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Supplementary Materials: Multi-Response Optimization of Electrothermal Micromirror Using Desirability Function-Based Response Surface Methodology

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Table S1. Screening design matrix with 20 simulation runs and the corresponding output responses obtained using Finite Element Modeling (FEM) simulations.

Run No.	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	Deflection angle (Degree)	Temperature rise (°C)	Input power (mW)	Figure of Merit
1	+1	−1	−1	−1	−1	+1	−1	+1	−1	40.5	28.2	3.2	0.443
2	+1	+1	+1	+1	−1	−1	+1	+1	−1	35.0	46.0	15.2	0.049
3	−1	−1	−1	−1	+1	−1	+1	−1	+1	15.7	22.8	2.1	0.329
4	+1	−1	+1	+1	−1	−1	−1	−1	+1	51.0	72.6	16.2	0.043
5	−1	−1	+1	+1	−1	+1	+1	−1	−1	25.6	59.6	16.1	0.026
6	+1	+1	−1	+1	+1	−1	−1	−1	−1	45.6	39.4	10.0	0.115
7	+1	−1	+1	−1	+1	+1	+1	+1	−1	21.2	19.3	2.0	0.526
8	−1	−1	−1	−1	−1	−1	−1	−1	−1	25.6	36.2	3.3	0.218
9	+1	+1	−1	−1	−1	−1	+1	−1	+1	36.8	22.3	3.1	0.540
10	−1	+1	−1	+1	+1	+1	+1	−1	−1	14.7	29.5	10.0	0.049
11	−1	+1	+1	+1	+1	−1	−1	+1	+1	11.0	34.9	10.0	0.031
12	−1	+1	−1	+1	−1	+1	+1	+1	+1	22.6	40.8	15.3	0.036
13	−1	+1	+1	−1	+1	+1	−1	−1	−1	6.4	13.1	2.0	0.244
14	−1	+1	+1	−1	−1	−1	−1	+1	−1	9.5	21.4	3.1	0.146
15	+1	−1	+1	+1	+1	+1	−1	−1	+1	40.1	42.6	10.4	0.090
16	+1	−1	−1	+1	+1	−1	+1	+1	−1	61.6	61.0	10.3	0.096
17	−1	−1	+1	−1	+1	−1	+1	+1	+1	8.6	21.5	2.1	0.191
18	+1	+1	+1	−1	−1	+1	+1	−1	+1	23.6	19.4	3.0	0.398
19	−1	−1	−1	+1	−1	+1	−1	+1	+1	32.5	61.9	16.1	0.032
20	+1	+1	−1	−1	+1	+1	−1	+1	+1	20.9	30.6	2.0	0.769

Table S2. Central Composite Design (CCD) design matrix with 53 simulation runs. Output responses are obtained for each simulation run using FEM.

