



Iron Nitride Permanent Magnets

The Clean Earth Magnet®

The Clean Earth Magnet®

High performance at low cost

- Niron Magnetics has developed the world's first & only powerful permanent magnet free of critical minerals
- Made from environmentally clean, abundant and affordable commodity raw material inputs
- Free from supply chain disruptions
- Protected Intellectual Property



Milestones in the Development of Iron Nitride Magnets

The magnetic α'' -Fe₁₆N₂ phase was first observed in the 1950's

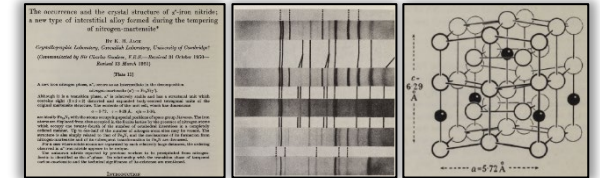
Iron Nitride's "giant saturation magnetization" was first observed in the 1970's, making public the material's potential for attractive magnetic performance properties

However, the difficulty of synthesizing the material and inconsistent reproducibility of the giant M_{sat} meant the material remained an academic curiosity

1950

K.H. Jack, University of Cambridge

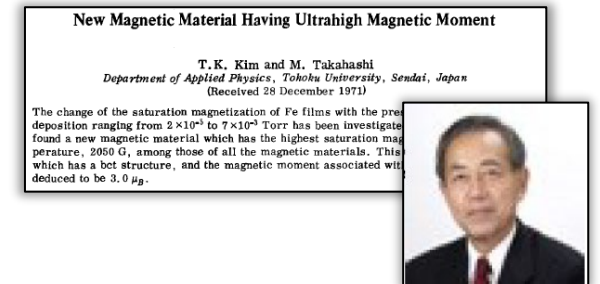
- Observed α'' -Fe₁₆N₂ from tempering of iron - nitrogen martensite
- Determination of crystal structure and lattice parameters



1971

M. Takahashi, Tohoku University

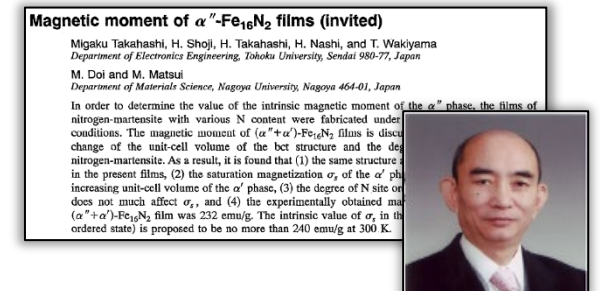
- Synthesis of iron nitride thin films
- First report of giant saturation magnetization (2.58 Tesla at room temperature)



1994

M. Takahashi, Tohoku University

- Difficulty replicating giant saturation magnetization in thin film samples
- Only achieved 2.24 Tesla at 300K



Milestones in the Development of Iron Nitride Magnets



Prof. Jian-Ping Wang
Univ. of Minnesota

Over the past decade, work led by Prof. Jian-Ping Wang significantly advanced the understanding of α "-Fe₁₆N₂

Critical milestones include:

- Demonstrating multiple Iron Nitride synthesis methods in thin film & bulk
- Measurement of giant M_{sat} in strained Iron Nitride in strained thin films
- Development of "Cluster + Atom" model to explain M_{sat} and K_u

Out of this work, Niron Magnetics was founded to commercialize Iron Nitride magnets



2010

Confirmed giant saturation magnetization. Proposed "Cluster + Atom" model to explain giant M_{sat}

N. Ji, X. Liu, J-P Wang, "Theory of giant saturation magnetization in α "-Fe₁₆N₂: role of partial localization in ferromagnetism of 3d transition metals," *New Journal of Physics*, 12, 2010, p. 063032.

2012

Observation of localized 3d electron states by XMCD

J-P Wang et al., "Fabrication of Fe₁₆N₂ Films by Sputtering Process and Experimental Investigation of Origin of Giant Saturation Magnetization in Fe₁₆N₂," *IEEE Trans. Magn*, Vol. 48, 2012, pp. 1710-7.

