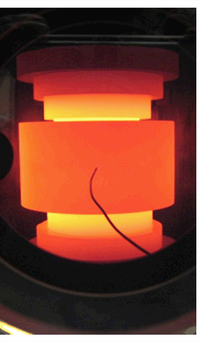

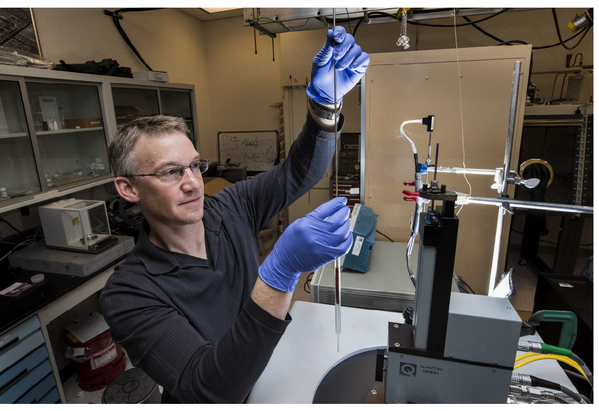

Sandia National Laboratories

Exceptional service in the national interest

A revolutionary new soft magnetic material: γ'-Fe_4N

SAND2016-12036C

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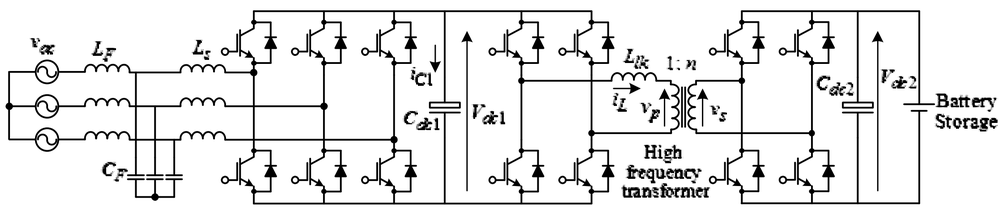
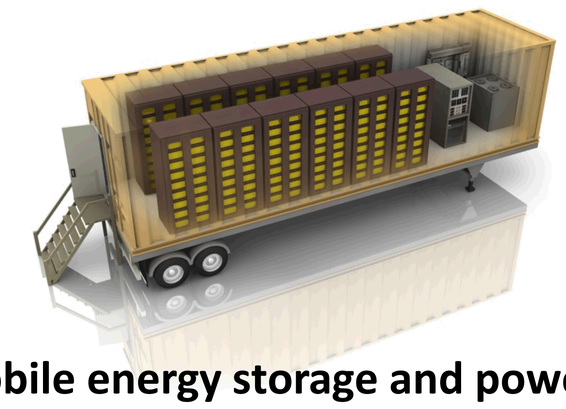
The new concept of a high frequency DC link would increase the power density and performance of power conversion systems (PCSs). This would be an enabling technology for mobile energy storage and PCSs, which can fit inside a single ISO container, and would make it more cost effective to rapidly deploy power grid systems in even the most remote locations. Such a goal requires the identification and synthesis of new advanced magnetic core materials that can perform at high frequencies and elevated temperatures. The γ' phase of iron nitride, fabricated as a bulk material for the first time ever, will lead to lighter, smaller, cheaper and better-performing high-frequency transformers required for agile energy storage systems in forward deployed locations.

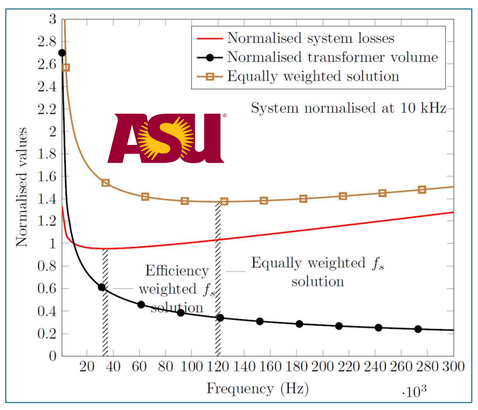
Motivation



High frequency link power conversion system

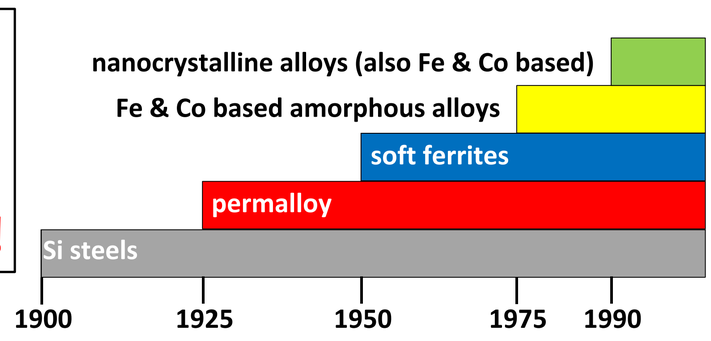


Mobile energy storage and power conversion systems (PCS)



Optimum switching frequency with SiC MOSFETs

However, new soft magnetic materials are required to enable high frequency link converters!



