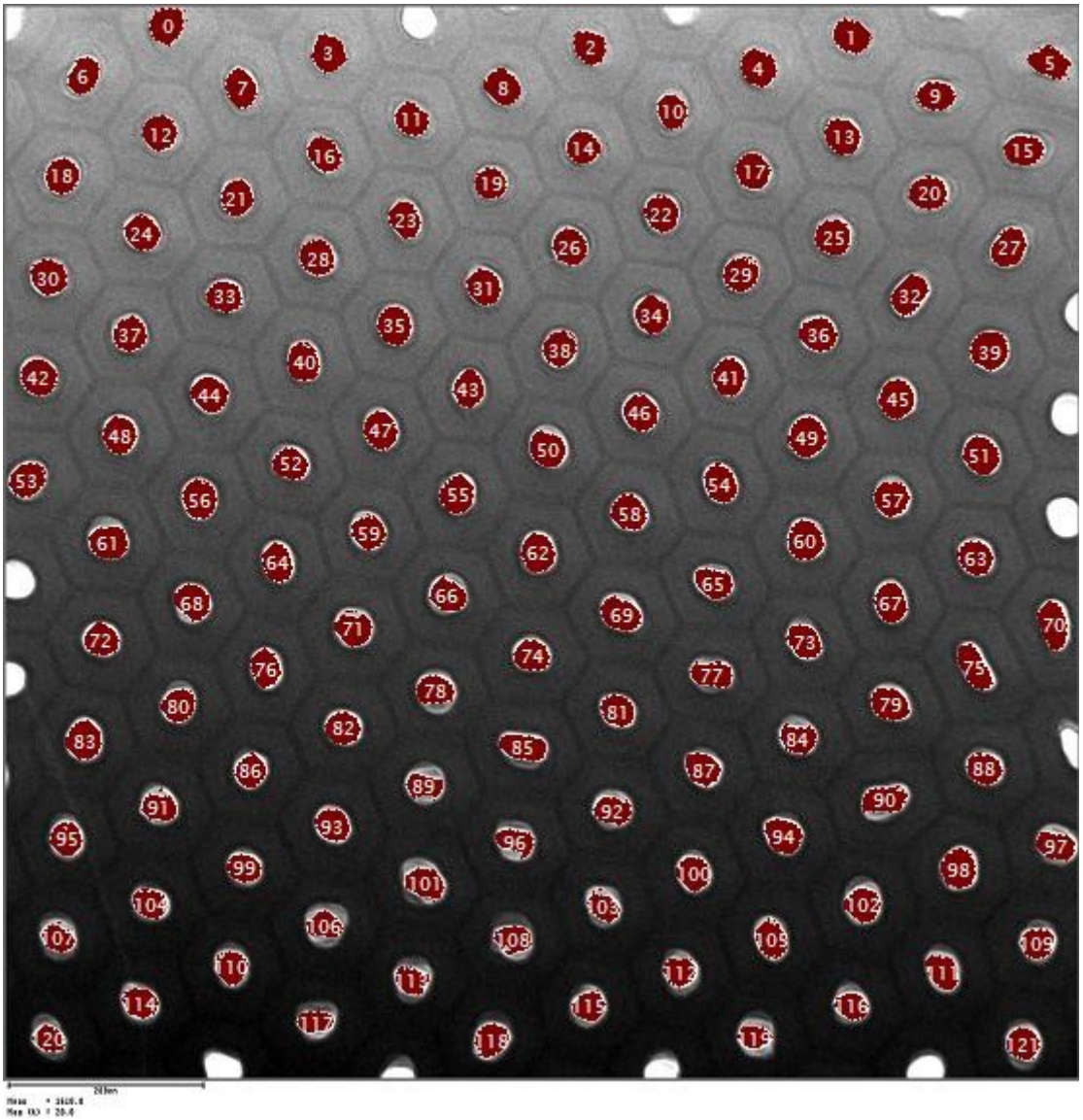

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	FilledArea	CircDiameter
R0	1212.0	40.7816
R1	1136.0	39.0978
R2	1050.0	37.6815
R3	1165.0	39.5144
R4	1214.0	40.0522
R5	1187.0	42.2894
R6	1071.0	37.5399
R7	1094.0	38.0045
R8	1130.0	38.1085
R9	1032.0	36.6269
R10	985.0	36.0752
R11	1022.0	36.3757
R12	1101.0	37.3141
R13	1153.0	38.2606
R14	1001.0	35.7282
R15	1102.0	37.6669
R16	1031.0	37.0847
R17	1123.0	37.6348
R18	1097.0	37.2347
R19	911.0	33.795
R20	1153.0	38.407
R21	1039.0	36.5035
R22	1119.0	37.6464
R23	1036.0	36.6747
R24	1125.0	37.6184
R25	1162.0	38.6152
R26	1141.0	38.0711
R27	1184.0	39.1168
R28	1127.0	38.0294
R29	1122.0	37.6734
R30	1175.0	38.5696
R31	1105.0	37.2242
R32	1234.0	40.3507
R33	994.0	35.7273
R34	1143.0	37.9146
R35	1163.0	38.3248
R36	1139.0	37.9085
R37	1052.0	36.507
R38	1076.0	36.831
R39	1312.0	40.6739
R40	1115.0	38.002

	FilledArea	CircDiameter
R41	1108.0	37.511
R42	1194.0	38.7896
R43	1016.0	35.8478
R44	1175.0	38.5558
R45	1248.0	39.8211
R46	1156.0	38.0765
R47	1147.0	38.2229
R48	1148.0	37.9748
R49	1330.0	40.9326
R50	1224.0	39.9818
R51	1231.0	39.4616
R52	1004.0	35.7097
R53	1115.0	37.6572
R54	1127.0	37.8719
R55	1150.0	38.1429
R56	1201.0	38.9853
R57	1124.0	37.7206
R58	1133.0	37.8086
R59	1048.0	36.661
R60	1274.0	40.3679
R61	1156.0	38.6927
R62	1174.0	38.6338
R63	1096.0	37.1784
R64	1070.0	37.1062
R65	1022.0	36.8071
R66	1062.0	37.009
R67	1137.0	38.3158
R68	1109.0	37.8245
R69	1218.0	40.1503
R70	1233.0	42.0844
R71	1192.0	38.8727
R72	1040.0	36.2887
R73	1025.0	36.4949
R74	1037.0	36.2803
R75	1179.0	42.3216
R76	1025.0	36.381
R77	981.0	37.7903
R78	1017.0	36.792
R79	1130.0	38.4
R80	980.0	35.2584
R81	972.0	35.1081

	FilledArea	CircDiameter
R82	1050.0	36.2174
R83	1250.0	39.8998
R84	966.0	36.1272
R85	1156.0	40.8783
R86	940.0	34.4313
R87	1044.0	36.6519
R88	1006.0	35.8128
R89	821.0	35.0884
R90	1112.0	41.1961
R91	954.0	36.2103
R92	965.0	36.4195
R93	1024.0	36.2218
R94	1143.0	38.4667
R95	989.0	35.4871
R96	881.0	35.7923
R97	1011.0	37.5725
R98	1262.0	40.2573
R99	869.0	33.2996
R100	1022.0	36.0035
R101	1088.0	39.2078
R102	1093.0	37.1719
R103	853.0	34.637
R104	939.0	34.7722
R105	1058.0	37.3571
R106	818.0	34.441
R107	823.0	33.4585
R108	925.0	35.4906
R109	942.0	34.8839
R110	936.0	34.8972
R111	989.0	36.7248
R112	871.0	33.6716
R113	834.0	33.5545
R114	963.0	35.3774
R115	870.0	33.4513
R116	829.0	32.4873
R117	731.0	32.3164
R118	1027.0	36.6706
R119	726.0	31.7116
R120	739.0	30.8731
R121	994.0	35.6867

Fig. S1 a2. (a) Histogram of thresholding the TEM image of the bottom surface of the AAO membrane without the chemical etching. (b) The TEM image with the analyzed nanochannels after the thresholding. (c) Measurements of the sizes (diameter, unit: nm) of the analyzed nanochannels on the bottom surface of the AAO membrane.

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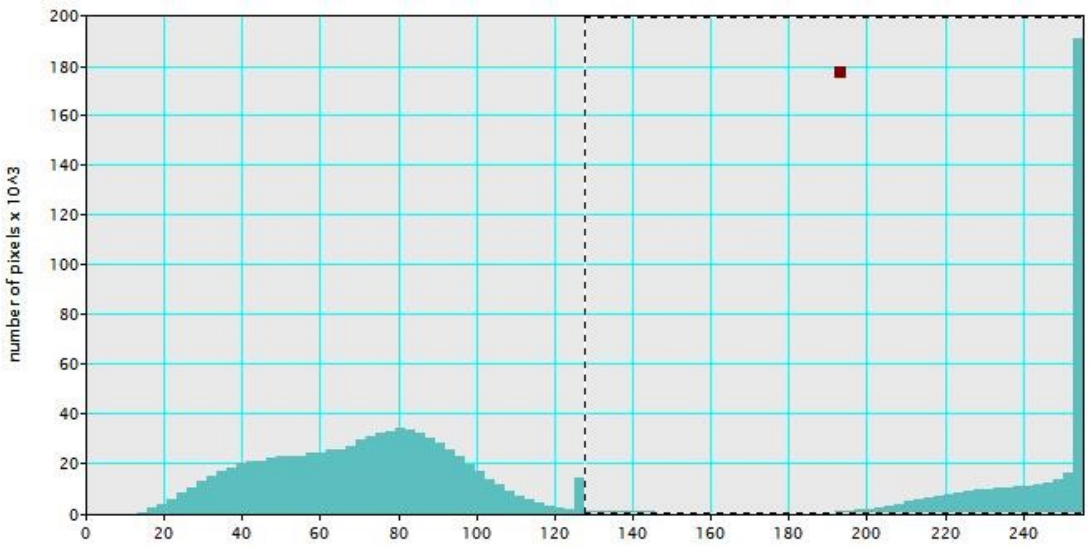
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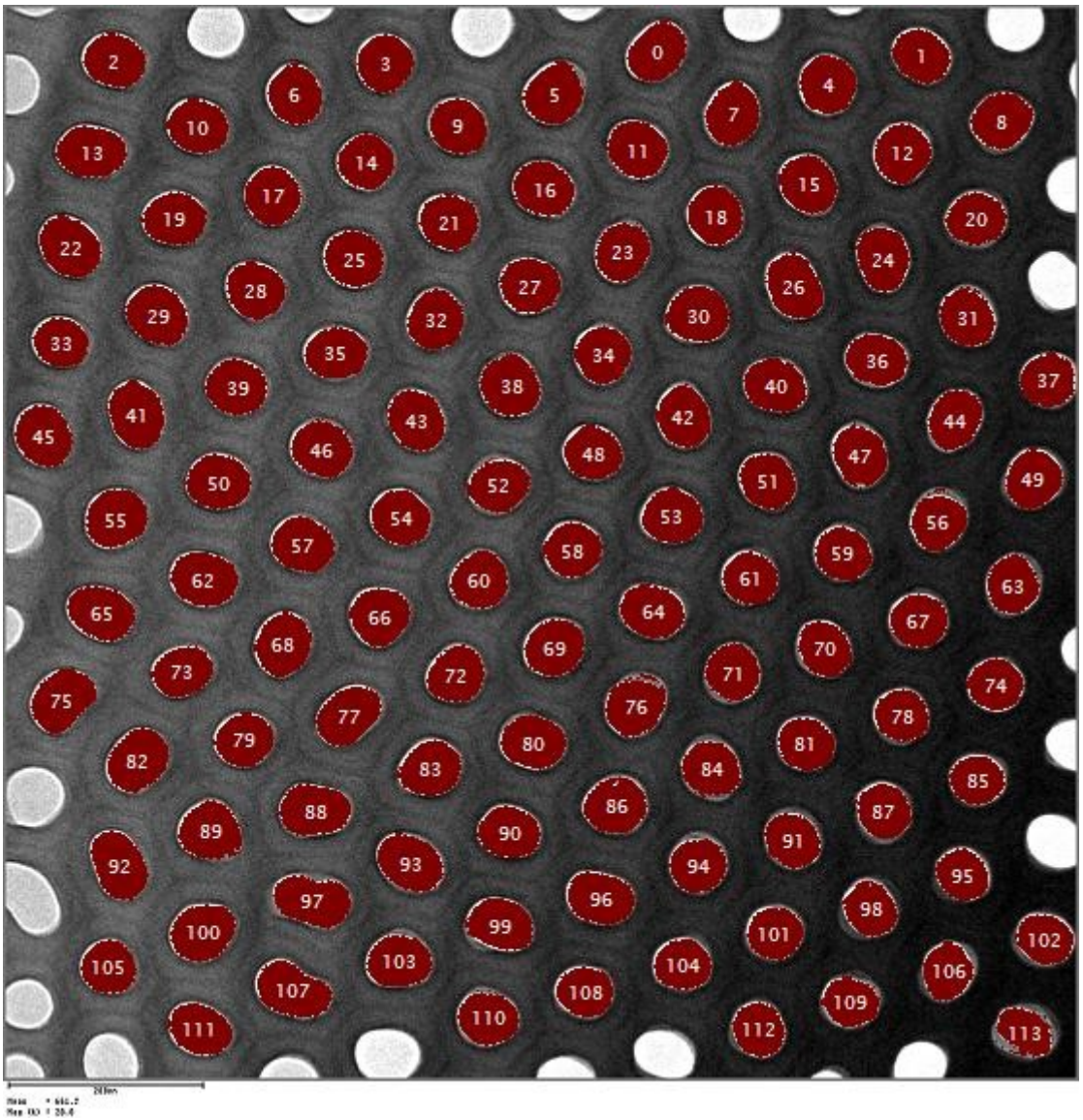
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c