2013

Measurement of Giant M_{sat} (2.89 Tesla) by PNR

N. Ji, V. Lauter, X. Zhang, H. Ambaye, J-P Wang, "Strain induced giant magnetism in epitaxial Fe₁₆N₂ thin film," *Appl. Phys. Lett.*, Vol. 102, 2013, p. 072411.

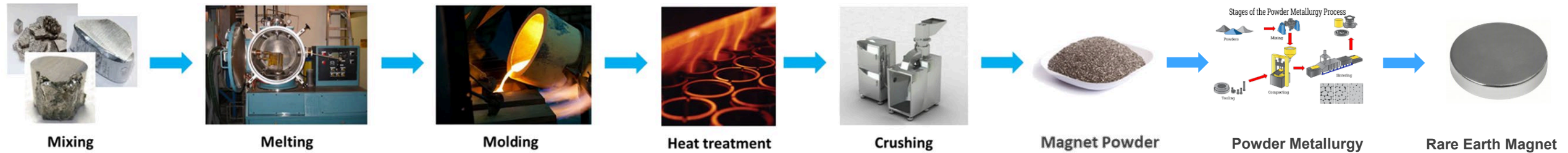
2018

Measured magnetocrystalline anisotropy (1.9×10^7 erg/cm³) in CPP GMR device

X. Li, et al., "Heavy-Metal-Free, Low-Damping, and Non-Interface Perpendicular Fe₁₆N₂ Thin Film and Magnetoresistance Device," *Phys. Status Solidi RRL*, 2019, p. 1900089.

