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

Supplementary Data

Boosting hydrogen and oxygen evolution on nickel electrodes via simultaneous mesoporosity, magnetohydrodynamics and high gradient magnetic force

Amir Ali Farmani and Farzad Nasirpouri

Supplementary document provides information on the high cycle CVs demonstrating the HER and OER performance of the Ni electrodes, Experimental details of electrochemcial tests, Comprehensive HER and OER performance data for various electrode materials reported in the literature, and calculation method of high gradient magnetic fields.

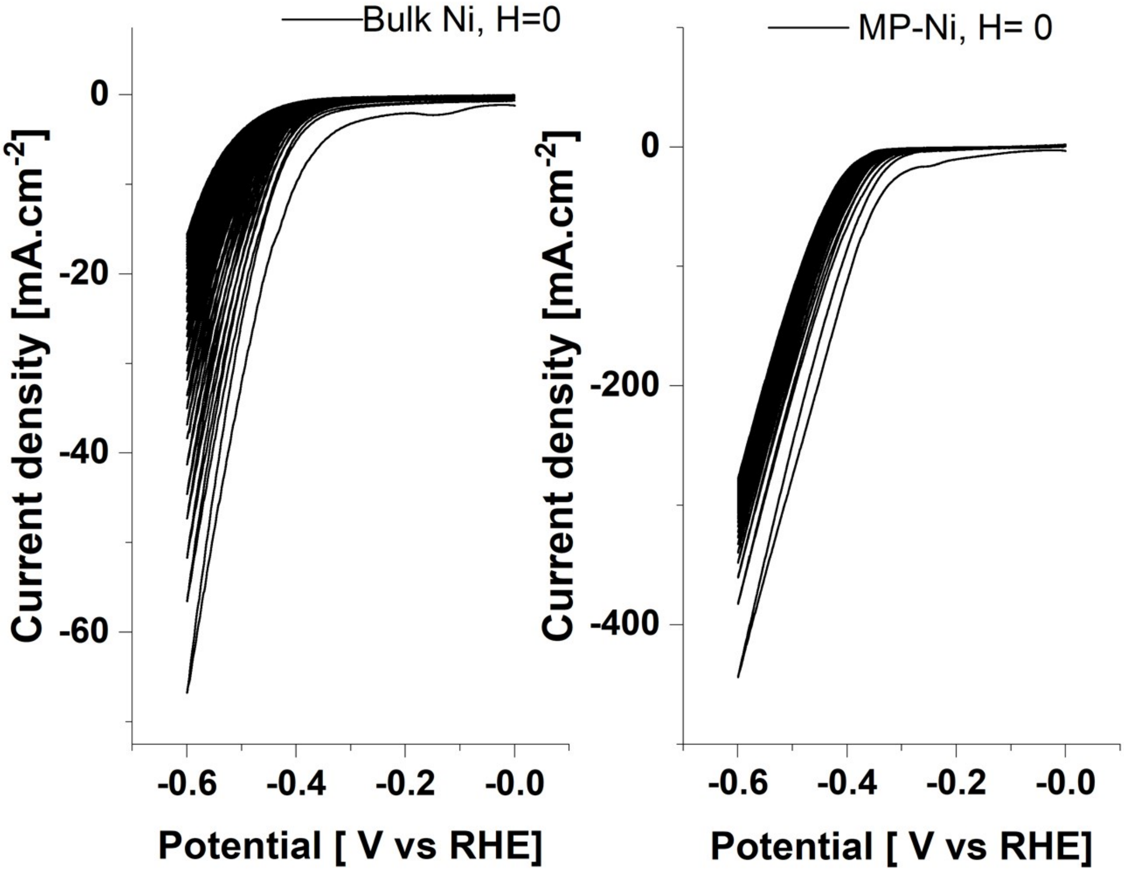

Figure S1 Cyclic voltammograms of HER for bulk and mesoporous Ni electrodes in the absence of magnetic field.