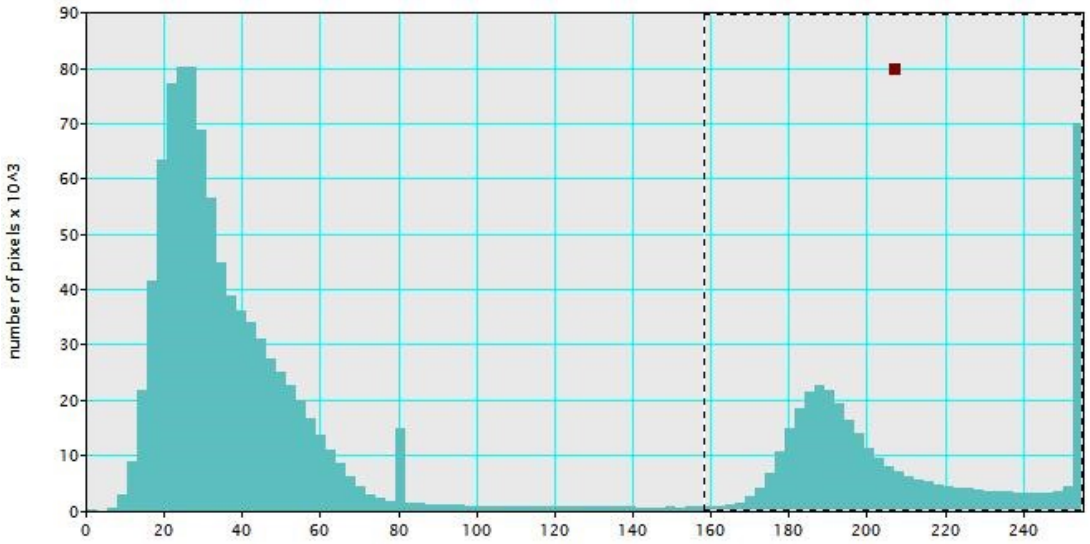
	FilledArea	CircDiamete
R0	2976.0	62.2774
R1	2707.0	59.0188
R2	2973.0	62.4856
R3	2829.0	59.9069
R4	2926.0	61.0393
R5	3181.0	64.5274
R6	2841.0	60.3354
R7	2951.0	61.5941
R8	2949.0	61.3917
R9	2801.0	59.759
R10	2881.0	60.5366
R11	3015.0	61.9733
R12	2958.0	61.2484
R13	3193.0	64.7387
R14	2707.0	58.8062
R15	2928.0	61.253
R16	2944.0	61.4501
R17	2849.0	60.0395
R18	2829.0	59.9455
R19	2945.0	61.5334
R20	2741.0	59.3944
R21	2883.0	60.6896
R22	3255.0	64.9712
R23	2780.0	60.01
R24	2948.0	61.8623
R25	2955.0	61.6259
R26	3191.0	64.6561
R27	2939.0	61.3329
R28	2928.0	61.051
R29	3187.0	64.0739
R30	3093.0	62.8647
R31	2839.0	60.3045
R32	2935.0	61.1582
R33	2451.0	56.4877
R34	2814.0	60.005
R35	2912.0	61.624
R36	2820.0	60.4058
R37	2625.0	57.7863

	FilledArea	CircDiamete
R38	3220.0	64.2655
R39	3000.0	62.4507
R40	2924.0	61.4205
R41	3273.0	65.2237
R42	2921.0	61.4512
R43	3029.0	62.3418
R44	2797.0	60.2125
R45	3062.0	62.6296
R46	3060.0	62.712
R47	2934.0	61.635
R48	2772.0	59.354
R49	2893.0	60.6294
R50	3129.0	63.2648
R51	2744.0	59.1598
R52	2849.0	61.0016
R53	2947.0	61.3297
R54	2894.0	61.0189
R55	3202.0	64.1048
R56	2823.0	60.9166
R57	3016.0	62.2202
R58	2807.0	59.6338
R59	2637.0	57.8778
R60	2887.0	60.7785
R61	2578.0	57.1243
R62	3239.0	64.8055
R63	2663.0	58.8507
R64	3031.0	62.8699
R65	3191.0	64.698
R66	3063.0	62.5359
R67	2723.0	58.7299
R68	3102.0	63.206
R69	3008.0	62.0011
R70	2614.0	57.9827
R71	2718.0	59.0786
R72	2867.0	60.6495
R73	2707.0	59.3573
R74	2549.0	56.7578
R75	3319.0	66.7417

	FilledArea	CircDiamete
R76	3218.0	64.5793
R77	3188.0	65.3238
R78	2483.0	56.202
R79	2782.0	59.4414
R80	3069.0	63.2162
R81	2612.0	57.4491
R82	3305.0	65.4487
R83	3030.0	62.4776
R84	2868.0	60.9586
R85	2401.0	55.2348
R86	3132.0	63.3223
R87	2636.0	58.1456
R88	3280.0	66.4663
R89	3242.0	65.1175
R90	2850.0	60.5221
R91	2639.0	58.3041
R92	3246.0	66.0661
R93	3250.0	65.5012
R94	2740.0	59.4182
R95	2389.0	55.0889
R96	3124.0	64.0771
R97	3457.0	70.3582
R98	2583.0	57.5036
R99	3056.0	63.7019
R100	3236.0	64.6044
R101	2596.0	57.4737
R102	2530.0	57.0326
R103	3048.0	63.3906
R104	2602.0	57.7868
R105	2573.0	57.4307
R106	2509.0	57.2233
R107	3453.0	69.9792
R108	2545.0	57.118
R109	2482.0	56.7034
R110	2935.0	61.4644
R111	2841.0	60.9965
R112	2497.0	56.3536
R113	2456.0	58.2178

Fig. S1 b1. (a) Histogram of thresholding the TEM image of the top surface of the AAO membranewiththe chemical etching for 10 min. (b) The TEM image with the analyzed nanochannels after the thresholding. (c) Measurements of the sizes (diameter, unit: nm) of the analyzed nanochannels on the top surface of the AAO membrane.

a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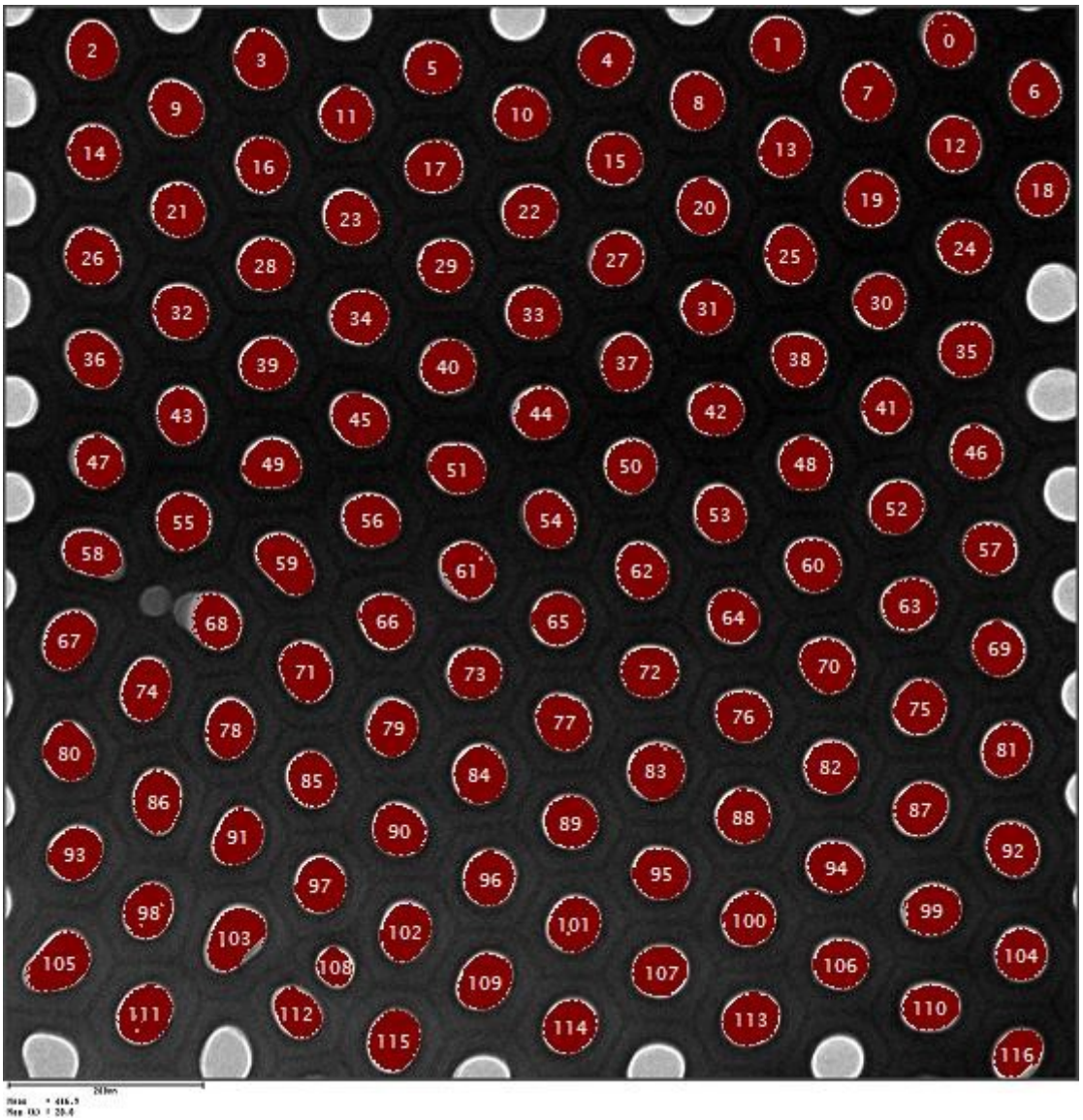
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c

