Supporting Information

Temperature and Environmental Stable Titanium Carbide as Electron-Selective Heterocontact for Crystalline Silicon Solar Cells

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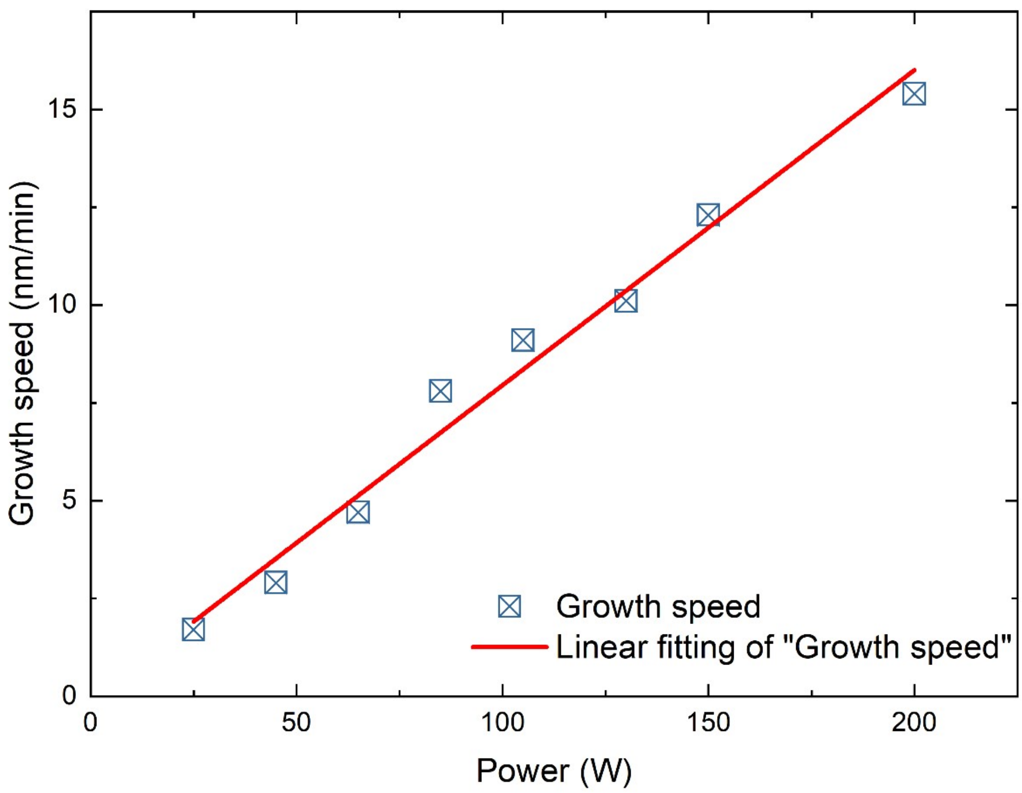

Figure S1. Growth speed of 200 W 2.0 Pa RF-sputtered TiC_x film.