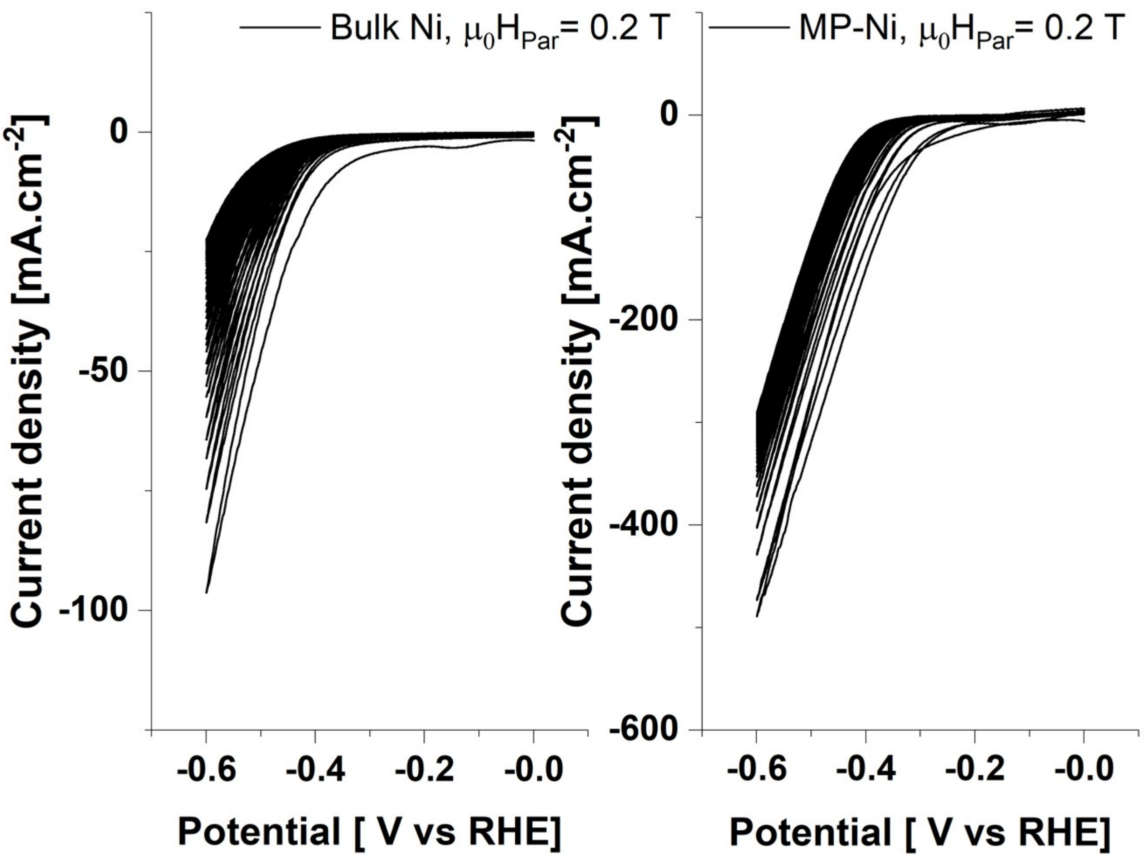

Figure S2 Cyclic voltammograms of HER for bulk and mesoporous Ni electrodes in the absence of magnetic field applied parallel to the electrical field.