	FilledArea	CircDiameter
R0	2385.0	54.979
R1	2507.0	56.2444
R2	2486.0	56.2287
R3	2687.0	58.5875
R4	2568.0	56.9548
R5	2525.0	56.4488
R6	2361.0	54.692
R7	2585.0	57.2023
R8	2626.0	57.7382
R9	2511.0	56.5831
R10	2503.0	56.2327
R11	2490.0	56.0033
R12	2470.0	55.8405
R13	2591.0	57.4309
R14	2467.0	55.8186
R15	2451.0	55.5807
R16	2517.0	56.3735
R17	2574.0	57.0733
R18	2382.0	54.8596
R19	2578.0	57.0106
R20	2481.0	55.9733
R21	2459.0	55.7407
R22	2490.0	56.0846
R23	2581.0	57.2588
R24	2391.0	54.8849
R25	2529.0	56.7501
R26	2639.0	57.8196
R27	2426.0	55.564
R28	2545.0	56.7003
R29	2450.0	55.5967
R30	2420.0	55.2453
R31	2396.0	54.8945
R32	2584.0	57.1176
R33	2467.0	55.822
R34	2666.0	58.0666
R35	2503.0	56.2141
R36	2581.0	57.7064
R37	2465.0	56.015
R38	2453.0	55.7788
R39	2527.0	56.5803
R40	2542.0	56.6486
R41	2314.0	54.1446
R42	2431.0	55.3958
R43	2421.0	55.5789
R44	2473.0	55.9004
R45	2613.0	57.7747
R46	2365.0	54.5706
R47	2223.0	53.061
R48	2460.0	55.7557
R49	2541.0	57.0904
R50	2401.0	54.9957
R51	2459.0	55.9579
R52	2459.0	55.6812
R53	2497.0	56.3422
R54	2437.0	56.0736
R55	2618.0	57.4961
R56	2594.0	57.3637
R57	2329.0	54.3182
R58	2329.0	55.3426
R59	2733.0	61.067
R60	2526.0	56.5218
R61	2587.0	57.5564
R62	2469.0	55.9465
R63	2480.0	56.1341
R64	2325.0	54.2545
R65	2421.0	55.2546
R66	2576.0	57.2036
R67	2546.0	57.4861
R68	2340.0	55.5953
R69	2409.0	55.1448
R70	2562.0	56.997
R71	2646.0	58.3942
R72	2570.0	57.0884
R73	2399.0	55.0125
R74	2618.0	58.4887
R75	2454.0	55.6645
R76	2455.0	55.7906
R77	2617.0	57.6509
R78	2499.0	56.5853
R79	2471.0	56.1419
R80	2497.0	56.4652
R81	2306.0	54.0724
R82	2449.0	55.6152
R83	2762.0	59.0161
R84	2648.0	57.8426
R85	2322.0	54.3714
R86	2616.0	58.5354
R87	2490.0	56.1533
R88	2561.0	56.7946
R89	2460.0	55.68
R90	2396.0	55.1461
R91	2395.0	55.6194
R92	2438.0	55.5566
R93	2507.0	56.3904
R94	2525.0	56.6127
R95	2508.0	56.3659
R96	2449.0	55.5352
R97	2462.0	55.8514
R98	2315.0	54.3925
R99	2514.0	56.8708
R100	2500.0	56.1541
R101	2527.0	56.585
R102	2557.0	57.2041
R103	2937.0	64.2105
R104	2320.0	54.0686
R105	3077.0	64.6539
R106	2378.0	54.8118
R107	2454.0	55.8584
R108	1250.0	39.721
R109	2634.0	58.0326
R110	2367.0	55.234
R111	2752.0	59.3963
R112	2027.0	51.3734
R113	2613.0	57.5258
R114	2480.0	56.0281
R115	2722.0	58.9894
R116	1981.0	50.9957

Fig. S1 b2. (a) Histogram of thresholding the TEM image of the bottom surface of the AAO membranewiththe chemical etching for 10 min. (b) The TEM image with the analyzed nanochannels after the thresholding. (c) Measurements of the sizes (diameter, unit: nm) of the analyzed nanochannels on the bottom surface of the AAO membrane.

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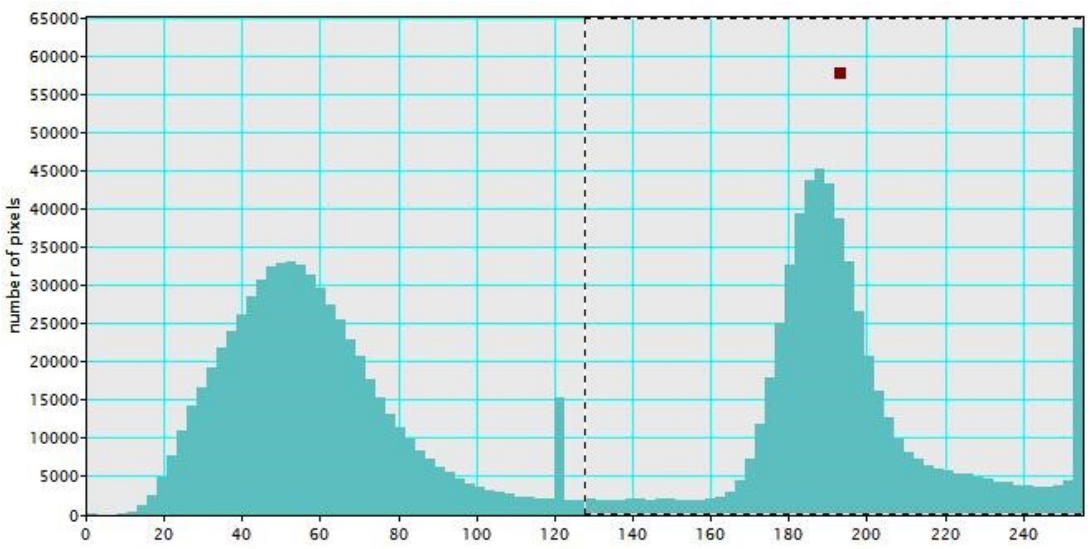
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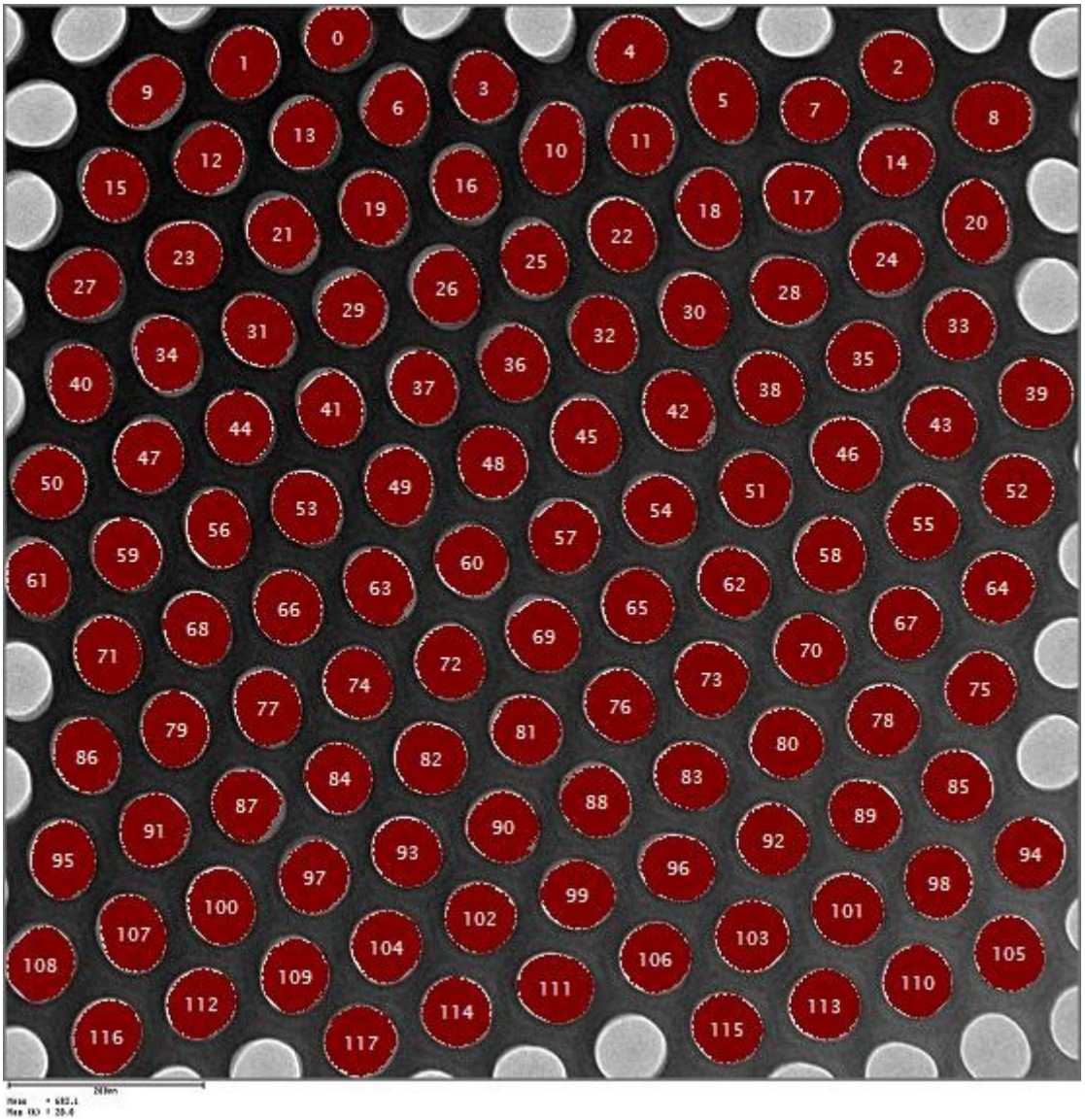
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c

	FilledArea	CircDiameter
R0	3552.0	67.9835
R1	4116.0	72.6253
R2	4189.0	73.0959
R3	3835.0	70.1718
R4	4206.0	73.6827
R5	4816.0	79.4783
R6	4152.0	73.6957
R7	3676.0	68.2294
R8	4664.0	77.2519
R9	4128.0	74.0236
R10	4847.0	81.1199
R11	3885.0	70.4055
R12	3998.0	71.9283
R13	3865.0	71.2642
R14	4314.0	74.3494
R15	3978.0	71.2075
R16	4104.0	72.8015
R17	4473.0	75.8051
R18	4389.0	75.5791
R19	4252.0	74.2087
R20	4534.0	77.2444
R21	4202.0	73.5527
R22	4218.0	73.4022
R23	4416.0	75.0325
R24	4430.0	75.3533
R25	4112.0	72.8282
R26	4272.0	74.1326
R27	4227.0	73.7177
R28	4418.0	75.2791
R29	4206.0	73.8589
R30	4320.0	74.2817
R31	4313.0	74.3429
R32	4336.0	74.7032
R33	4233.0	73.4511
R34	4295.0	74.4427
R35	4262.0	73.6073
R36	4374.0	74.8592
R37	4227.0	73.7537
R38	4274.0	73.6014
R39	4408.0	74.7371

	FilledArea	CircDiameter
R40	4254.0	74.3755
R41	4175.0	73.4702
R42	4781.0	79.0817
R43	4366.0	74.4546
R44	4134.0	72.3801
R45	4489.0	75.7973
R46	4369.0	74.6302
R47	4292.0	73.7864
R48	4280.0	73.692
R49	4415.0	75.2287
R50	4409.0	75.241
R51	4473.0	75.4518
R52	4349.0	74.216
R53	4328.0	74.2827
R54	4292.0	74.1086
R55	4565.0	76.1575
R56	4271.0	74.1906
R57	4316.0	74.4316
R58	4563.0	76.3833
R59	4169.0	72.7993
R60	4255.0	73.8808
R61	4097.0	72.8124
R62	4236.0	73.3673
R63	4450.0	75.857
R64	4289.0	73.7691
R65	4492.0	75.5307
R66	4265.0	73.6193
R67	4404.0	74.6551
R68	4235.0	73.4903
R69	4501.0	75.9696
R70	4336.0	74.254
R71	4364.0	74.6168
R72	4356.0	74.4979
R73	4611.0	76.9095
R74	4138.0	72.4885
R75	4348.0	74.2481
R76	4337.0	74.1792
R77	4338.0	74.666
R78	4375.0	74.3719
R79	4341.0	74.3378