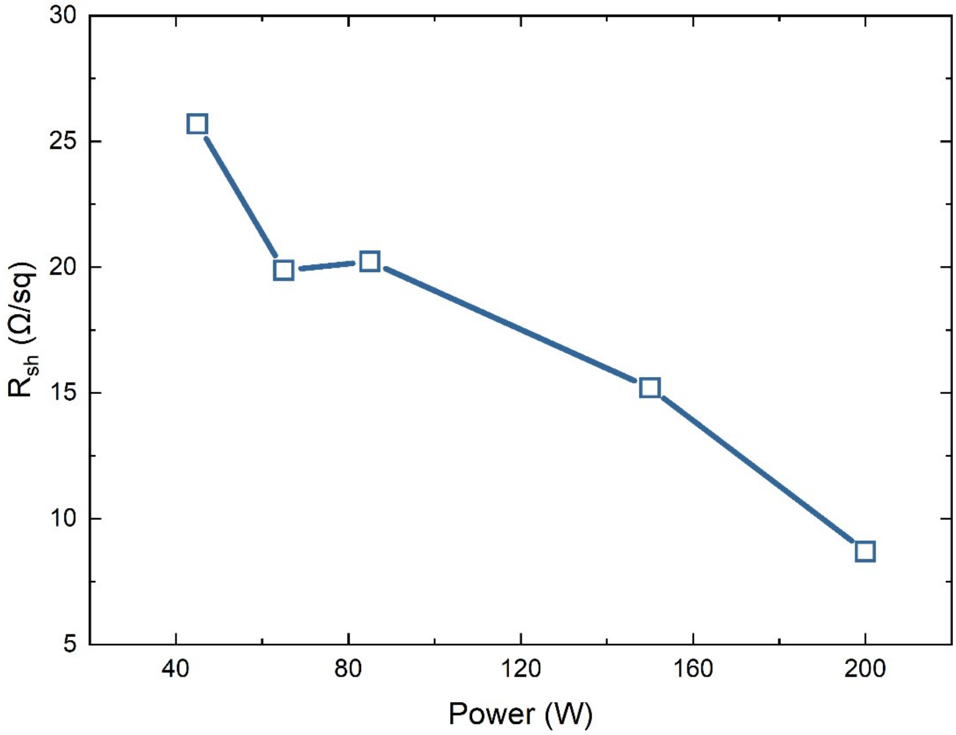

Figure S2. Square resistance of 300 nm TiC_x films at different sputtering powers with working pressure of 2.0 Pa.

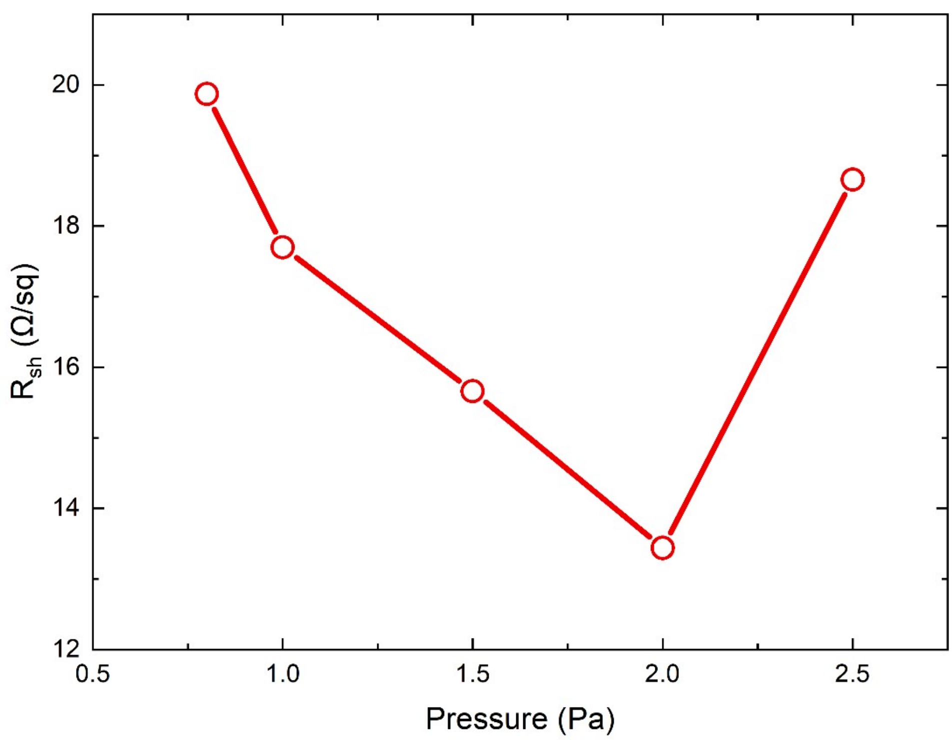

Figure S3. Square resistance of 300 nm TiC_x films at different working pressures with sputtering power of 200 W.