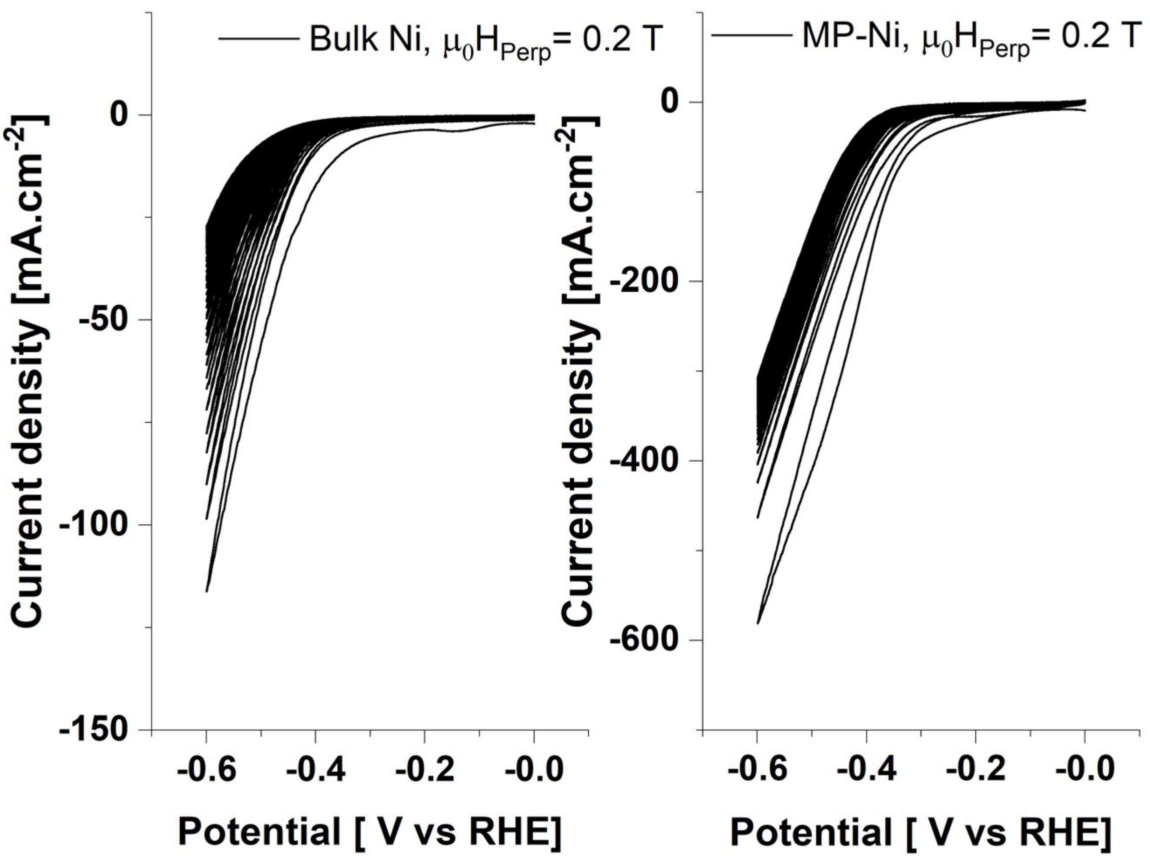

Figure S3 Cyclic voltammograms of HER for bulk and mesoporous Ni electrodes in the absence of magnetic field applied perpendicular to the electrical field.