	FilledArea	CircDiameter
R80	4369.0	74.3152
R81	4124.0	72.6245
R82	4455.0	75.1245
R83	4192.0	72.9685
R84	3966.0	70.8961
R85	4317.0	74.0235
R86	4228.0	73.8903
R87	4168.0	73.5076
R88	4307.0	74.442
R89	4317.0	74.3104
R90	4306.0	74.0989
R91	4274.0	73.8365
R92	4319.0	73.9769
R93	4123.0	72.2203
R94	4293.0	73.6768
R95	4303.0	74.3797
R96	4254.0	73.8752
R97	4239.0	73.4896
R98	4200.0	72.9818
R99	4314.0	74.0355
R100	4456.0	75.4674
R101	4332.0	74.0334
R102	4204.0	72.8714
R103	4420.0	74.6968
R104	4321.0	74.0493
R105	4463.0	75.4159
R106	4185.0	72.936
R107	4426.0	75.5251
R108	4315.0	74.2294
R109	4235.0	73.6303
R110	4230.0	73.1997
R111	4500.0	75.6899
R112	4130.0	72.4951
R113	4253.0	73.4124
R114	4154.0	72.5939
R115	4164.0	72.6914
R116	4345.0	74.6353
R117	4287.0	73.9779

Fig. S1 c1. (a) Histogram of thresholding the TEM image of the top surface of the AAO membrane withthe chemical etching for 35 min. (b) The TEM image with the analyzed nanochannels after the thresholding. (c) Measurements of the sizes (diameter, unit: nm) of the analyzed nanochannels on the top surface of the AAO membrane.

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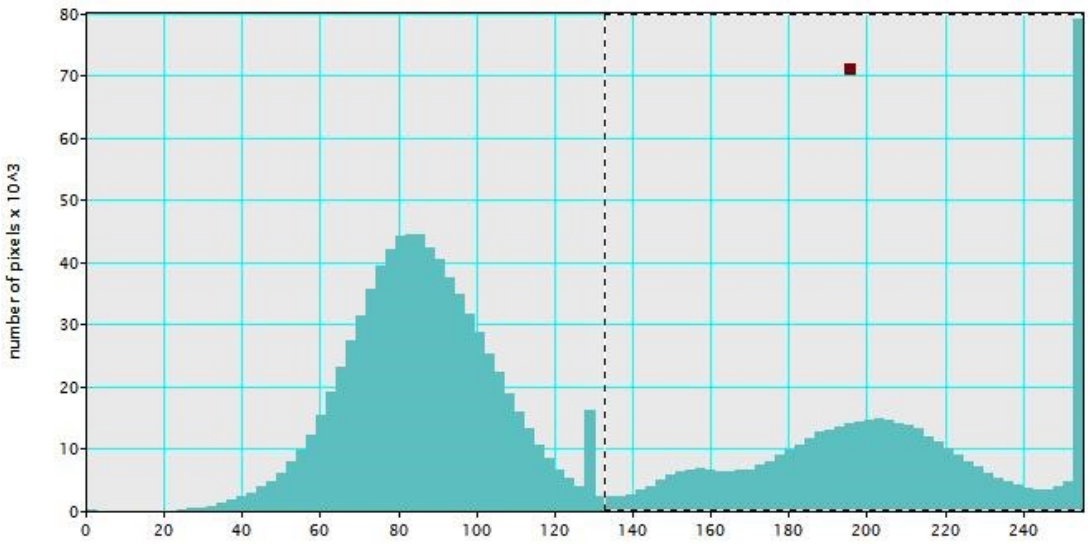
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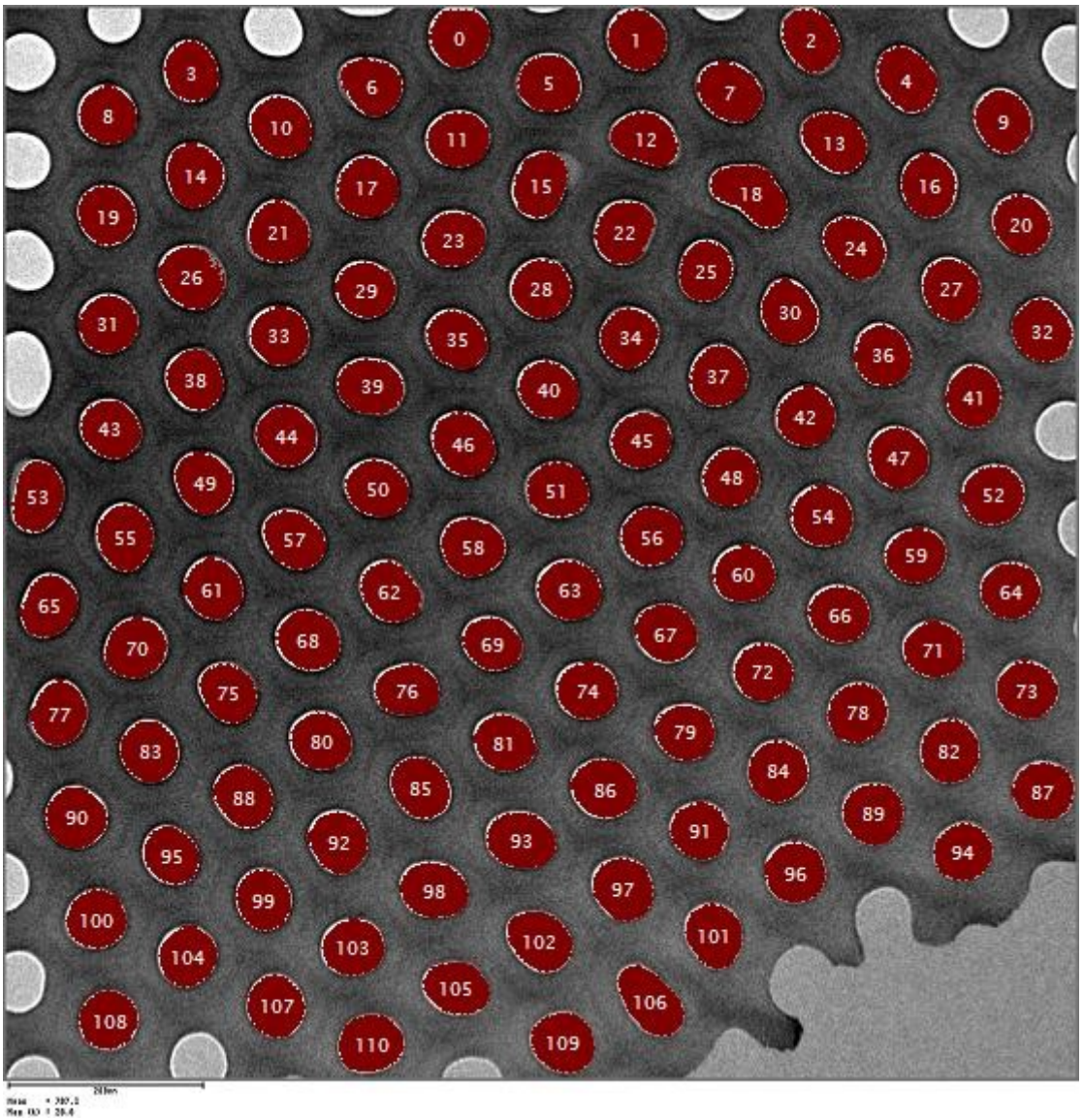
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c

	FilledArea	CircDiameter
R0	3169.0	63.5654
R1	3108.0	62.8887
R2	3113.0	63.5111
R3	2864.0	60.3896
R4	3269.0	65.1316
R5	3218.0	64.0918
R6	3046.0	63.1114
R7	3332.0	65.3778
R8	2937.0	60.8814
R9	3106.0	63.1597
R10	3292.0	64.6593
R11	3060.0	62.3516
R12	3110.0	64.5936
R13	3329.0	65.6322
R14	3155.0	63.3172
R15	3137.0	64.215
R16	3055.0	62.3345
R17	3202.0	63.6172
R18	3632.0	73.0501
R19	2979.0	61.3815
R20	2977.0	61.5192
R21	3293.0	64.9319
R22	3225.0	64.9882
R23	3013.0	62.0269
R24	3199.0	64.472
R25	2830.0	60.0526
R26	3529.0	67.2563
R27	3115.0	63.1057
R28	3119.0	62.8967
R29	2918.0	60.8183
R30	3088.0	62.8346
R31	3002.0	61.5385
R32	3225.0	64.1258
R33	3009.0	61.8969
R34	2988.0	61.5507
R35	3002.0	61.931
R36	3024.0	62.0527

	FilledArea	CircDiameter
R37	3010.0	61.7591
R38	2997.0	61.7537
R39	3245.0	64.5928
R40	2982.0	61.5867
R41	2928.0	61.015
R42	3026.0	61.935
R43	3021.0	61.9381
R44	3134.0	63.0758
R45	2937.0	61.0122
R46	3394.0	65.8991
R47	3155.0	63.3163
R48	2839.0	60.0119
R49	3097.0	62.8379
R50	3113.0	63.0164
R51	3001.0	61.9512
R52	3221.0	63.8431
R53	3204.0	66.1963
R54	3259.0	64.1958
R55	3229.0	64.2947
R56	3173.0	63.3034
R57	3075.0	62.8915
R58	3238.0	64.1836
R59	2890.0	60.5961
R60	3052.0	62.2018
R61	3078.0	62.4383
R62	3114.0	63.661
R63	3294.0	64.6231
R64	2943.0	61.0869
R65	3024.0	62.3407
R66	3050.0	62.1399
R67	3124.0	63.0253
R68	3339.0	65.1154
R69	2729.0	59.0007
R70	3242.0	64.1237
R71	2967.0	61.4773
R72	2983.0	61.4481
R73	3072.0	62.5322

	FilledArea	CircDiameter
R74	3076.0	62.4755
R75	2891.0	60.9949
R76	2885.0	61.0949
R77	3122.0	63.279
R78	3102.0	62.7675
R79	2931.0	61.0103
R80	3094.0	62.7077
R81	3044.0	62.4396
R82	3295.0	64.7358
R83	3084.0	62.5503
R84	3226.0	63.8954
R85	3132.0	63.3711
R86	3394.0	65.6363
R87	3174.0	63.6983
R88	3126.0	63.2619
R89	3249.0	64.3007
R90	3240.0	64.0746
R91	2909.0	60.8939
R92	3164.0	63.4827
R93	3431.0	66.6906
R94	2966.0	61.4734
R95	2801.0	59.789
R96	3270.0	64.4427
R97	3332.0	65.1767
R98	3349.0	65.7015
R99	2928.0	61.0447
R100	3073.0	62.4453
R101	3214.0	64.494
R102	3351.0	66.0961
R103	3131.0	63.1179
R104	3061.0	62.2325
R105	3100.0	63.7486
R106	3530.0	70.9099
R107	3138.0	63.2225
R108	3011.0	61.8929
R109	3365.0	65.785
R110	3368.0	65.7676

Fig. S1 c2. (a) Histogram of thresholding the TEM image of the bottom surface of the AAO membrane withthe chemical etching for 35 min. (b) The TEM image with the analyzed nanochannels after the thresholding. (c) Measurements of the sizes (diameter, unit: nm) of the analyzed nanochannels on the bottom surface of the AAO membrane.

