

SmFeN - A Shorter Path to Secure Magnet Material?

By Mark McPherson | Tengam Engineering



Samarium iron nitride deserves a closer look from the agencies and manufacturers investing in secure magnet supplies. SmFeN already exists as a commercial bonded magnet material, and injection molding provides an established route to finished components. For applications suited to those criteria, the development task can begin with an available material and a defined manufacturing process. That could shorten the path to a qualified product.

Domestic neodymium iron boron production and rare-earth-free alternatives both have a place in the effort to strengthen American manufacturing. SmFeN adds another option. The question is how quickly it can meet a specific requirement, what investment that would take, and which supply-chain gaps remain. Our work with Oak Ridge National Laboratory provides a concrete starting point for that discussion.

What is SmFeN

SmFeN is a permanent magnet material based on samarium, iron, and nitrogen. Samarium is a rare-earth element, so the material should never be described as rare-earth-free. Nichia's commercial anisotropic SmFeN materials do, however, avoid Lanthanides like neodymium as well as heavy rare-earth additions. They provide a different material choice for manufacturers seeking to diversify the inputs used in their magnets. [1]

In an injection molded bonded magnet, magnetic powder is mixed with a polymer that holds the finished part together. The polymer occupies space that otherwise could contain magnetic material, so the properties of the molded component differ from those of the powder. This distinction matters whenever someone compares a research result, a theoretical material limit, and a finished production magnet.

Commercial compounds are already available. Nichia also identifies a material with 0.85 T remanence as a prototype under development. That development is worth following, but an OEM should base a production program on the properties and availability of the grade it can actually procure and qualify. [1]

What does injection molding enable

Injection molding changes the shapes we can manufacture and the way a magnet can be incorporated into an assembly. Magnetic material can be molded into complex cavities or around inserts. In an appropriate rotor design, it can be molded directly into a lamination stack. Those possibilities allow an engineer to reconsider the space occupied by the magnets and the operations required to install them.

With anisotropic material, an applied magnetic field aligns the particles during molding. Tooling can be engineered to vary that orientation within the part, subject to the field and processing conditions that can actually be achieved. The component is subsequently magnetized to establish its final magnetic state. Alignment during molding and final magnetization are separate operations, and both require engineering.

At Tengam, this is where manufacturing experience becomes part of magnetic design. A simulation may specify an attractive magnetic orientation, but the tooling must produce it while the material flows, fills the cavity, and solidifies. The practical design has to account for that process from the beginning.

Where can those capabilities matter

Motors and sensors are natural candidates, particularly where geometry, assembly, and the placement of magnetic flux influence the finished product. The relevant comparison is the performance of the component or machine over its operating conditions. A magnet datasheet alone cannot establish that result.

One study, with ORNL, focused on a 380 kW brushless interior permanent magnet motor with an approximately 700 Nm torque benchmark was evaluated using injection-molded anisotropic

SmFeN in place of the original high-grade sintered NdFeB magnet design. The stator architecture was retained, while the rotor was redesigned around the molded material. The analysis predicted approximately the same torque in the same overall motor volume. [2]

The SmFeN design used approximately 1.95 times the magnet volume. Because its density was lower, the increase in magnet mass was approximately 30 percent. These are magnet quantities, not increases in the total motor's volume or mass. They illustrate why the geometry and density of the finished magnetic component must be considered alongside its magnetic properties. [2]

An especially useful result concerned manufacturing. The initially optimized orientation produced a calculated torque of 700.7 Nm. Using the orientation assessed as achievable through the anisotropic molding process produced a calculated 699.4 Nm, a difference of about 0.18 percent. That close agreement supports taking the design into physical validation. It does not replace that testing. [2]

There is a separate experimental precedent. In a 2025 Nichia–Akita University study, SmFeN magnets were injection molded into a rotor core, and measured induced voltage closely matched the simulation. A simulation comparison with the studied sintered NdFeB motor design also predicted comparable torque. Together, these results support evaluating integrated molding in specific motor architectures. [3]

What are the limits

SmFeN will not suit every application. Bonded material generally offers lower remanence than high-grade sintered NdFeB. A design may need more magnetic volume, and the rotor may not have room for it. Temperature capability depends on the magnetic grade, polymer, geometry, and operating conditions. Corrosion performance likewise belongs to the specific powder treatment and finished compound, rather than to the material name alone.

