TOWARDS METALLIC NEODYMIUM PRODUCTION FROM Nd_2O_3 USING HYDROGEN PLASMA SMELTING REDUCTION (HPSR)

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ABSTRACT

HPSR was investigated for rapid, fluorine-free reduction of Nd_2O_3. High-purity oxide briquettes underwent 80% H_2–20% Ar plasma treatment for 2–6 min. SEM–EDS and EPMA revealed oxygen depletion and Nd enrichment. Oxygen removal reached 92.35% at 6 min, but longer exposure also caused greater Nd volatilization. Optimization is needed to improve Nd retention.

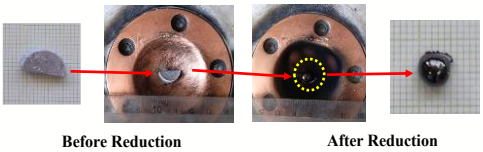
92.35%
oxygen removal after 6 min

Keywords : Neodymium · Rare earths · Hydrogen plasma · Nd_2O_3

INTRODUCTION

- Global permanent magnet demand is projected to increase by 95% by 2050, driven by EV adoption and renewable energy expansion.
- Nd is a key input to high-performance Nd–Fe–B permanent magnets for EV drives and wind power.
- Conventional electrolysis and metallothermic production involve complex processing and, in many routes, fluorinated chemicals.
- This work tests reactive H plasma as a fast reduction route and evaluates oxygen removal versus Nd losses.

SAMPLE TRANSFORMATION





Nd_2O_3 before and after reduction and stages of oxidation of the reduced Nd_2O_3 sample (manuscript Fig. 4).

Handling precaution: reduced samples were promptly stored in paraffin oil to restrict contact with O_2 and moisture.

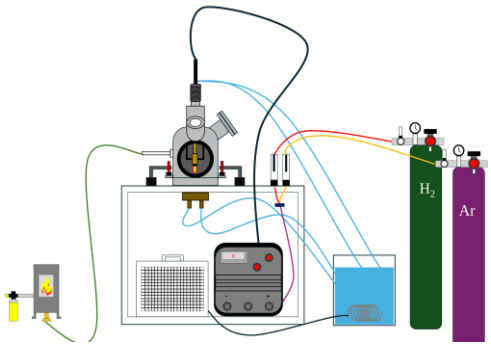
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RESEARCH METHOD



Feed	Nd_2O_3 >99%; 1 g briquette
Binder	2 wt.% starch
Plasma	80% H_2 / 20% Ar · 5 L/min

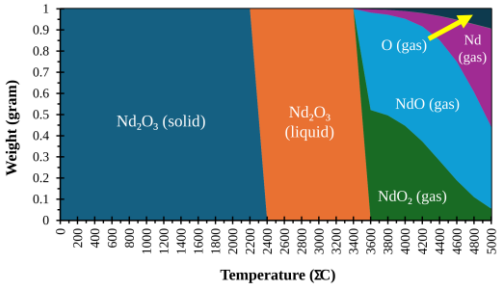
30 A arc II 2, 4, 6 min exposure II SEM–EDS / EPMA



Modified HPSR reactor and gas supply (Fig. 3).

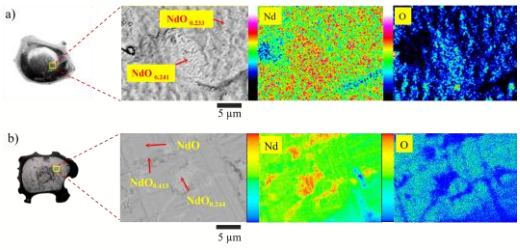
THERMODYNAMIC ASSESSMENT

FactSage 8.4 predicts thermally stable Nd_2O_3 at lower temperatures; with H_2, high-temperature reduction can form volatile Nd, NdO, NdO_2 and NdOH species.



Calculated Nd_2O_3 equilibrium without H_2 (Fig. 5).

ELEMENTAL MAPPING

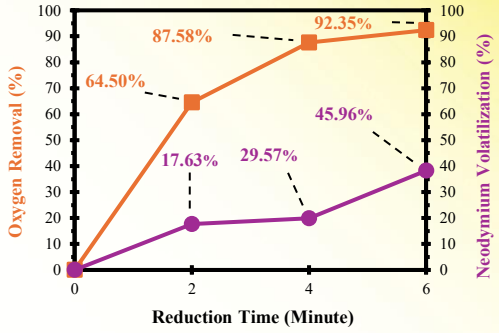


SEM–EDS and EPMA Nd/O maps after 4 min (Fig. 9).

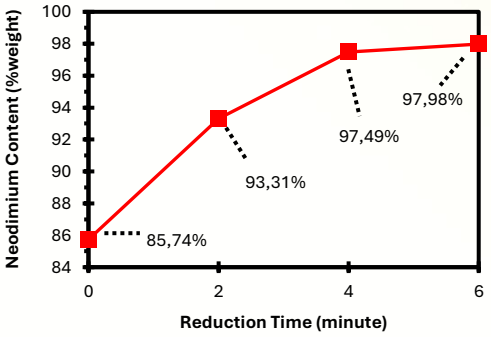
Local Nd-rich areas approached $NdO_{0.233}$–$NdO_{0.244}$ by microanalysis; this is not independent confirmation of a pure metallic Nd phase.

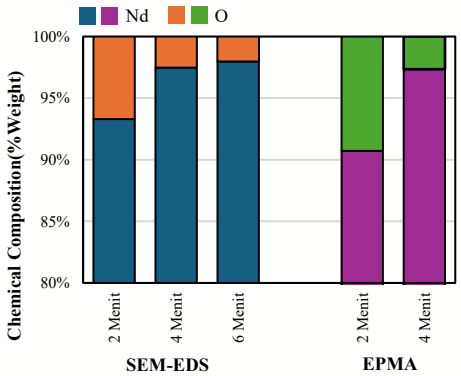
DISCUSSION & RESULTS

Oxygen removal improves with plasma exposure; neodymium losses also increase.



ND ENRICHMENT





EPMA: Nd = 90.72 wt.% (2 min) and 97.36 wt.% (4 min).

CONCLUSION

- HPSR removed up to 92.35% of oxygen from Nd_2O_3 within 6 min.
- SEM–EDS measured up to 97.98 wt.% Nd in the reduced product.
- Nd-rich, oxygen-deficient areas formed; additional phase analysis is needed to establish the metallic fraction.
- Future work: improve Nd retention, confirm phases and quantify process recovery.