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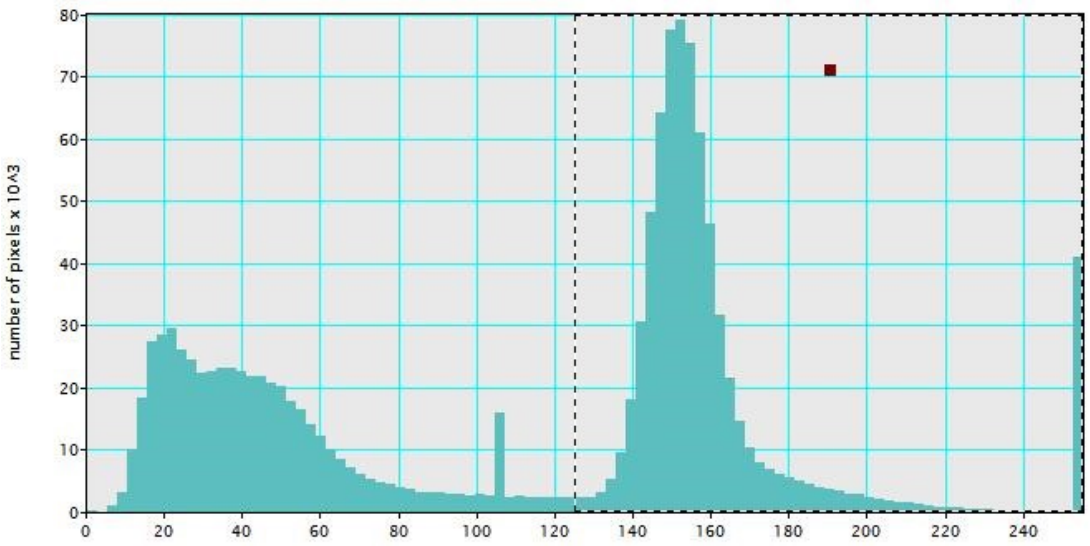
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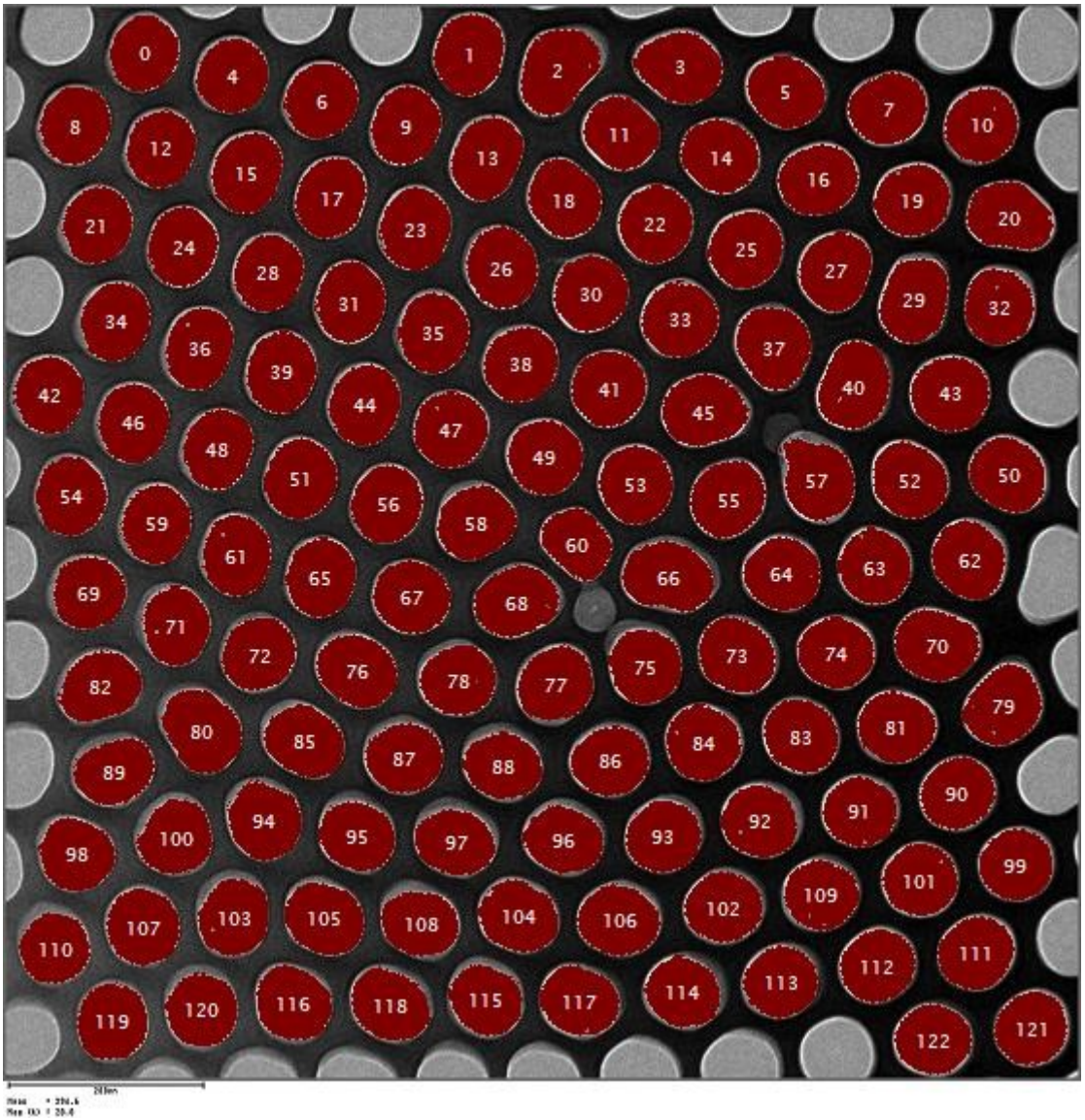
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c

	FilledArea	CircDiameter
R0	4568.0	76.5802
R1	4968.0	79.8858
R2	5630.0	87.4328
R3	5263.0	82.7199
R4	4617.0	76.7469
R5	4752.0	77.9552
R6	4771.0	77.9496
R7	4834.0	78.5741
R8	4810.0	78.4675
R9	4690.0	77.5035
R10	4694.0	77.4146
R11	4673.0	77.1719
R12	4623.0	76.8362
R13	5118.0	81.7028
R14	4904.0	78.9611
R15	4903.0	79.5249
R16	4890.0	78.9581
R17	4909.0	79.3493
R18	4846.0	78.9165
R19	4772.0	77.8291
R20	5093.0	82.1633
R21	4640.0	77.4865
R22	4923.0	78.9377
R23	5101.0	80.8191
R24	4820.0	78.5646
R25	4920.0	79.1804
R26	4988.0	79.8756
R27	4934.0	79.5847
R28	4637.0	76.9871
R29	5091.0	81.9846
R30	4860.0	78.6165
R31	4898.0	79.1538
R32	4581.0	76.4989
R33	4998.0	79.7423
R34	4755.0	78.2507
R35	4917.0	79.3002
R36	4816.0	79.3333
R37	5234.0	82.1829
R38	4819.0	78.2075
R39	4935.0	79.5547
R40	5380.0	83.9321

	FilledArea	CircDiameter
R41	4863.0	78.4527
R42	4675.0	77.3738
R43	5113.0	80.5808
R44	4944.0	79.5753
R45	5237.0	82.7838
R46	4861.0	78.8848
R47	4822.0	78.1981
R48	4809.0	78.6584
R49	4847.0	78.3599
R50	4869.0	79.0277
R51	4999.0	79.8362
R52	4974.0	79.6466
R53	4966.0	79.3182
R54	4832.0	78.7846
R55	4944.0	79.4761
R56	4819.0	78.4469
R57	5193.0	85.6847
R58	4963.0	79.8565
R59	4750.0	78.2428
R60	3977.0	72.5839
R61	4847.0	79.0639
R62	4913.0	79.3923
R63	4723.0	77.4985
R64	4851.0	78.5172
R65	4746.0	77.885
R66	5475.0	85.5046
R67	4817.0	78.1661
R68	5091.0	81.4523
R69	4654.0	77.4856
R70	5159.0	81.6563
R71	4582.0	76.8288
R72	4679.0	77.4834
R73	4997.0	79.9619
R74	4676.0	77.2001
R75	4732.0	77.6406
R76	4986.0	80.099
R77	4914.0	79.5299
R78	4612.0	76.7019
R79	5172.0	81.9411
R80	5527.0	85.2271
R81	4759.0	77.9088

	FilledArea	CircDiameter
R82	4945.0	80.5931
R83	4740.0	77.7449
R84	4853.0	78.5633
R85	4932.0	80.5126
R86	4706.0	77.7905
R87	4742.0	77.9933
R88	4526.0	76.4609
R89	4623.0	78.3772
R90	4617.0	76.5033
R91	4450.0	75.4477
R92	4722.0	77.997
R93	4675.0	77.0076
R94	4950.0	80.1156
R95	4647.0	77.607
R96	4641.0	77.8432
R97	4600.0	77.7291
R98	4748.0	78.2325
R99	4531.0	75.8724
R100	4780.0	79.4727
R101	4693.0	77.1865
R102	4744.0	78.0927
R103	4723.0	78.2459
R104	4906.0	79.5246
R105	4967.0	80.0389
R106	4997.0	80.1985
R107	4893.0	79.0327
R108	4440.0	76.5349
R109	4510.0	75.9942
R110	4338.0	74.852
R111	4760.0	77.742
R112	4740.0	77.5891
R113	4567.0	76.194
R114	4579.0	76.5753
R115	4450.0	75.9733
R116	4871.0	79.2332
R117	4744.0	78.267
R118	4860.0	79.5717
R119	4771.0	78.3018
R120	4598.0	76.8264
R121	4632.0	76.7481
R122	4717.0	77.4152

Fig. S1 d1. (a) Histogram of thresholding the TEM image of the top surface of the AAO membranewiththe chemical etching for 60 min. (b) The TEM image with the analyzed nanochannels after the thresholding. (c) Measurements of the sizes (diameter, unit: nm) of the analyzed nanochannels on the top surface of the AAO membrane.