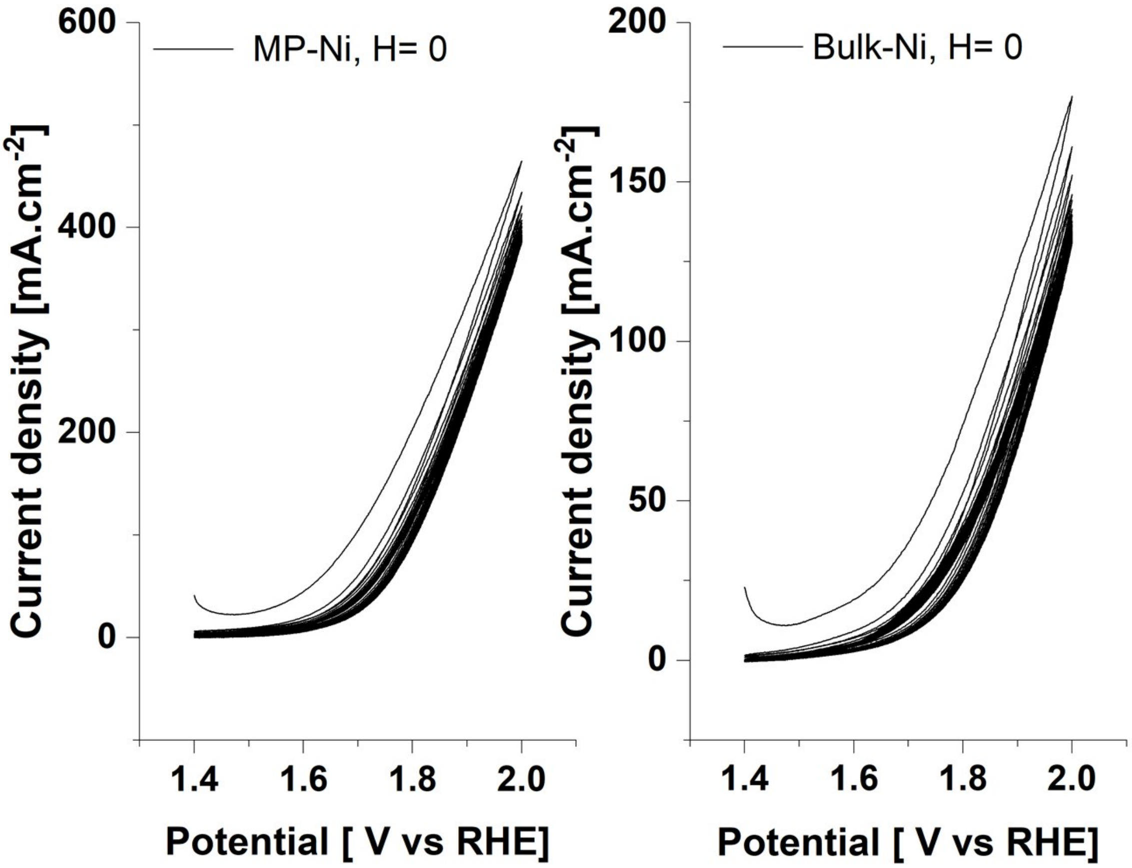

Figure S4 Cyclic voltammograms of OER for bulk and mesoporous Ni electrodes in the absence of magnetic field.

