

Supplementary Materials: Overcoming the Dilemma between Low Electrical Resistance and High Corrosion Resistance Using a Ta/(Ta,Ti)N/TiN/Ti Multilayer for Proton Exchange Membrane Fuel Cells

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Table S1. Deposition parameters of Ta/(Ta,Ti)N/TiN/Ti multilayer coatings.

Layer	Pressure (Pa)	Temperature (°C)	Power (W)		Flow rate (sccm)	
			Ta	Ti	Ar	N ₂
TaN	2	350	50	0	5	10
TaTiN	2	350	50	50	5	10
TiN	0.5	350	0	50	5	10
Ti	0.5	350	0	50	12	0

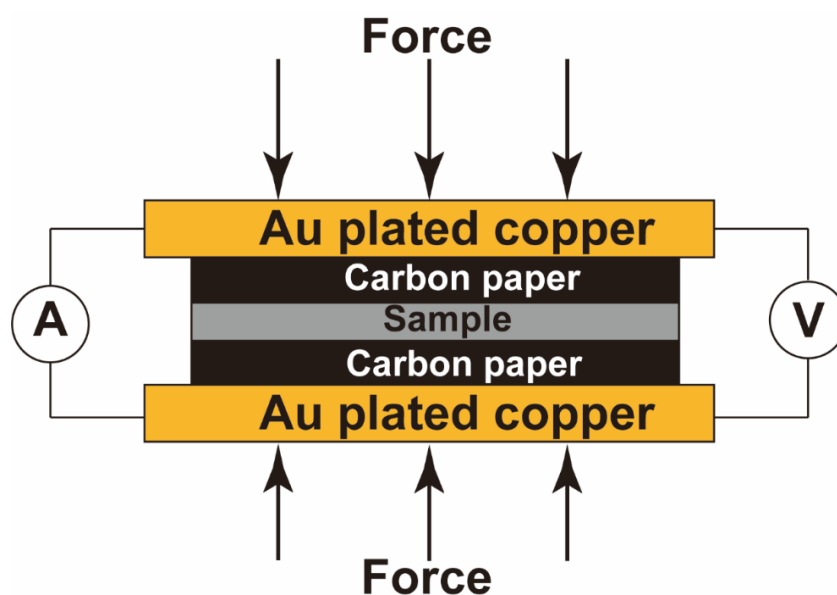


Figure S1. Schematic diagram of interface contact resistance measuring fixture.

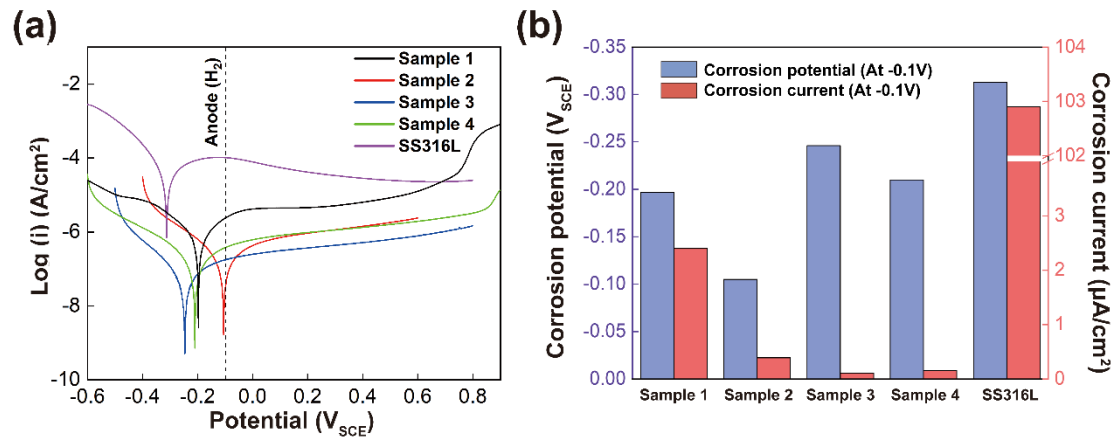


Figure S2. Electrochemical performance of thin films (a) Potentiodynamic polarization curves of uncoated SS316L and coated samples in 0.5 M H₂SO₄ solution at 70 °C (anode). (b) Self-corrosion potential and corrosion current at -0.1 V measured by potentiodynamic polarization curves.

Table S2. Tantalum series protective coating test data reported in literature.

Substrate	Surface modification	Electrolyte	Corrosion current density (μA/cm ²)	ICR (mΩ cm ²)	Ref.
316	TaN/(Ta,Ti)N/TiN/Ti	0.5 M H ₂ SO ₄ + 2 ppm HF at 70 °C	0.28 at 0.6 V vs. SCE	6	This work
316	TaN	0.5 M H ₂ SO ₄ + 0.02 M HF at 80 °C	0.33 at 0.6 V vs. SCE	11	[1]
430	PL-Ta/TaN	85 % H ₃ PO ₄ solution at 80 °C	0.79 at 0.6 V vs. SCE	9	[2]
316	TaN	H ₂ SO ₄ pH = 3 at 80 °C	1 at 0.6 V vs. SCE	7	[3]
430	Ta	0.5 M H ₂ SO ₄ + 5 M ethanol + 1 M acetic acid solution at 60 °C	1.01 at 0.6 V vs. SCE	30	[4]
316	Ta	0.5 M H ₂ SO ₄ at 70 °C	9.25 at 0.6 V vs. SCE	Not Available	[5]
316	Ta	H ₂ SO ₄ + 0.1 ppm HF pH = 3	0.05	22	[6]
316	PL-Ta/TaN	0.5 M H ₂ SO ₄ + 2 ppm HF 80 °C	0.05	12	[7]
Mg	Ta/Ag	0.5 M H ₂ SO ₄ + 0.1 ppm HF electrolyte at 80 °C	0.007	28	[8]

Table S3. Comparison of graphite bipolar plate and SS316L.

-	Electrical conductivity (S/cm)	Yield strength (MPa)	Flexural strength (MPa)	corrosion resistance (μA/cm ²)	Density (g/cm ³)	ICR (mΩ cm ²)	Cost (\$/kg)	Ref.
SS316L	133	177	Not Available	1178	7.98	about 300	1.2	This work
Graphite BP	127	Not Available	54	0.42	1.5	8	18	[9,10]
DOE target	>100	Not Available	>25	<1	Not Available	<10	Not Available	[11]

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