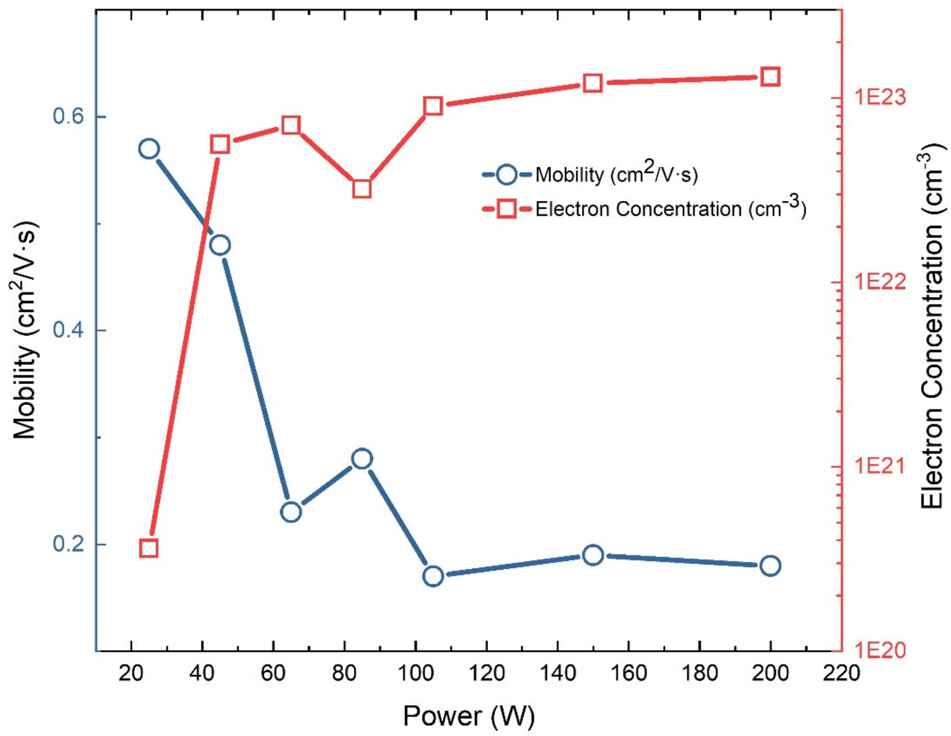

Figure S4. Electron concentration and mobility at different sputtering powers.

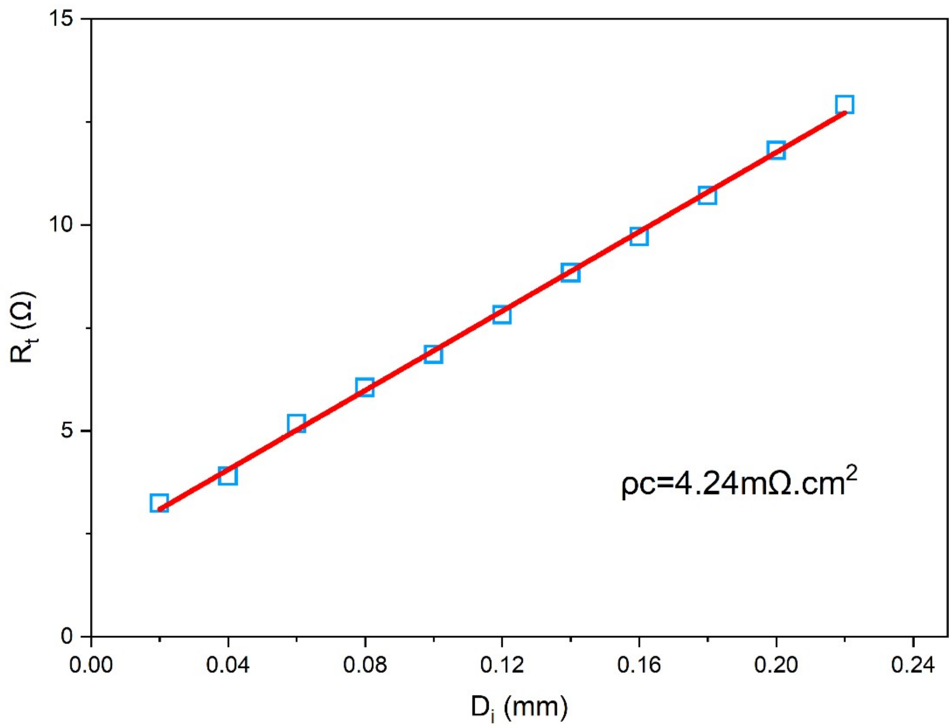

Figure S5. Linear fit to R_t to calculate contact resistivity.

