Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Hybrid Physical-Chemical Deposition Process at Ultra Low Temperatures for High-Performance Perovskite Solar Cells – Supplementary Information

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Power conversion efficiency (PCE) was obtained from the corresponding perovskite solar cell device. Solar cells synthesized at certain temperature were fabricated in one batch. The gold electrode films at the same temperature were evaporated at the same time. There were 27, 9, 26, 27 pieces of solar cells made by four different batches to identify the best reaction temperature for HPCVD.

Table S1. Photovoltaic parameters of solar cells structured from $CH_3NH_3PbI_3$ film by HPCVD at 73, 82, 90, 100°C measured under 100mW·cm^{-2} simulated AM1.5G irradiation.

100°C	**PCE**	***Jsc***	***Voc***	**FF**
1	7.9	11.50	0.90	0.71
2	12.9	20.28	1.01	0.61
3	12.7	20.41	0.91	0.64
4	13.8	20.12	0.96	0.69
5	14.2	20.00	0.95	0.75
6	14.1	19.62	1.04	0.66
7	8.5	17.97	0.87	0.47
8	10.2	18.15	0.90	0.60
9	12.6	19.31	0.95	0.66
10	11.8	17.05	1.00	0.65
11	13.6	21.22	0.94	0.66
12	10.7	20.00	0.91	0.56
13	9.6	22.68	0.88	0.43
14	11.9	22.18	0.90	0.54
15	10.9	20.12	0.93	0.56
16	6.2	20.51	0.85	0.35
17	12.0	19.93	1.00	0.58
18	9.6	21.88	0.94	0.44
19	11.5	18.96	0.93	0.63
20	9.8	16.06	0.92	0.64
21	13.7	21.37	0.98	0.67
22	10.8	18.74	0.96	0.57

23	8.1	17.43	0.93	0.45
24	11.8	17.05	1.00	0.65
25	10.0	17.84	0.96	0.55
26	11.7	16.10	1.01	0.67
27	9.5	17.43	0.96	0.53

90°C	**PCE**	***Jsc***	***Voc***	**FF**
1	13.3	20.66	1.03	0.62
2	12.5	20.34	1.07	0.57
3	12.7	19.97	1.03	0.62
4	14.1	18.72	1.12	0.67
5	10.6	19.48	0.97	0.55
6	9.3	20.03	0.90	0.52
7	13.8	20.67	1.06	0.63
8	8.7	18.64	0.91	0.52
9	10.6	19.34	0.97	0.57

82°C	**PCE**	***Jsc***	***Voc***	**FF**
1	11.3	17.74	1.00	0.59
2	11.6	18.19	1.00	0.59
3	13.7	21.04	1.09	0.60
4	14.1	22.31	1.04	0.61
5	9.3	19.06	0.96	0.49
6	10.8	18.96	0.94	0.57
7	10.1	18.60	0.92	0.53
8	8.4	19.63	0.90	0.47
9	12.6	19.89	1.04	0.61
10	12.6	17.35	1.12	0.65
11	9.1	17.65	1.10	0.49
12	11.0	16.77	1.02	0.65
13	10.5	18.63	1.06	0.53
14	13.7	19.56	0.99	0.71
15	13.5	19.39	1.10	0.63
16	9.7	18.67	1.00	0.52
17	14.1	19.18	1.06	0.69
18	8.0	15.67	1.06	0.50

19	11.4	20.16	1.00	0.56
20	10.7	20.60	0.90	0.58
21	6.9	15.67	0.90	0.49
22	14.7	21.40	1.02	0.68
23	12.3	19.67	1.05	0.60
24	14.2	19.64	1.03	0.70
25	11.0	20.10	1.02	0.54
26	12.2	18.61	1.03	0.64

