Supplemental Information

Key Developments in Magnesiothermic Reduction of Silica: Insights into Reactivity and Future Prospects

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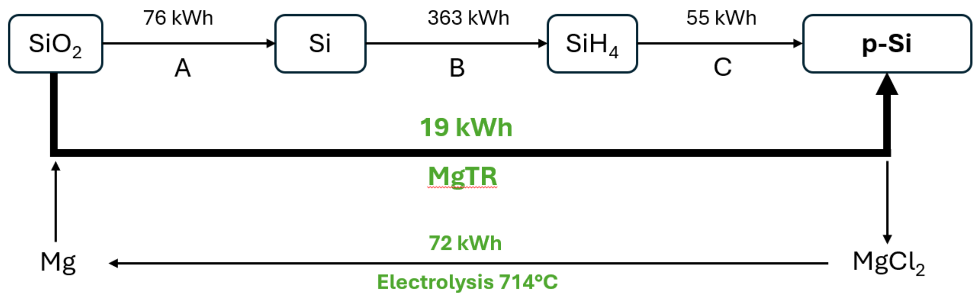

Figure S1: Schematic showing high volume production routes to making porous Si, and the energy requirement of each step, normalised to 1 kg of Si.

Table S1: Chemical process occurring in each step described in Figure S1, along with associated energy cost and reference source.

Step	Process	Energy cost (kWh/kg Si)	doi
A	Carbothermal reduction	76	https://doi.org/10.1016/j.jpowsour.2023.233720 *
B	Silane production	363	https://doi.org/10.1016/j.resconrec.2012.10.002
C	Siemens process	55	https://doi.org/10.1016/j.applthermaleng.2021.117522 https://doi.org/10.1016/j.jcrysgro.2014.05.020
MgTR	Magnesiothermic reduction	19	https://doi.org/10.1016/j.jpowsour.2023.233720 *
Electrolysis	Molten salt electrolysis	72	Calculated here, see Table S3

*Energy cost was calculated with the model used in our previous work[1] under the following conditions:

- Rotary tube furnace with L/D ratio of 5:1
- Ramp rate of 10°C/min
- 1 hour dwell time
- Thermal efficiency of 80%
- Heat capacity of C = 0.71 J/gK
- Mole ratio of $C:SiO_2$ = 1:1
- Tap density of $C:SiO_2$ mixture = 1000 kg/m^3
- Mole ratio of $Mg:SiO_2$ mixture = 2:1
- Tap density of $Mg:SiO_2$ mixture = 1000 kg/m^3

Electrolysis was calculated as follows:

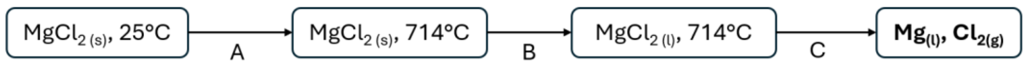

Figure S2: Schematic showing the steps of recycling $MgCl_2$ into Mg.

Table S2: Physical process occurring in each step described in Figure S2, and associated energy requirements

Step	Process	Energy requirement (kWh/kg Si)
A	Sensible heating	1.02
B	Enthalpy of fusion	0.85
C	Electrolysis	69.3*

*This value was calculated assuming an energy efficiency of 20% for the electrolysis process.

Table S3. Data for Figure 4A regarding reaction time and temperatures in 50 literature sources.