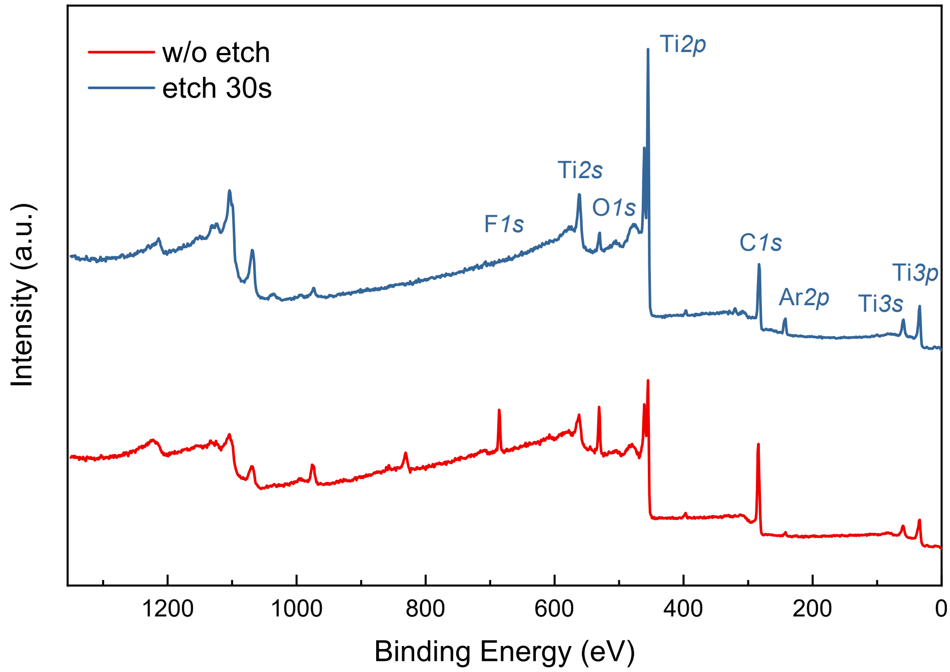

Figure S6. XPS survey of 200 W 2.0 Pa sputtered TiC_x film before and after surface etching.

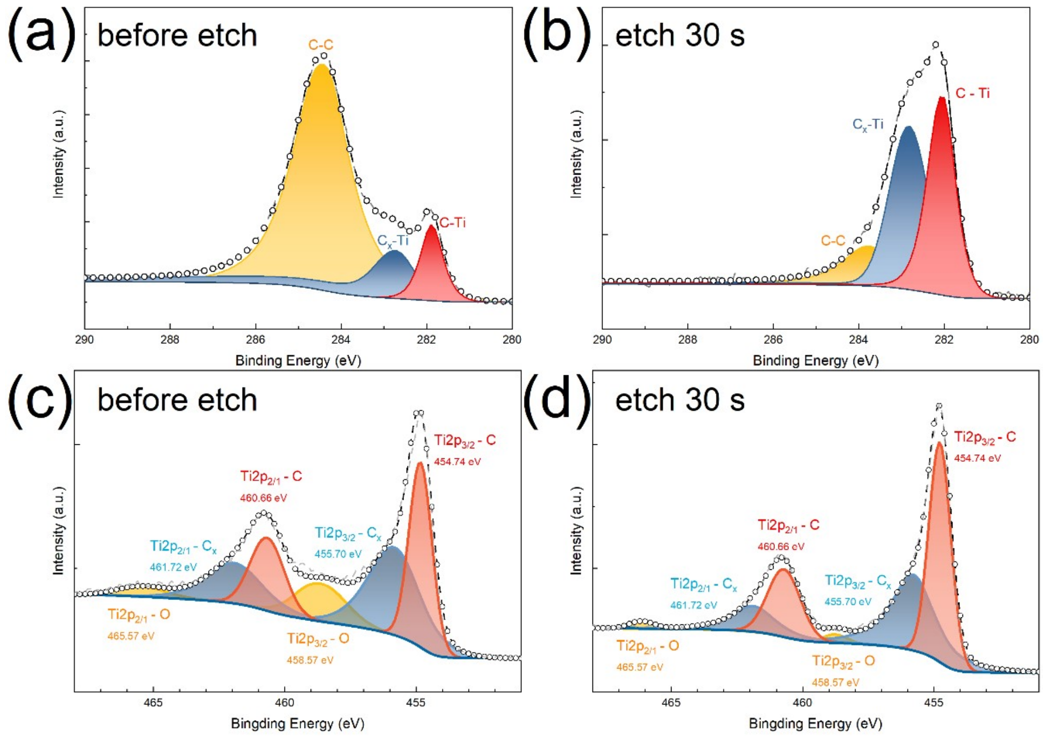

Figure S7. a) and **b)** XPS core-level spectra of C*1s* for the TiC_x films before and after surface etching, **c)** and **d)** XPS core-level spectra of Ti*2p* for the TiC_x films before and after surface etching.