73°C	**PCE**	***Jsc***	***Voc***	**FF**
1	10.61	19.65	1.03	0.52
2	10.10	19.43	0.96	0.54
3	11.83	19.77	0.99	0.60
4	12.56	20.34	1.01	0.61
5	11.76	19.64	1.05	0.57
6	12.33	20.49	1.05	0.57
7	13.24	20.61	1.03	0.62
8	12.30	21.03	0.90	0.61
9	12.38	20.50	0.91	0.64
10	11.18	20.07	0.90	0.58
11	11.41	21.60	0.94	0.56
12	14.13	22.63	1.05	0.60
13	11.19	19.60	0.95	0.57
14	13.20	18.67	1.01	0.70
15	12.91	19.74	1.04	0.63
16	10.95	20.13	0.89	0.57
17	12.47	18.94	1.01	0.65
18	12.83	19.64	1.09	0.60
19	13.62	20.17	1.05	0.64
20	12.30	18.67	1.05	0.63
21	12.59	19.58	1.03	0.62
22	13.09	19.34	1.00	0.68
23	13.21	19.73	1.08	0.62
24	10.30	18.57	0.90	0.57
25	10.08	18.39	0.90	0.57
26	11.30	20.50	0.95	0.55
27	10.80	19.66	0.94	0.56

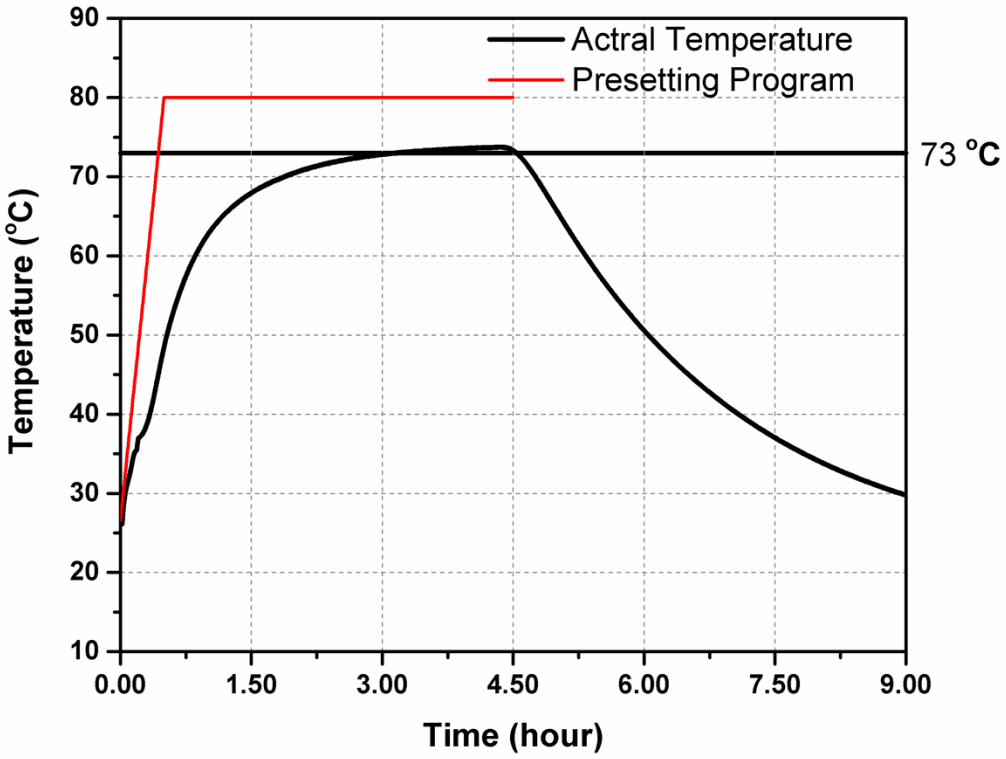

Figure S1. Actual temperature curve in the quartz recorded by a wireless thermometer when the furnace heating up program was set as: taking 30min to heat up from the room temperature to 80°C, maintaining for four hours, then end the program. Finally the quartz tube cooled down to the room temperature.