Making the Magnets

Manufacturing process for NdFeB rare earth Magnets



Niron Magnetics Manufacturing process for **Clean Earth Magnet™**



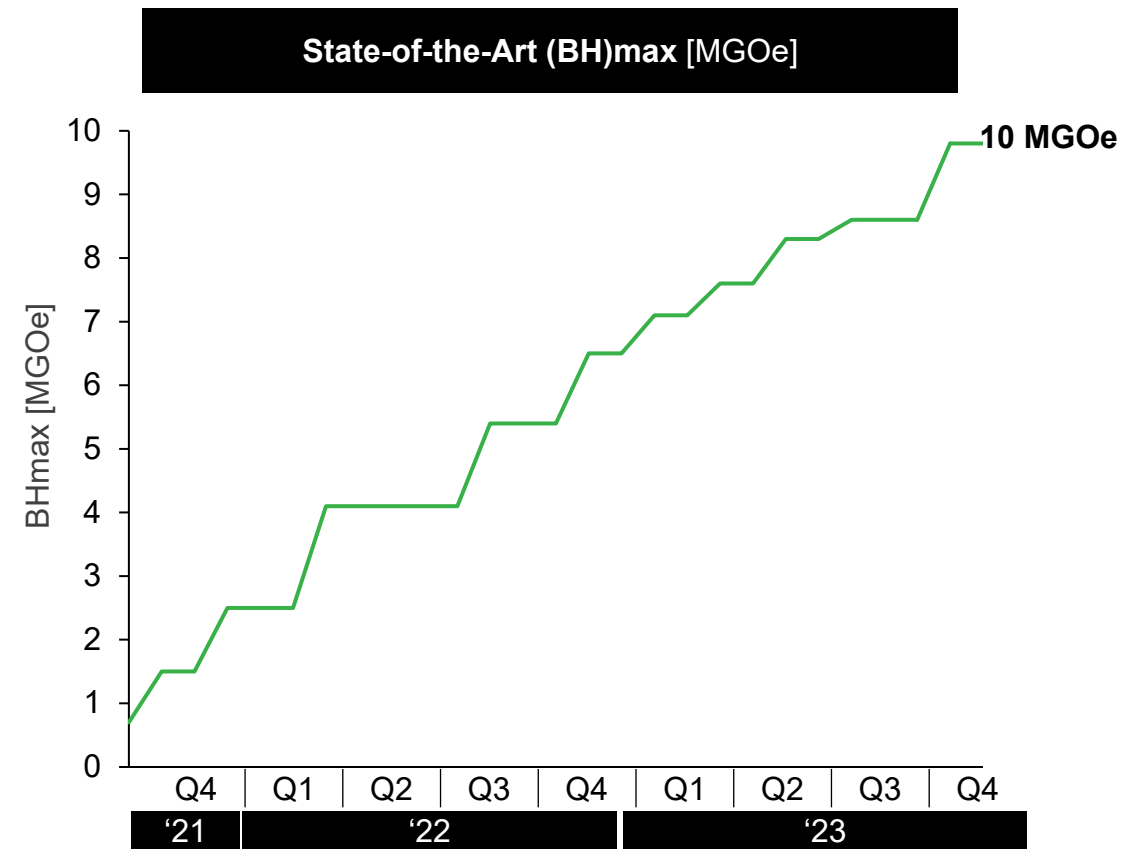
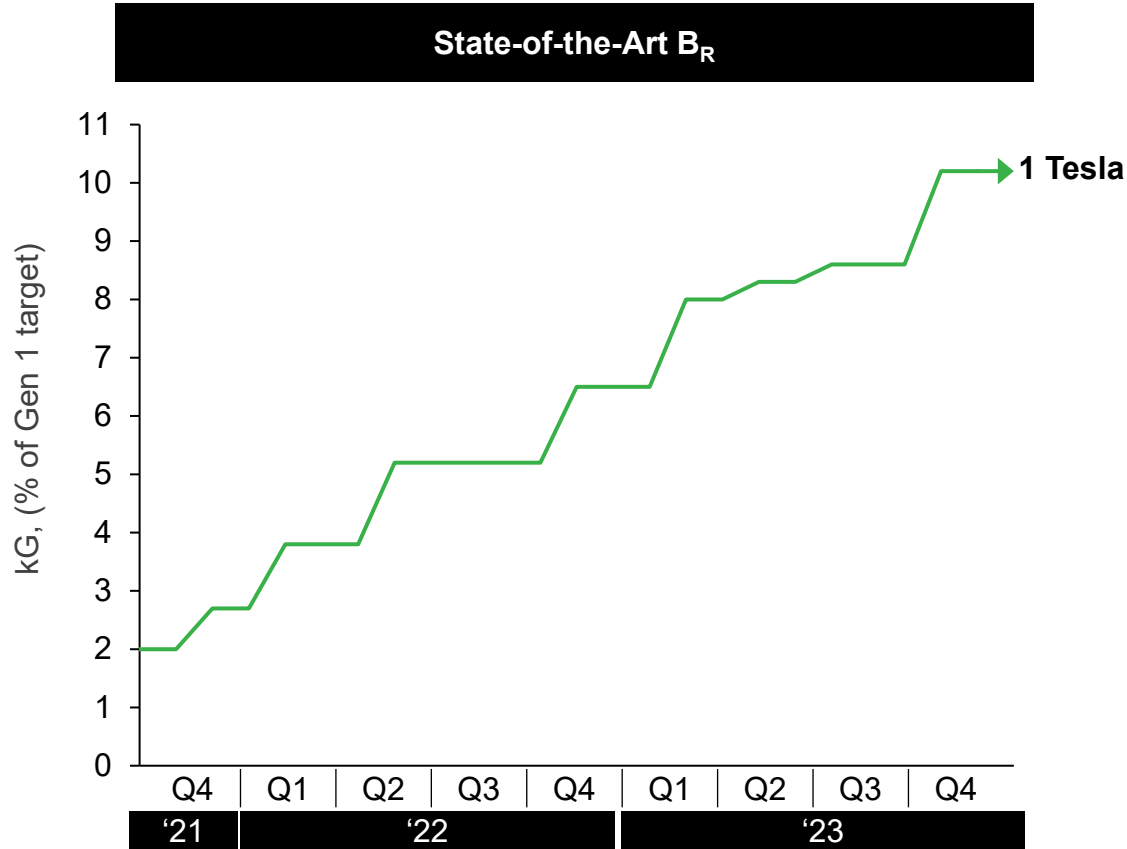
Making the Magnets



1. Iron nitride has **no rare earths or any other critical elements** in its alloy composition
2. Iron nitride thus **avoids the use of environmentally hazardous chemicals** used to refine rare earth ore
3. Iron nitride magnets can be manufactured to the **same size and shape as NdFeB** magnets using similar pressing equipment