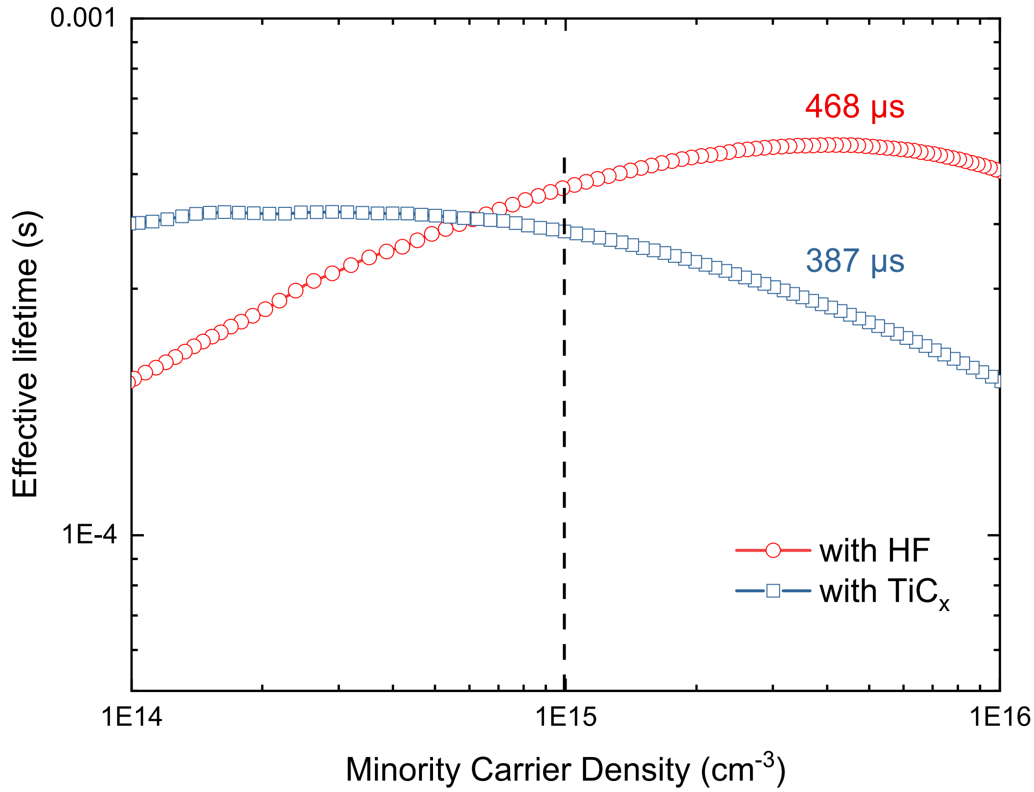

Figure S8. The effective minority carrier lifetimes of n-Si substrate (FZ, 3 Ωcm) passivated by 5 nm TiC_x thin film or HF treatment.