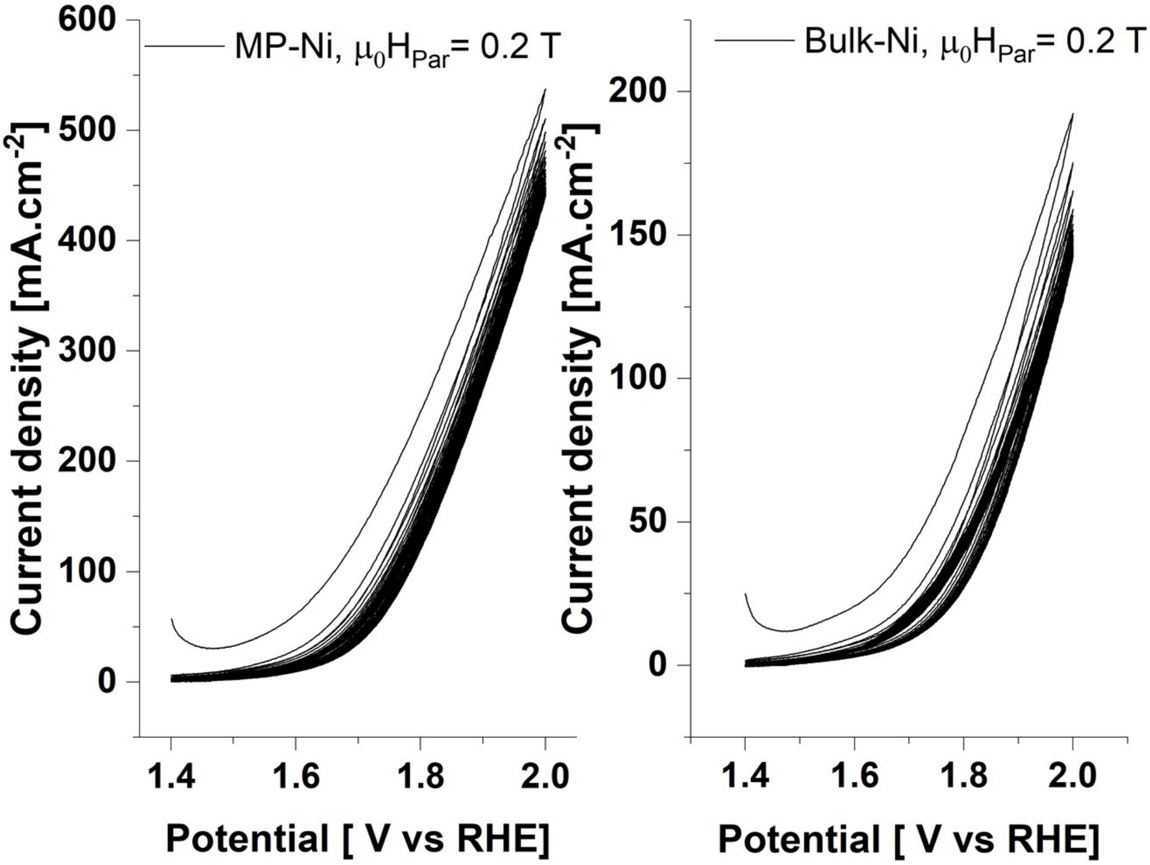

Figure S5 Cyclic voltammograms of OER for bulk and mesoporous Ni electrodes in the absence of magnetic field applied parallel to the electrical field

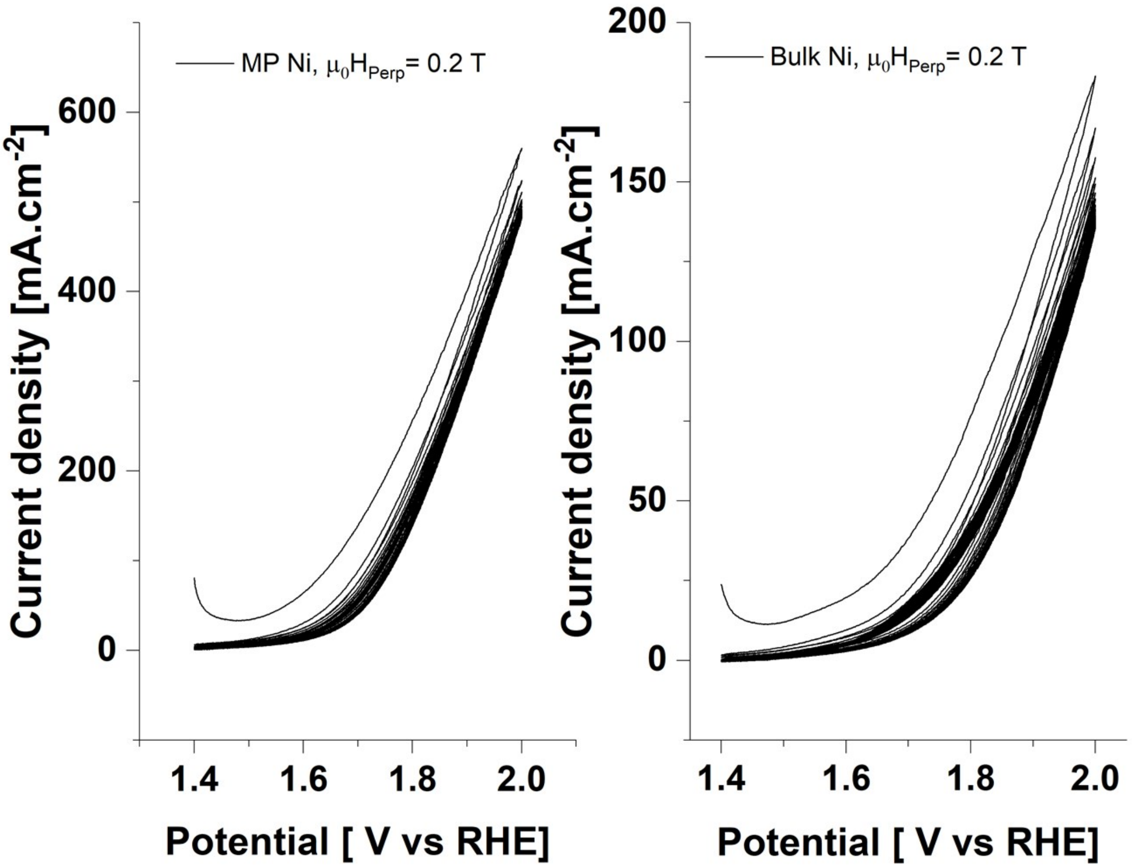

Figure S6 Cyclic voltammograms of OER for bulk and mesoporous Ni electrodes in the absence of magnetic field applied perpendicular to electrical field

Table S1 Electrochemical test parameters for OER and HER.