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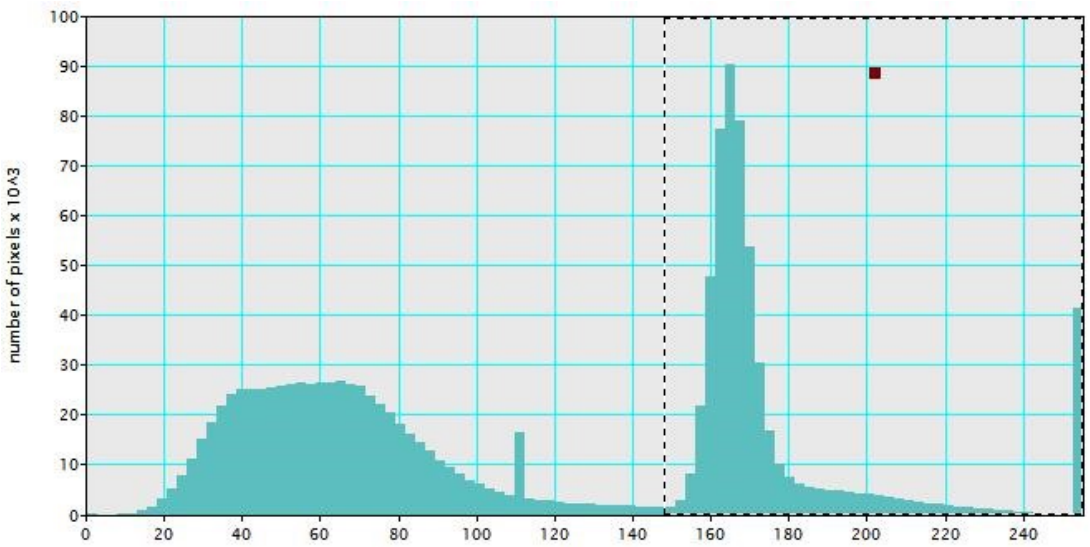
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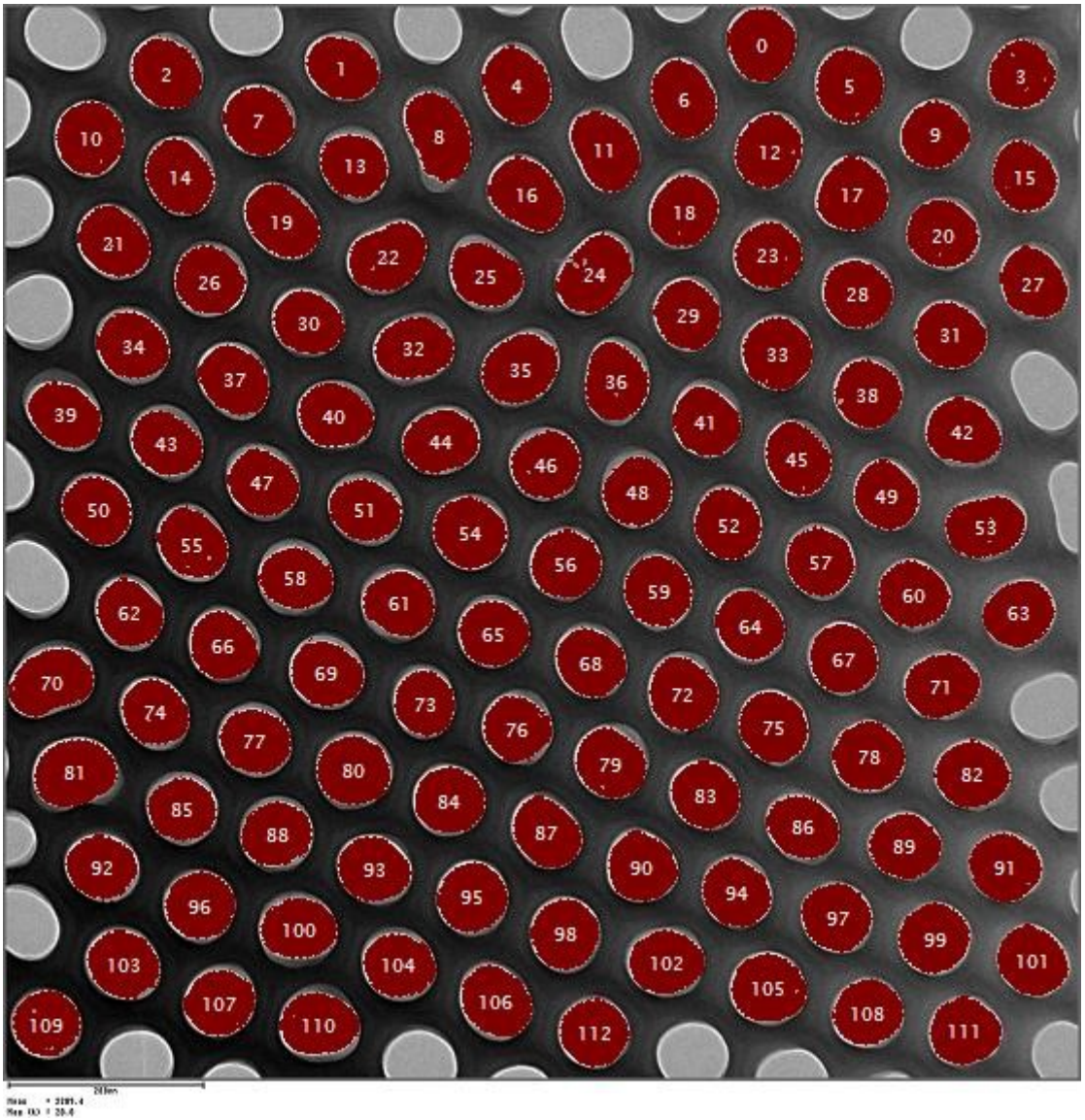
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	FilledArea	CircDiameter
R0	4351.0	74.4814
R1	3913.0	71.1496
R2	4176.0	73.2114
R3	3898.0	70.5541
R4	4513.0	76.2908
R5	4283.0	73.8512
R6	4279.0	74.6841
R7	4110.0	72.3599
R8	4731.0	81.1929
R9	3886.0	70.3717
R10	4314.0	74.0581
R11	4518.0	77.4906
R12	4217.0	73.3471
R13	3746.0	69.4789
R14	4281.0	74.4724
R15	3885.0	70.6437
R16	4548.0	77.3318
R17	4510.0	75.7672
R18	4167.0	72.973
R19	4461.0	76.6444
R20	4187.0	73.0346
R21	4240.0	73.9524
R22	4469.0	76.6027
R23	3844.0	69.9344
R24	4703.0	79.1102
R25	3940.0	72.3725
R26	4087.0	72.3714
R27	4042.0	72.2685
R28	4035.0	71.6612
R29	3946.0	70.9561
R30	3862.0	70.4513
R31	4039.0	71.7147
R32	4241.0	74.5296
R33	4344.0	74.1346
R34	4178.0	73.3488
R35	4505.0	76.6008
R36	4257.0	74.71
R37	4117.0	73.1963

	FilledArea	CircDiameter
R38	3924.0	70.5693
R39	3989.0	72.4125
R40	4084.0	72.8666
R41	4004.0	71.6967
R42	4191.0	73.6599
R43	3826.0	70.5926
R44	4151.0	73.4741
R45	3985.0	72.0252
R46	4025.0	71.699
R47	3995.0	71.7955
R48	4066.0	72.0314
R49	3807.0	69.612
R50	3961.0	71.2015
R51	3828.0	70.2516
R52	4040.0	71.7557
R53	4237.0	74.8735
R54	4458.0	75.2399
R55	4163.0	73.5554
R56	4114.0	72.2912
R57	4034.0	71.7824
R58	3901.0	71.4232
R59	4108.0	72.2959
R60	3995.0	71.4537
R61	3983.0	71.5773
R62	3827.0	70.4823
R63	4077.0	72.2955
R64	4009.0	71.5543
R65	3958.0	70.8915
R66	3906.0	70.6968
R67	4100.0	72.3055
R68	4087.0	72.3434
R69	4150.0	73.5714
R70	4725.0	79.9389
R71	4141.0	73.1097
R72	4329.0	74.4306
R73	3447.0	66.2277
R74	3788.0	69.782
R75	4184.0	72.9903

	FilledArea	CircDiameter
R76	3794.0	70.0497
R77	3984.0	71.668
R78	4287.0	73.7957
R79	4191.0	73.1567
R80	4398.0	74.7588
R81	4820.0	79.0982
R82	4268.0	73.8212
R83	4004.0	71.2485
R84	4078.0	72.135
R85	3788.0	69.7833
R86	3922.0	71.0941
R87	4048.0	72.4078
R88	3964.0	71.4014
R89	3969.0	71.0538
R90	4163.0	72.837
R91	4200.0	73.2581
R92	3977.0	71.5431
R93	4059.0	72.0638
R94	3999.0	71.4423
R95	4212.0	73.0933
R96	4040.0	71.5664
R97	4077.0	71.9553
R98	4154.0	72.6587
R99	4280.0	73.6209
R100	4043.0	72.8003
R101	4218.0	73.4581
R102	4099.0	72.5999
R103	4217.0	73.7076
R104	3960.0	71.7782
R105	4474.0	75.5897
R106	4264.0	74.1156
R107	4007.0	71.3977
R108	3994.0	71.2198
R109	3833.0	69.7446
R110	4302.0	75.034
R111	4135.0	72.6054
R112	4009.0	71.193

Fig. S1 d2. (a) Histogram of thresholding the TEM image of the bottom surface of the AAO membrane with the chemical etching for 60 min. (b) The TEM image with the analyzed nanochannels after the thresholding. (c) Measurements of the sizes (diameter, unit: nm) of the analyzed nanochannels on the bottom surface of the AAO membrane.

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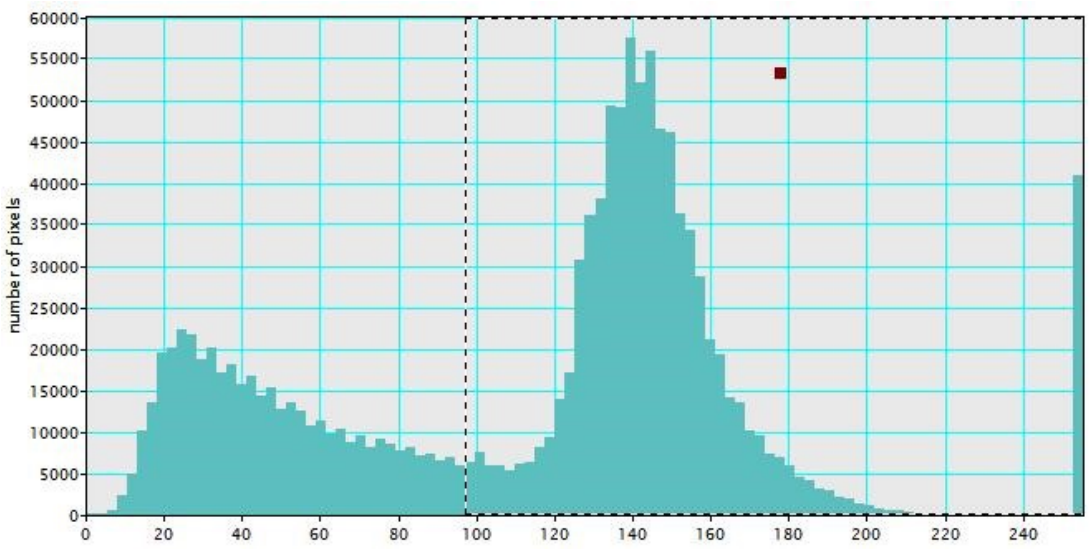
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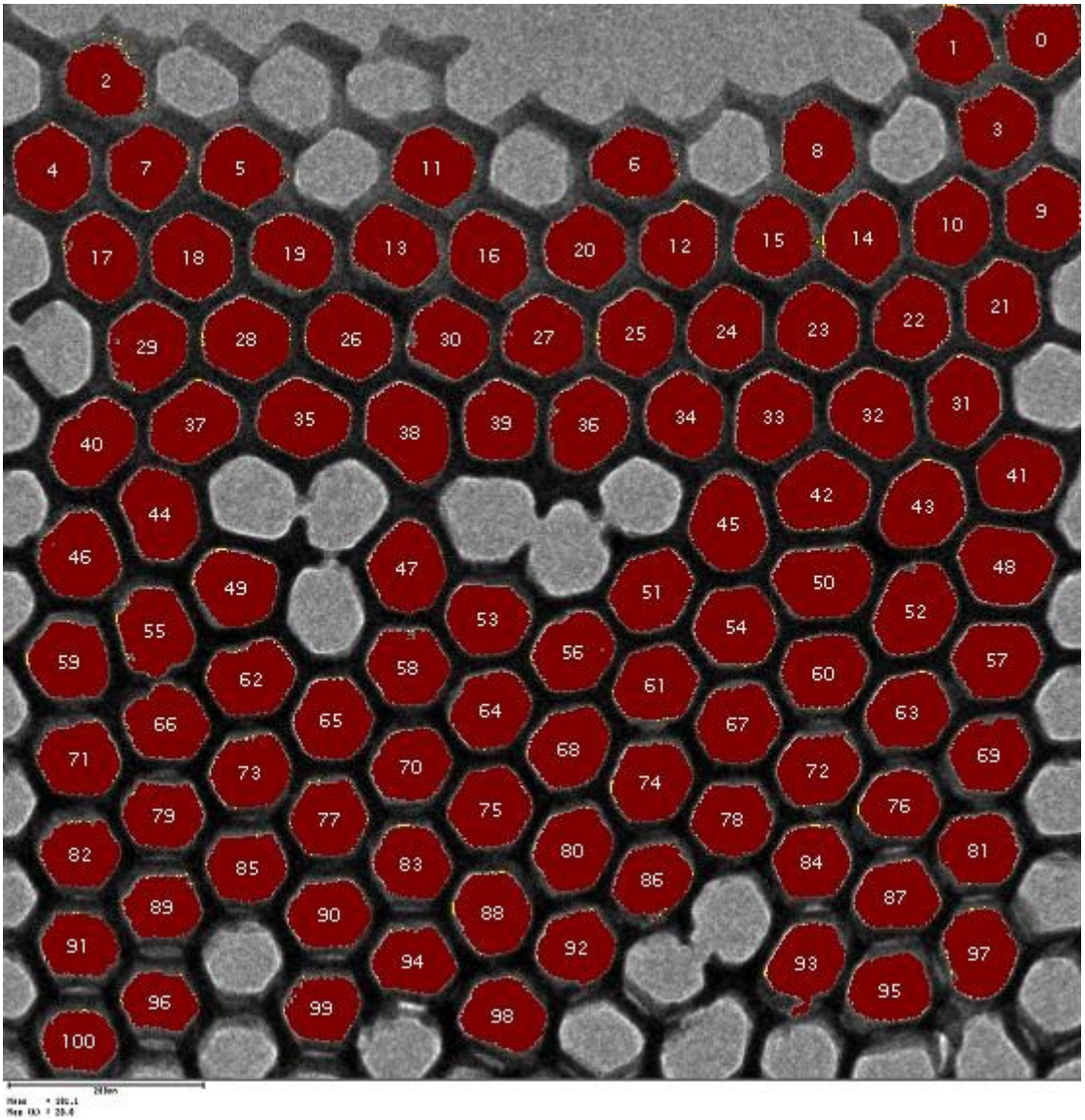
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	FilledArea	CircDiameter
R0	4978.0	81.8822
R1	5088.0	87.703
R2	5094.0	87.7224
R3	5479.0	86.04
R4	5698.0	86.4934
R5	5610.0	88.0779
R6	5079.0	85.1692
R7	5436.0	86.3797
R8	5718.0	88.7703
R9	5643.0	86.6662
R10	5769.0	87.784
R11	5472.0	87.3711
R12	5511.0	85.8943
R13	5823.0	89.9843
R14	5727.0	88.1377
R15	5519.0	86.4275
R16	5886.0	88.5924
R17	5620.0	85.8694
R18	5980.0	88.3658
R19	5249.0	84.8815
R20	5650.0	87.1099
R21	5772.0	87.7065
R22	5406.0	84.6727
R23	5887.0	87.4503
R24	5465.0	84.4805
R25	5615.0	85.9934
R26	6130.0	90.1136
R27	5383.0	84.2784
R28	6055.0	89.0579
R29	5860.0	87.8903
R30	5323.0	84.8343
R31	5723.0	87.6105
R32	6292.0	91.6382
R33	6029.0	89.8498