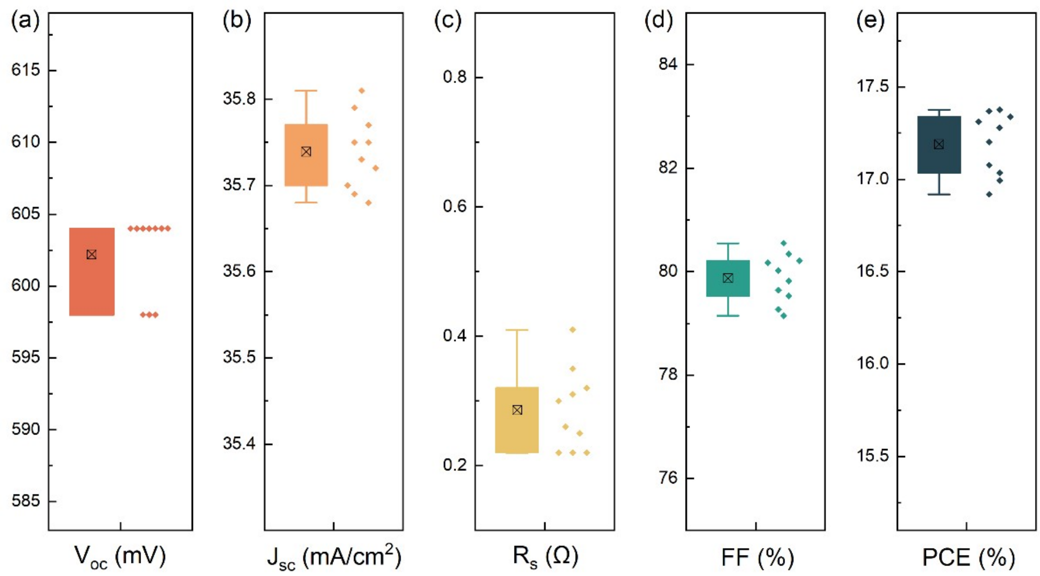

Figure S9. Reproducibility of the device with TiC_x ETL.

Table S1. Thermal stability Key parameters of representative silicon solar cells, device configurations and best power conversion efficiencies (PCE).

Materials	Contact structure	Thickness	Withstand temperature (°C)	PCE (%)	Reference
TiO_x	n-Si/ SiO_2/ TiO_x/ Al/ Ag	3.5	300	20.5	[1]
TiO_x/LiF/Al	n-Si/ a-Si:H(i)/ TiO_x/ LiF/ Al	1.5	300 b)	20.7	[2]
TiO_x/LiF/Yb	n-Si/ a-Si:H(i)/ TiO_x/ LiF/ Yb/ Ag	1.0	175 b)	19.2	[3]
MgO_x	n-Si/ MgO_x/ Al	1.0	400	20.0	[4]
Sc	n-Si/ SiO_2/ Sc/ Al	14.0	700	14.2	[5]
TiO_x	n-Si/ SiO_2/ TiO_x/ Al	4.5	300	21.6	[6]
TiO_x	n-Si/ TiO_x/ Al d)	1.5	400	23.1	[7]
TiO_x/Yb	n-Si/ a-Si:H(i)/ TiO_x/ Yb/ Ag	1.0	300 b)	17.6	[8]
$YbSi_x$	n-Si/ a-Si:H(i)/ $YbSi_x$/ Ag	2.1	300 b)	17.0	[9]
AMC or AEMC a)	n-Si/ AMC or AEMC/ Al	1.0	350 b)	19.4	[10]
MAcac c)	n-Si/ a-Si:H(i)/ MAcac/ Al	1.0	350 b)	21.6	[11]

a) alkali metal carbonate (AMC), alkali earth metal carbonate (AEMC)

b) Passed 100 H 85°C 85% Humidity damp heat test

c) metal acetylacetone (MAcac)

d) SiN_x passivated Partial Rear Contact

Table S2. Principal input parameters of back contact TiC_x electron transport solar cell

	p+	n	TiC_x ETL
Thickness (μm)	0.40	180	0.004
E_g (eV)	1.12	1.12	2.8
N_D (cm^{-3})	0	1.6 e^{15}	1 e^{19}
N_A (cm^{-3})	Gauss diffusion 1 e^{20}	0	0
χ (eV)	4.05	4.05	4.04
μ_n (cm^2/Vs)	1450	1450	0.5
μ_p (cm^2/Vs)	450	450	0.2
N_C (cm^{-3})	2.8 e^{19}	2.8 e^{19}	2.8 e^{19}
N_V (cm^{-3})	1.04 e^{19}	1.04 e^{19}	1.04 e^{19}

Table S3. Cell performance at 1000H damp heat test.

85°C 85% Humidity test time (H)	V_{oc} (mV)	J_{sc} (mA/cm^2)	FF (%)	PCE (%)
40	604	35.75	80.02	17.28
100	600	35.53	81.09	17.31
200	604	35.34	80.82	17.25
300	600	35.57	80.98	17.31
500	604	35.53	81.18	17.42
700	598	35.41	80.49	17.07
800	600	34.83	80.44	16.83
900	600	34.80	79.65	16.65
1000	598	34.76	78.23	16.29

References

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