Run	X_1	X_2	X_3	X_4	X_5	X_6	Y_1 Deflection angle (°)	Y_2 Input power (mW)	Y_3 Temperature rise (°C)
1	+1	−1	−1	+1	−1	−1	25.84	3.23	30.65
2	−1	+1	+1	−1	+1	+1	14.77	10.04	29.70
3	−1	−1	−1	−1	−1	−1	25.53	3.23	36.50
4	+1	+1	+1	−1	−1	+1	49.88	15.26	40.93
5	+1	−1	+1	−1	−1	−1	35.54	3.05	21.80
6	−1	−1	−1	−1	+1	+1	12.11	2.08	19.26
7	0	0	0	0	0	0	23.53	7.48	26.98
8	0	0	0	−1	0	0	28.41	7.48	27.93
9	−1	−1	+1	+1	+1	+1	6.34	2.00	13.10
10	+1	−1	−1	−1	−1	+1	39.82	3.23	28.10
11	+1	+1	−1	−1	+1	+1	51.11	10.43	45.50
12	0	0	0	0	0	0	23.53	7.48	26.98
13	+1	−1	+1	+1	−1	+1	23.08	3.05	19.26
14	0	0	0	0	0	0	17.89	7.48	26.98
15	−1	+1	+1	+1	−1	+1	8.947	15.26	39.80
16	0	0	0	0	0	0	23.53	7.48	26.98
17	0	0	0	0	0	0	23.53	7.48	26.98
18	+1	+1	−1	+1	+1	−1	37.19	10.43	54.77
19	+1	−1	+1	+1	+1	−1	13.99	2.00	14.73
20	0	0	0	0	0	0	23.53	7.48	26.98
21	0	+1	0	0	0	0	28.14	12.47	36.46
22	−1	+1	−1	−1	+1	−1	29.33	10.43	62.50
23	+1	+1	+1	−1	+1	−1	42.85	10.04	37.94
24	−1	+1	−1	+1	+1	+1	17.70	10.43	43.00
25	0	0	0	0	+1	0	19.91	6.17	23.28
26	+1	−1	−1	+1	+1	+1	21.29	2.08	19.20
27	−1	−1	+1	−1	−1	+1	13.44	3.05	19.92
28	−1	−1	−1	+1	+1	−1	8.69	2.08	21.57
29	−1	−1	+1	−1	+1	−1	10.52	2.00	15.64
30	0	0	0	0	−1	0	28.53	9.55	32.24
31	0	−1	0	0	0	0	17.71	2.49	17.76
32	0	0	−1	0	0	0	35.16	7.58	41.99
33	0	0	0	0	0	0	23.53	7.48	26.98
34	+1	+1	−1	+1	−1	+1	54.26	16.19	59.22
35	−1	+1	+1	+1	+1	−1	10.99	10.04	34.95
36	+1	+1	+1	+1	−1	−1	35.28	15.26	45.84
37	−1	+1	−1	+1	−1	−1	24.31	16.19	73.20
38	0	0	0	0	0	0	23.53	7.48	26.98
39	0	0	0	0	0	+1	20.69	7.48	24.76
40	+1	0	0	0	0	0	33.10	7.48	26.73
41	−1	+1	+1	−1	−1	−1	27.01	15.26	51.00
42	0	0	+1	0	0	0	23.51	7.23	27.66
43	0	0	0	+1	0	0	19.40	7.48	25.90
44	+1	−1	+1	−1	+1	+1	20.43	2.00	13.54
45	0	0	0	0	0	−1	22.68	7.48	31.00
46	+1	+1	+1	+1	+1	+1	28.30	10.04	28.34
47	+1	−1	−1	−1	+1	−1	33.47	2.08	23.22
48	0	0	0	0	0	0	23.53	7.48	26.98
49	−1	+1	−1	−1	−1	+1	32.40	16.19	61.90
50	+1	+1	−1	−1	−1	−1	79.55	16.19	82.35
51	−1	−1	+1	+1	−1	−1	9.58	3.05	21.40
52	−1	0	0	0	0	0	14.88	7.48	26.90
53	−1	−1	−1	+1	−1	+1	14.15	3.23	27.73

Table S3. Regression analysis results for the response surface models developed for three output responses deflection angle (Y_1), input power (Y_2), and micromirror plate temperature rise from the ambient (Y_3).