Development Progress

Leading edge lab scale demonstrations



Scaling iron nitride manufacturing processes and raw materials

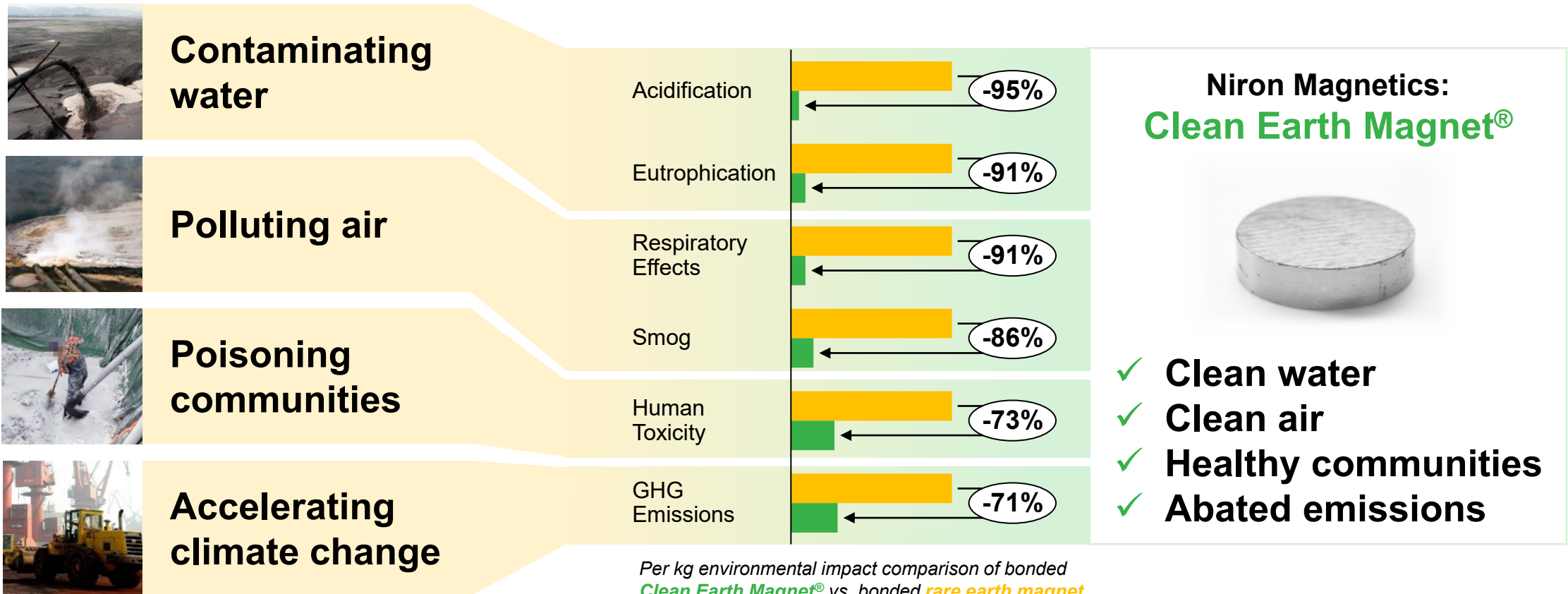


CONFIDENTIAL

The Clean Earth Magnet®

Sustainable Magnet Manufacturing Process

Rare earth magnets



**Niron Magnetics:
Clean Earth Magnet®**

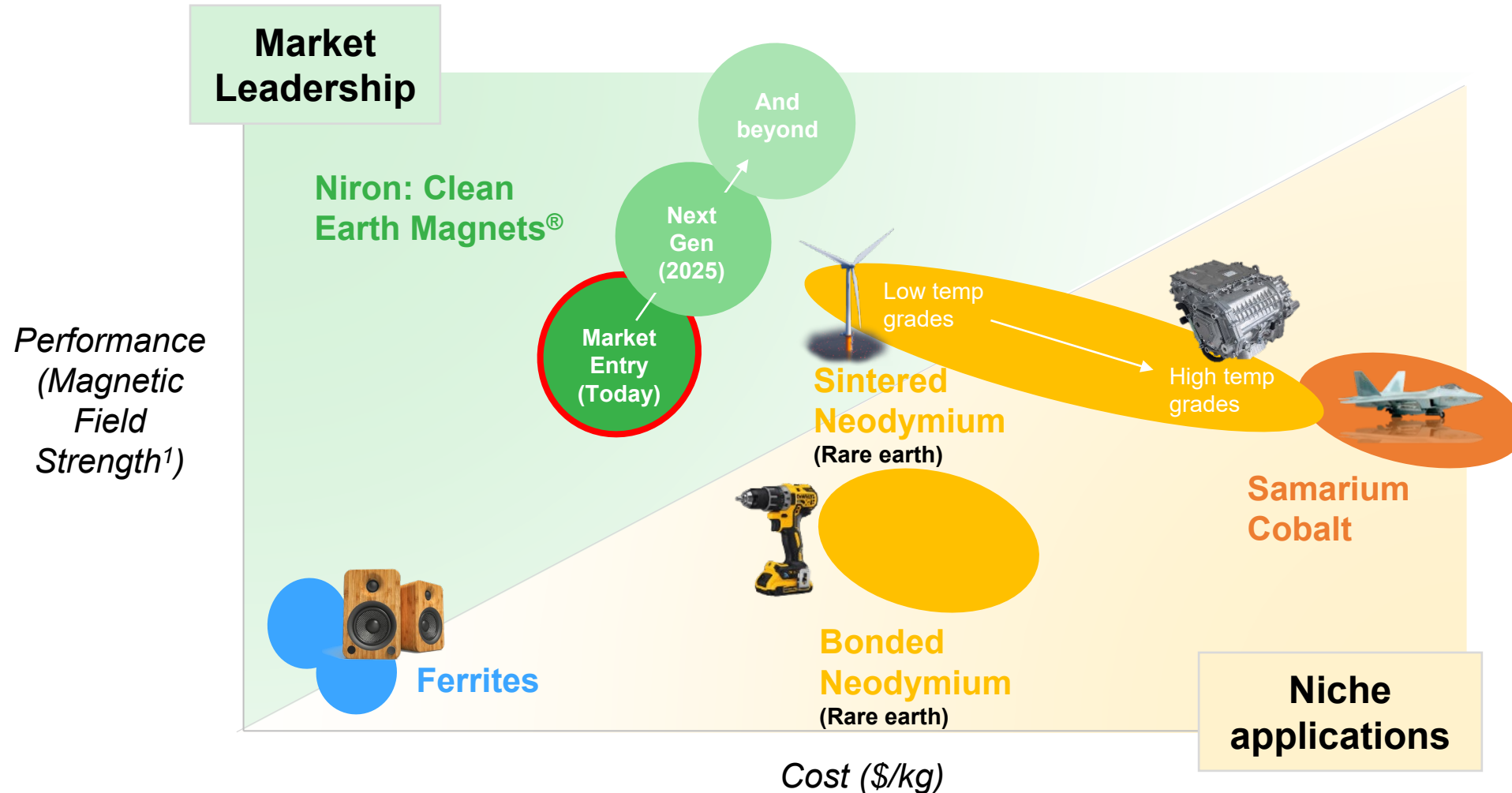


- ✓ Clean water
- ✓ Clean air
- ✓ Healthy communities
- ✓ Abated emissions

Per kg environmental impact comparison of bonded Clean Earth Magnet® vs. bonded rare earth magnet (Rare earths indexed to 100)



Market Entry Performance Reached



The Clean Earth Magnet®

¹Magnetic Field strength is measured in units of Gauss or Tesla. Higher field strength enables more power per unit mass or volume

Strong customer pull
with collaborations
across industries and
success leading to
major investment from
leading automotive &
electronics OEMs

Niron's active customer
pipeline represents

20%

of total global
NdFeB demand

Including publicly disclosed partnerships with...