Reaction Temp (°C)	Reaction time (h)	Year	Author	doi
800	6	2024	Andriayani *et al.*	10.1016/j.mset.2023.09.003
800	3	2015	Andriayani *et al.*	10.14716/ijtech.v6i7.1493
750	2			
850	3			
800	3			
950	3			
700	1.5	2021	Hamedani *et al.*	10.1002/celc.202100683
700	0			
700	3			
700	6			
650	3	2017	Arunmetha *et al.*	10.1007/s11664-017-5794-0
600	1	1982	Banerjee *et al.*	10.1016/0025-5416(82)90046-5
750	1			
850	1			
650	2.5	2007	Bao *et al.*	10.1038/nature05570
650	2			
650	3	2023	Klinbumrung *et al.*	10.1007/s12633-023-02380-z
800	0.5	2022	Guo *et al.*	10.1021/acssuschemeng.2c00632
680	3	2023	Jaswal *et al.*	10.1016/j.jenvman.2022.116912
650	6	2023	Wang *et al.*	10.1016/j.electacta.2023.141950
680	3	2023	Su *et al.*	10.1016/j.cej.2022.138394
750	2	2024	Ma *et al.*	10.1016/j.cej.2024.148542
700	5	2023	Ma *et al.*	10.3390/ molecules28073274
660	5			
650	6	2021	Entwistle *et al.*	10.1039/d0ra09000j
600	1	1982	Banerjee *et al.*	10.1016/0025-5416(82)90046-5
750	1			
850	1			
700	3	2014	Zhang *et al.*	10.1002/adma.201402813
675	0.5	2014	Yoo *et al.*	10.1002/aenm.201400622
900	4	2002	Sandhage *et al.*	10.1002/1521-4095(20020318)14:6<429::AID-ADMA429>3.0.CO;2-C
600	5	2017	Jiang *et al.*	10.1016/j.cej.2017.08.061
650	5	2019	Xing *et al.*	10.1007/s42452-019-0196-y
700	6	2016	Li *et al.*	10.1038/s41598-017-01086-8
700	1	2014	Chen *et al.*	10.1007/s12274-013-0374-y
700	2			
700	3			
700	4			

700	5			
680	3	2021	Wang *et al.*	10.1016/j.jallcom.2020.157955
700	6	2016	Zhou *et al.*	10.1016/j.jpowsour.2016.05.058
650	7	2013	Xing *et al.*	10.1039/c3ra41889h
750	3	2016	Xu *et al.*	10.1039/c6ta01344a
800	12	2014	Xie *et al.*	10.1039/c4nj00752b
500	7	2015	Shuhe *et al.*	10.1007/s11595-016-1476-7
800	2	2016	Gao *et al.*	10.1016/j.electacta.2017.01.119
700	6	2014	Favors *et al.*	10.1038/srep05623
650	7	2011	Jia *et al.*	10.1002/aenm.201100485
650	6	2015	Liu *et al.*	10.1002/ange.201503150
500	1	2013	Xing *et al.*	10.1039/c3cc43134g
500	12			
700	6	2015	Wang *et al.*	10.1038/srep08781
700	16	2022	Zuo *et al.*	10.3390/molecules27217486
800	16			
900	16			
800	5	2019	Falk *et al.*	10.1016/j.ceramint.2019.07.157
675	2	2012	Yoo *et al.*	10.1002/adma.201201601
700	1	2026	Waitzinger *et al.*	10.1007/s00706-015-1611-8
750	1			
600	1	2012	Batchelor *et al.*	10.1007/s12633-012-9129-8
600	12	2015	Liu *et al.*	10.1016/j.jmmm.2015.06.074
700	12			
800	12			
800	10	2020	Guo *et al.*	10.1007/s12613-019-1900-z
800	6			
800	2			
800	14			
700	4	2023	Seroka *et al.*	10.3390/coatings13020221
650	6	2018	Khanna *et al.*	10.1139/cjc-2018-0165
650	4	2019	Miao *et al.*	10.1007/s11581-019-03256-2
650	2	2016	Uehira *et al.*	10.1246/cl.160544
700	2	2021	Sekar *et al.*	10.3390/nano11030613
650	3	2018	Tang *et al.*	10.1016/j.clay.2018.07.004
700	6	2021	Hamedani *et al.*	10.1002/celc.202100683
700	3			
700	1.5			
700	0			
650	2.5	2011	Chen *et al.*	10.1149/1.3611433
600	3			
500	3.5			
800	10	2019	Sun *et al.*	10.1016/j.ijhydene.2019.01.270

References

1. M. Yan, S. Martell, M. Dasog, S. Brown and S. V. Patwardhan, *Journal of Power Sources*, 2023, **588**, 233720.