Source	DF	Sum of Squares			Mean Square			*F*-Value			*p*-value (Prob > *F*)		
		Y_1	Y_2	Y_3	Y_1	Y_2	Y_3	Y_1	Y_2	Y_3	Y_1	Y_2	Y_3
Model	27	8616.54	1047.14	11446.92	319.13	38.78	423.96	102.90	5526.83	138.90	<0.0001	<0.0001	<0.0001
X_1	1	3307.59	0.000	1.04	3307.59	0.000	1.04	1066.51	0.000	0.34	<0.0001	1.0000	0.5655
X_2	1	1854.95	912.81	6332.26	1854.95	912.81	6332.26	598.11	1.301×10^5	2074.54	<0.0001	<0.0001	<0.0001
X_3	1	738.52	1.31	1914.02	738.52	1.31	1914.02	238.13	186.30	627.06	<0.0001	<0.0001	<0.0001
X_4	1	931.21	0.000	59.70	931.21	0.000	59.70	300.26	0.000	19.56	<0.0001	1.0000	0.0002
X_5	1	726.61	92.43	1079.62	726.61	92.43	1079.62	234.29	13171.36	353.70	<0.0001	<0.0001	<0.0001
X_6	1	35.27	0.000	465.59	35.27	0.000	465.59	11.37	0.000	152.53	0.0024	1.0000	<0.0001
X_1X_2	1	258.05	0.000	0.37	258.05	0.000	0.37	83.21	0.000	0.12	<0.0001	1.0000	0.7305
X_1X_3	1	48.90	0.000	6.933×10^{-3}	48.90	0.000	6.933×10^{-3}	15.77	0.000	2.271×10^{-3}	0.0005	1.0000	0.9624
X_1X_4	1	104.74	0.000	3.140×10^{-3}	104.74	0.000	3.140×10^{-3}	33.77	0.000	1.029×10^{-3}	<0.0001	1.0000	0.9747
X_1X_5	1	51.72	0.000	0.021	51.72	0.000	0.021	16.68	0.000	7.036×10^{-3}	0.0004	1.0000	0.9338
X_1X_6	1	0.073	0.000	0.82	0.073	0.000	0.82	0.023	0.000	0.27	0.8796	1.0000	0.6088
X_2X_3	1	81.20	0.56	358.51	81.20	0.56	358.51	26.18	80.21	117.45	<0.0001	<0.0001	<0.0001
X_2X_4	1	34.04	0.000	15.65	34.04	0.000	15.65	10.97	0.000	5.13	0.0028	1.0000	0.0325
X_2X_5	1	24.72	38.59	85.97	24.72	38.59	85.97	7.97	5499.05	28.16	0.0092	<0.0001	<0.0001
X_2X_6	1	1.89	0.000	147.68	1.89	0.000	147.68	0.61	0.000	48.38	0.4420	1.0000	<0.0001
X_3X_4	1	30.00	0.000	8.98	30.00	0.000	8.98	9.67	0.000	2.94	0.0046	1.0000	0.0987
X_3X_5	1	14.51	0.20	46.65	14.51	0.20	46.65	4.68	29.09	15.28	0.0403	<0.0001	0.0006
X_3X_6	1	2.73	0.000	55.47	2.73	0.000	55.47	0.88	0.000	18.17	0.3572	1.0000	0.0003
X_4X_5	1	25.56	0.000	1.89	25.56	0.000	1.89	8.24	0.000	0.62	0.0082	1.0000	0.4392
X_4X_6	1	140.60	0.000	18.95	140.60	0.000	18.95	45.34	0.000	6.21	<0.0001	1.0000	0.0197
X_5X_6	1	0.25	0.000	4.64	0.25	0.000	4.64	0.080	0.000	1.52	0.7797	1.0000	0.2289

X_1^2	1	0.32	2.079×10^{-7}	0.25	0.32	2.079×10^{-7}	0.25	0.10	2.963×10^{-5}	0.083	0.7512	0.9957	0.7754
X_2^2	1	5.48	9.995×10^{-8}	2.197×10^{-3}	5.48	9.995×10^{-8}	2.197×10^{-3}	1.77	1.424×10^{-5}	7.198×10^{-4}	0.1957	0.9970	0.9788
X_3^2	1	77.86	0.013	140.80	77.86	0.013	140.80	25.11	1.90	46.13	<0.0001	0.1801	0.0001
X_4^2	1	0.19	2.079×10^{-7}	0.12	0.19	2.079×10^{-7}	0.12	0.060	2.963×10^{-5}	0.040	0.8090	0.9957	0.8430
X_5^2	1	0.86	0.34	0.91	0.86	0.34	0.91	0.28	49.00	0.30	0.6040	<0.0001	0.5893
X_6^2	1	8.98	2.079×10^{-7}	1.30	8.98	2.079×10^{-7}	1.30	2.90	2.963×10^{-5}	0.43	0.1012	0.9957	0.5198
Residual	25	77.53	0.18	76.31	3.10	7.017×10^{-3}	3.05	-	-	-	-	-	-
Total	52	8694.1	-	-	-	-	-	-	-	-	-	-	-