In the example above, ORNL/Tengam analysis did identify a performance tradeoff. Average modeled drive-cycle efficiency was 89.4 percent for the SmFeN design and 91.2 percent for the NdFeB baseline, although both approached 97 percent peak efficiency. The lower average efficiency must remain part of the evaluation. A program would need to determine how much further optimization could improve it and whether the resulting machine meets the intended duty cycle. [2]

The study predicted greater resistance to irreversible demagnetization under its modeled worst-case short-circuit conditions. The SmFeN designs retained approximately 0.90 to 0.92 per-unit torque, compared with approximately 0.50 for the NdFeB baseline. That is a result for the studied designs and fault conditions. Physical testing is needed to establish the behavior of manufactured rotors. [2]

These findings describe an engineering opportunity with identifiable work remaining. They do not establish a universally interchangeable material or a finished, qualified 380 kW motor. Qualification must demonstrate repeatable magnetic properties, mechanical integrity, and performance over the application's life.

What would American manufacturing need to capitalize on it

The shortest development path depends on where a program starts. With an available compound from a qualified allied supplier, a domestic manufacturer could focus on tooling, processing, and component qualification. Establishing domestic powder production is a larger task, requiring control over synthesis, particle characteristics, protection against oxidation, and compounding. A domestic molding operation supplied by imported powder is useful capacity, but it is not a wholly domestic supply chain.

Samarium metal deserves attention within that effort, although its availability alone does not establish a shorter route. There is also another pathway worth examining. Published reduction–diffusion work demonstrates formation of samarium–iron compounds from samarium oxide and iron using a reducing agent. The alloy precursor can then be nitrogenated through an appropriate process to produce SmFeN. Such routes can avoid a separately supplied samarium metal feedstock. [4, 5]

The strategic implication is that agencies should compare oxide-based and metal-based routes against the intended product. The comparison needs actual feedstock availability, process access, yield, cost, and production capacity. A documented chemical route still requires an industrial process capable of delivering consistent magnet powder.

Defense investment in the samarium bottleneck is already occurring. In March 2026, REalloys announced a Defense Logistics Agency contract to advance and scale metallothermal production of samarium and gadolinium metals. That is a relevant upstream development, although the announcement does not by itself establish commercial capacity available to a SmFeN program. [6]

For DOE, DoW, and OEMs, a focused program could connect a secure feedstock source and powder producer with an experienced magnet molder and a customer willing to qualify a defined component. The ORNL/Tengam motor study offers one candidate for physical validation. The program should measure manufacturing yield and cost as well as motor performance, and compare the time and investment required with the alternatives.

SmFeN deserves a place in the investment decisions because part of the development work has already been done. Commercial material exists, molding expertise exists, and motor studies provide designs that can be tested. Securing the upstream supply and proving repeatable production would determine how much of that head start can become a practical advantage for American manufacturers.

Sources and editorial verification

[1] Nichia Corporation, Magnetic Materials SmFeN. Commercial compound information and the 0.85 T prototype designation. [Source](#)

[2] ORNL/Tengam project analysis, as recorded in Tengam's existing article draft and project discussions. Confirm the motor specifications, volume and mass comparisons, orientation comparison, efficiencies, and fault results against the original ORNL presentation before publication.

[3] R. Yoshida et al., Development of Injection Molded IPMSM with Sm-Fe-N Bonded Magnets, Transactions of the Magnetics Society of Japan Special Issues, volume 9, pages 77–81, 2025. Measured induced voltage and simulated torque comparison. [Source](#)

[4] T. Tanabe et al., Formation of Sm–Fe Intermetallic Compounds by the Reduction-Diffusion Process with CaH₂, Materials Transactions JIM, volume 33, pages 1163–1169, 1992. [Source](#)

[5] Magnetic properties and microstructure of Ti-doped Sm-Fe-N synthesized by reduction diffusion process, Journal of Magnetism and Magnetic Materials, 2024. Research evidence for an oxide-based route; not a claim of a qualified U.S. commercial process. [Source](#)

[6] REalloys company announcement, March 2, 2026, reporting a DLA contract for samarium and gadolinium metal process development and scale-up. [Source](#)