*(Partner since 2020,
Investor since 2023)*



(Partner & Investor since 2023)



**Western
Digital.**

*(Partner & Investor
since 2021)*



(Partner since 2022)



**PREMIUM
SOUND SOLUTIONS**



(Partner & Investor since 2021) (Partner since 2022)

Building Industry Partnerships

Niron's Clean Earth Magnet[®] is coming to CES.

Visit Niron and ARPA-E in the DOE pavilion to hear a speaker made with the world's first powerful rare-earth-free permanent magnet.

Las Vegas | January 9 - 10, 2024 | Booth #10177



2024



The Clean Earth Magnet[®]

Recent Recognitions

TIME Best Invention Award



TIME

Niron's Clean Earth Magnets named a TIME Best Invention of 2023

[Link to Article](#)

Sustaining Sustainable Energy
Niron Magnetics Clean Earth Magnet

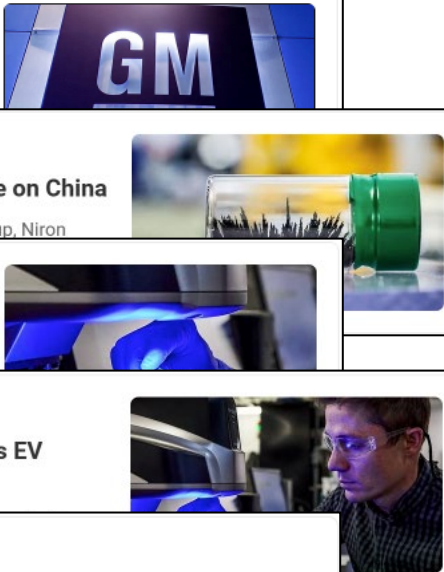
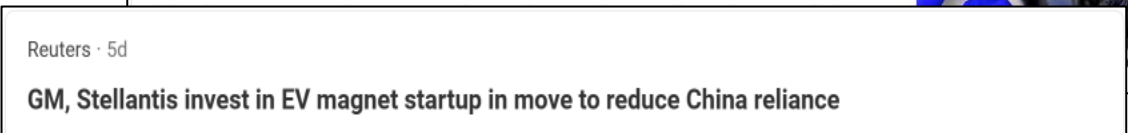
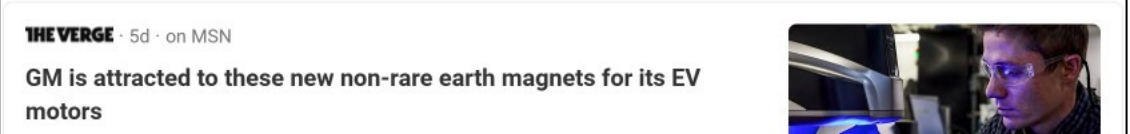
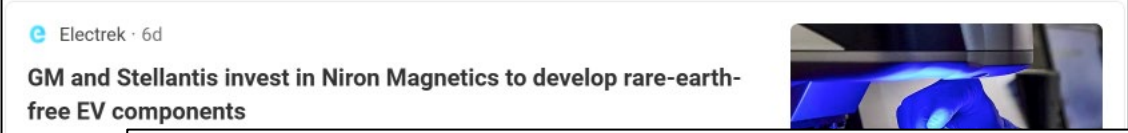

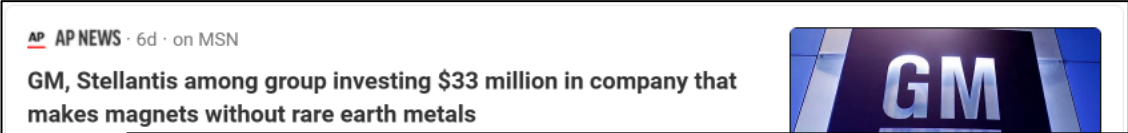


Local Life Changing Innovation

[Link to Video](#)

\$33M Fundraising Announcement

A few highlights of >170 articles



Links to Articles: [AP News](#), [CNN](#), [Electrek](#), [The Verge](#), [Reuters](#)



Our Vision

**Become the global leader in powerful,
rare earth-free permanent magnets**

**Creating a secure & reliable supply
chain for global electrification...all
while protecting the environment.**



Green materials for clean tech



Made in America



Innovation for electrification



Scaling production today