Reaction	**Electrochemical test**	**Conditions**
HER	LSV	-525 mV to -1700 mV vs SCE 1 $mV.s^{-1}$
	CV	-1.0 to -1.6 V vs SCE 50mV/s-50 cycles
	CA	-1.6 V vs SCE
	EIS	10 kHz to 1 Hz Amplitude: 5mV -1.4 V vs SCE -400 mV vs RHE
OER	LSV	-725 mV to 800 mV vs SCE $mV.s^{-1}$
	CV	0.4-1.0 V vs SCE 50mV/s-50 cycles
	CA	1 V vs SCE
	EIS	10 kHz to 1Hz Amplitude: 5mV 0.8 V vs SCE 1.8 V vs RHE

Table S2 Comparison of HER and OER activity from various reported electrocatalysts.

Reaction	Electrode	Overpotential 10mA/cm	Tafel slope	Reference
HER	NiO	710	100	[49]
	Co_3O_4	800	139	[49]
	NiS/NC	129	78	[62]
	Ni/NiS/NC	70	45	[62]
	Ni/NC	94	57	[62]
	Ni dendrite	441	102	[22]
	Ni particle	446	119	[22]
	Ni film	448	98	[22]
	Ni foil	554	300	[22]
	NiFeOF	253	-	[65]
	NiFe-NCs	197	130	[64]
	Pt/C	20	-	[49], [64]
	NiFe-NPs	374	197	[64]
	Fe_2O_3 NPs	424	158	[64]
	Nio Nps	576	236	[64]
	$CoSe_2$/DETA	386	107	[63]
	Co_2B	350	78	[63]
	$Co_2B/CoSe_2$	300	76	[63]
	Cu@NC NT/CF	123	63	[67]
	Cu 0.3 Co 2.7 P/NC	220	122	[68]
	Ru@C_2N	22	30	[69]
OER	Ru_2O	210	151	[49]
	NiO	530	170	[49]
	Co_3O_4		287	[49]
	NiS/NC	371	75	[62]
	Ni/NiS/NC	337	52	[62]
	Ni/NC	350	54	[62]
	RuO_2	357	58	[62]
	$CoSe_2$/DETA	392	83	[63]
	Co_2B	373	80	[63]
	$Co_2B/CoSe_2$	320	56	[63]
	$Cu(OH)_2$	470	78.9	[70]
	MWCNT/$Cu(OH)_2$	530	127.9	[70]
	MWCNT/CuO-400	420	59.9	[70]
	NiFe/Cu_2O NWs/CF	215	42	[71]
	Cu_2O NWs/CF	320	48	[71]
	$Fe(OH)_3$:$Cu(OH)_2$	365	42	[66]
	$Cu(OH)_2$@NiFe-LDH	283	88	[72]
	CuO/Fe-Co_3O_4	232		[73]
	CuO/Co_3O_4	227		[74]
	3D-OMNiSA	254	39	[25]

Calculation of magnetic field gradient profile of one-dimensional nanotube bodies

The stray magnetic field emanating from a periodic array is easily obtained from Fourier transformation of Maxwell's equations [38, 45]:

$$B_{1,x}(x,z_0) = \frac{u_0 M h d}{a} \sum_{n=1}^{\infty} q_n F(q_n) e^{-q_n\left(z_0 + \frac{h}{2}\right)} \sin\left(q_n - \theta\right),$$

$$B_{1,y}(x,z_0) = 0'$$

$$B_{1,z}(x,z_0) = \frac{u_0 M h d}{a} \sum_{n=1}^{\infty} q_n F(q_n) e^{-q_n\left(z_0 + \frac{h}{2}\right)} \cos\left(q_n - \theta\right),$$

where $q_n = 2\pi n/a$, a is the period of the array, h the height of the cobalt fingers and d their width, θ is the tilt angle of the magnetization and

$$F(q_n) = \frac{sin(\frac{q_n d}{2}) sinh(\frac{q_n h}{2})}{(\frac{q_n d}{2}) \left(\frac{q_n h}{2}\right)},$$

Because the electron's motion is limited to the plane, the magnetic effects depend only on the component of the perpendicular magnetic field component $B_{1,z}(x,z_0)$. which is plotted in **Fig. 10** .