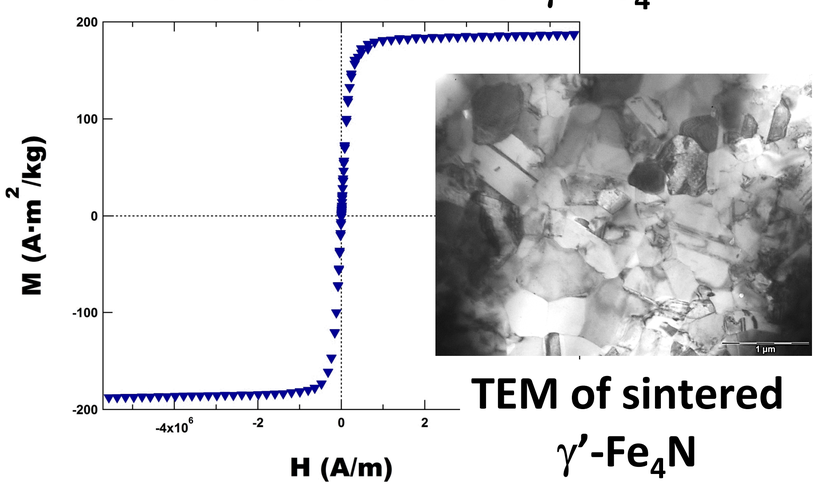
History of soft magnetic material development

adapted from: L.A. Dobrzański, M. Drak, B. Ziębowicz, Materials with specific magnetic properties, Journal of Achievements in Materials and Manufacturing Eng., 17, 37 (2006).

γ'-Fe_4N can meet all requirements of high frequency power electronics!

Magnetic Material	J_s (T)	$\rho(\mu\Omega\cdot m)$	Cost
VITROPERM (Vacuumschmelze)	1.20	1.15	High
Metglas 2605SC	1.60	1.37	High
Ferrite (Fexxocube)	0.52	$5x10^6$	Low
Si steel	1.87	0.05	Low
γ'-Fe_4N	1.89	> 200	Low

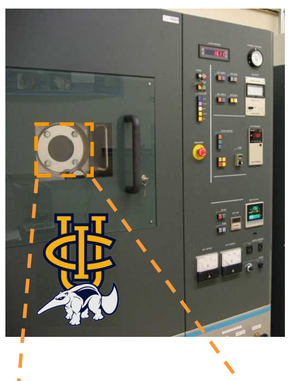
Characterization of γ'-Fe_4N

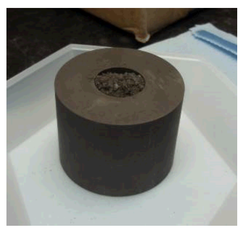


TEM of sintered γ'-Fe_4N

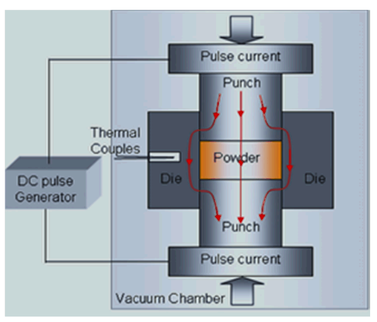
Spark plasma sintering (SPS) of γ'-Fe_4N

SPS Model: SPS-825S Dr. Sinter® at UCI

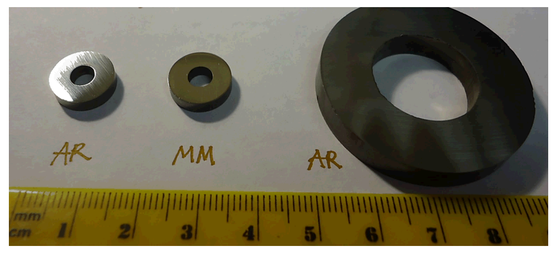




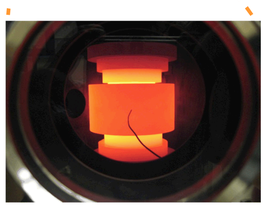
Starting Powder in Die



First ever bulk γ'-Fe_4N!



Net-shaped and sintered toroids (no machining required)



SPS Chamber

Patents:

T. C. Monson, K. Waldrip, "Electrochemical Solution Growth of Magnetic Nitrides," U.S. Patent Application # 14/531,075.

T. C. Monson, E. J. Lavernia, B. Zheng, Y. Zhou, "Method to Synthesize Nanocrystalline Iron Nitride," U.S. Patent Application # 15/002,220

Presentations:

MMM-Intermag, Advances in Magnetics, Magnetics 2015, IECON 2014

Acknowledgements

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