	FilledArea	CircDiameter
R33	6029.0	89.8498
R34	5615.0	85.6829
R35	5973.0	89.0597
R36	6148.0	90.7919
R37	5864.0	88.6455
R38	6781.0	96.1183
R39	5244.0	83.1339
R40	5984.0	89.9562
R41	5559.0	85.4738
R42	6224.0	91.1927
R43	6238.0	90.7197
R44	5962.0	89.8008
R45	6261.0	91.9188
R46	5890.0	88.2179
R47	5690.0	86.9638
R48	6452.0	92.7143
R49	5537.0	85.8349
R50	6308.0	93.6003
R51	5496.0	85.4803
R52	6213.0	91.2198
R53	5171.0	82.6717
R54	5592.0	85.8198
R55	5646.0	87.4796
R56	5431.0	84.621
R57	5827.0	88.129
R58	5332.0	83.8509
R59	5548.0	86.5412
R60	5600.0	86.1181
R61	5398.0	84.9508
R62	5473.0	86.1339
R63	5433.0	84.7612
R64	5234.0	83.3156
R65	5447.0	84.3877
R66	5231.0	83.5892

	FilledArea	CircDiameter
R68	5496.0	85.2236
R69	5110.0	83.1229
R70	4999.0	81.2296
R71	5237.0	83.8207
R72	5204.0	84.51
R73	5072.0	82.1817
R74	5527.0	85.3681
R75	5536.0	85.2147
R76	4753.0	79.2487
R77	4989.0	81.891
R78	5088.0	81.8933
R79	4762.0	80.7015
R80	5491.0	85.4153
R81	4984.0	81.6043
R82	4633.0	78.9927
R83	4844.0	79.7138
R84	4888.0	80.1579
R85	4795.0	80.2646
R86	4742.0	80.9021
R87	5080.0	82.9129
R88	5392.0	83.9622
R89	4366.0	77.2763
R90	4912.0	81.2395
R91	4317.0	76.9457
R92	4827.0	80.1741
R93	5227.0	88.3691
R94	4823.0	81.3935
R95	5016.0	83.1652
R96	3925.0	74.3633
R97	5535.0	86.66
R98	5159.0	83.5668
R99	4357.0	77.0118
R100	4034.0	73.5165

Fig. S1 e1. (a) Histogram of thresholding the TEM image of the top surface of the AAO membranewiththe chemical etching for 95 min. (b) M image with the analyzed nanochannels after the thresholding. (c) Measurements of the sizes (diameter, unit: nm) of the analyzed nanochannels on the top surface of the AAO membrane.

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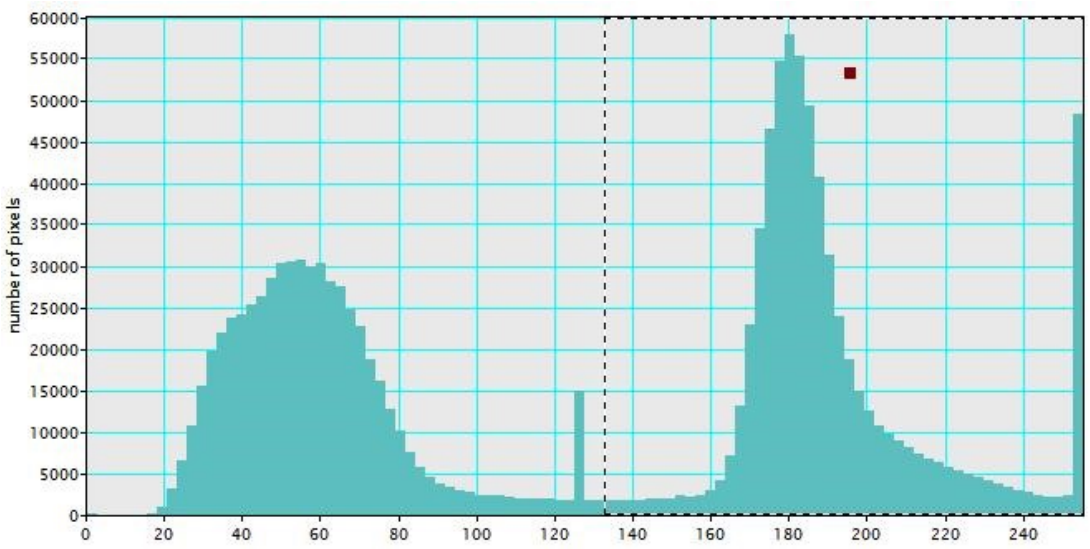
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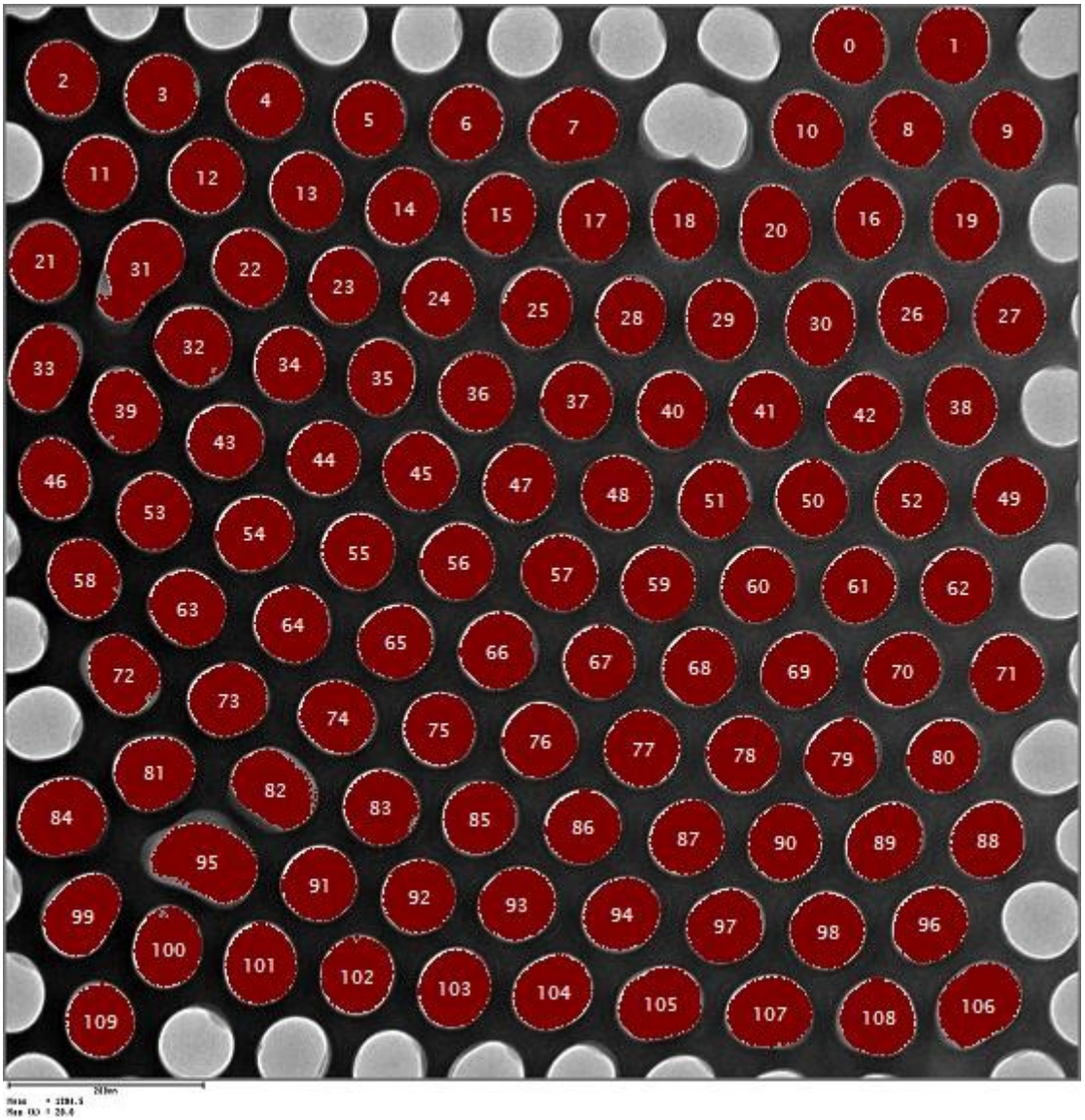
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	FilledArea	CircDiameter
R0	4767.0	78.0321
R1	4831.0	78.4676
R2	4632.0	76.5456
R3	4755.0	77.9833
R4	4854.0	78.4433
R5	4497.0	75.5487
R6	4647.0	76.8222
R7	5587.0	85.4296
R8	4652.0	76.8457
R9	4770.0	78.0438
R10	4669.0	77.4431
R11	4652.0	76.6957
R12	4786.0	77.8252
R13	4881.0	78.7413
R14	4718.0	77.377
R15	4964.0	79.6359
R16	4748.0	77.926
R17	4917.0	79.2265
R18	4626.0	77.0643
R19	4918.0	79.4826
R20	5364.0	83.3174
R21	4761.0	77.8541
R22	4766.0	77.9357
R23	4542.0	75.8999
R24	4757.0	77.6915
R25	4729.0	77.657
R26	4819.0	78.5774
R27	4913.0	79.164
R28	4531.0	76.152
R29	4896.0	78.9864
R30	5106.0	81.1171
R31	6265.0	95.8339
R32	5018.0	79.9857
R33	4984.0	80.9093
R34	4497.0	75.4533
R35	4294.0	73.9632
R36	5020.0	79.8786

	FilledArea	CircDiameter
R37	4643.0	76.8024
R38	4893.0	79.0234
R39	4856.0	79.2773
R40	4602.0	76.4081
R41	4766.0	77.6987
R42	4999.0	79.6338
R43	4787.0	77.901
R44	4552.0	75.8495
R45	4939.0	79.1793
R46	4823.0	78.4311
R47	4755.0	77.7094
R48	4592.0	76.2325
R49	4950.0	79.2432
R50	4681.0	77.0729
R51	4632.0	76.8698
R52	4649.0	76.7772
R53	4789.0	77.8662
R54	4968.0	79.4095
R55	4707.0	77.2531
R56	4792.0	77.8335
R57	4857.0	78.3956
R58	4776.0	78.0999
R59	4657.0	76.7708
R60	4761.0	77.6945
R61	4669.0	77.0073
R62	4618.0	76.557
R63	4843.0	78.4488
R64	4868.0	78.5388
R65	4670.0	76.9361
R66	4960.0	79.6207
R67	4423.0	74.8293
R68	4904.0	78.8634
R69	4865.0	78.5977
R70	4740.0	77.7319
R71	4744.0	77.6203
R72	4664.0	78.0062
R73	4890.0	78.8357

	FilledArea	CircDiameter
R74	4638.0	76.84
R75	4465.0	75.1655
R76	4806.0	77.9949
R77	4887.0	78.598
R78	4778.0	77.76
R79	4792.0	78.2543
R80	4530.0	75.8815
R81	5017.0	80.0634
R82	5220.0	83.2496
R83	4746.0	77.4823
R84	5781.0	86.0185
R85	4542.0	75.9184
R86	4696.0	77.1518
R87	4754.0	77.594
R88	4821.0	78.4345
R89	4896.0	79.5678
R90	4760.0	77.64
R91	4712.0	77.174
R92	4541.0	75.8017
R93	4749.0	77.5874
R94	4768.0	77.8102
R95	6569.0	96.2231
R96	4757.0	77.8984
R97	4784.0	77.9654
R98	4836.0	78.1915
R99	5099.0	82.0634
R100	4633.0	77.0426
R101	4974.0	79.5839
R102	4820.0	78.2183
R103	4820.0	78.2313
R104	5005.0	79.8898
R105	5203.0	82.217
R106	5594.0	86.0005
R107	5214.0	81.8508
R108	4948.0	79.4725
R109	4263.0	73.6111

Fig. S1 e2. (a) Histogram of thresholding the TEM image of the bottom surface of the AAO membrane withthe chemical etching for 95 min. (b) The TEM image with the analyzed nanochannels after the thresholding. (c) Measurements of the sizes (diameter, unit: nm) of the analyzed nanochannels on the bottom surface of the AAO membrane.

2. UV-vis absorption spectra of the AAO membranes with different thicknesses

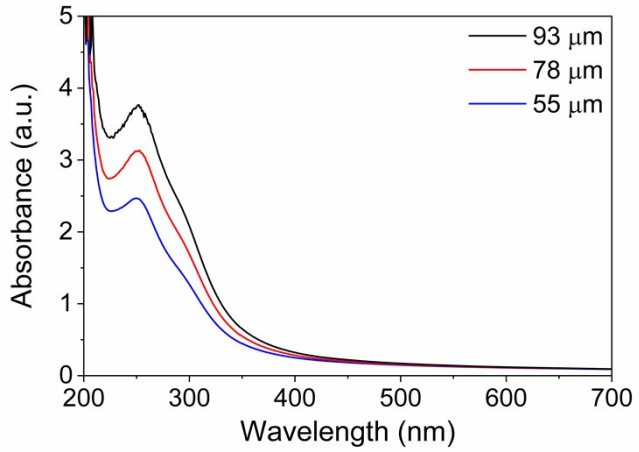

Fig. S2 UV-vis absorption spectra of the AAO membranes with different thicknesses (55 μm, 78 μm and 93 μm).

3. Measurement of the thicknesses d_i of the AAO membranes

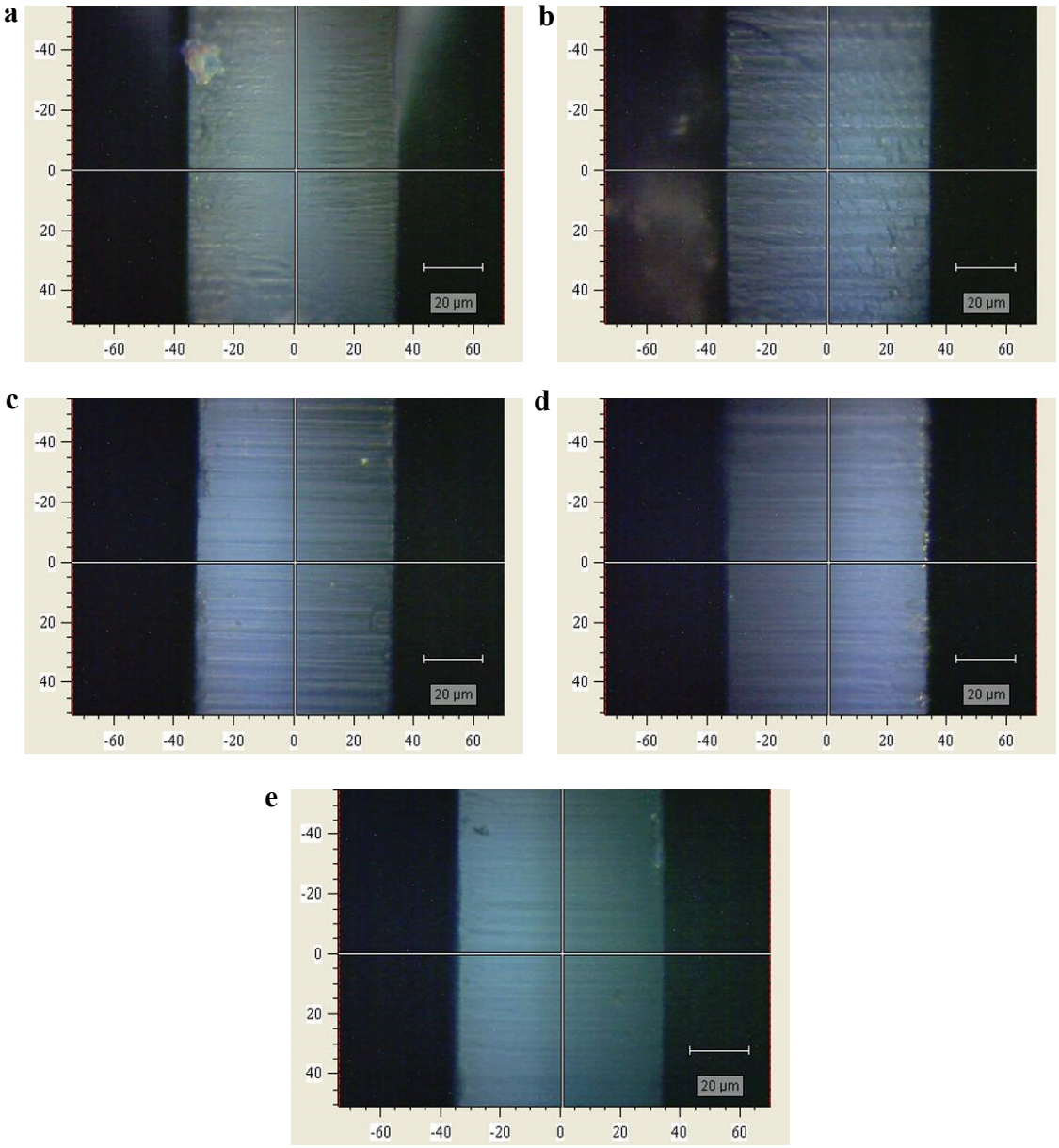

Fig. S3 Cross-section images of the whole AAO membranes after the chemical etching for 0 min (**a**), 10 min (**b**), 35 min (**c**), 60 min (**d**) and 95 min (**e**) by an optical microscope (Leica, DM2500 M, 50× objective (N.A. = 0.75), MS 20 encoded stage) with control of a Renishaw WiRE 3.2 software. On the basis of the measurements by the DM software, the thicknesses d_1, d_2, d_3, d_4 and d_5 are 70.57, 68.30, 66.42, 67.17 and 68.30 μm, respectively, which correspond to the AAO membranes after the chemical etching for 0, 10, 35, 60 and 95 min, respectively.

4. Appendix: Measurement of the molar extinction coefficient of aluminum oxalate

It is mentioned that the molar absorptivity of aluminum oxalate cannot be found in those references.[S1, S2] In this case, the ε value can approximately be measured according to the Beer-Lambert law,[S3, S4] which is expressed as $A'=\varepsilon cl$, where A', c and l are the absorbance of aluminum oxalate, concentration of solute (mol L^{-1}) and path length (cm), respectively. For a typically wide concentration range of aluminum oxalate from 0.05 to 2 mmol L^{-1}, it is noting that the concentration over the range will result into saturated or very weak absorption bands, the value of the molar extinction coefficient is about 238.5 at 260 nm, where a polar solvent shifts absorption to the longer wavelength (e.g., 260 nm in contrast to 254 nm) owing to the excited states forming stronger hydrogen bonds than the corresponding ground states. Similarly, the ε value is 229 at 253 nm for oxalic acid calcium salt ($C_2O_4Ca{\cdot}H_2O$) obtained by the reference S3. Notes that the molar extinction coefficient below 1000 are low-intensity absorptions with a forbidden transition,[S4] therefore, the absorption at 254 nm is originated from the $n\rightarrow\pi^*$ (nonbonding atomic n orbital to antibonding π orbital) transition of the carbonyl group of aluminum oxalate.

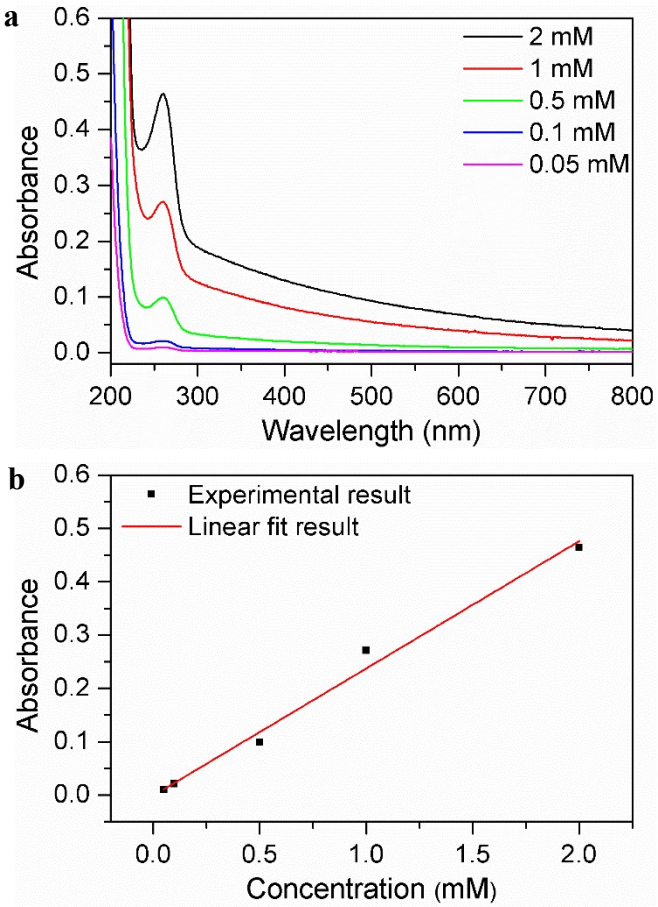

Fig. S4 (a) UV-Vis absorption spectra of aluminum oxalate solution with different concentration from 0.05 mM to 2mM. (b) Linear fit result of the absorbance with the concentration of the aluminum oxalate solution.

References

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