Advanced Soft Magnets and Magnetocaloric Materials: An FMD Symposium in Honor of Victorino Franco: Magnetocaloric Materials and Processing for Applications
Sponsored by: TMS Functional Materials Division, TMS: Magnetic Materials Committee
Program Organizers: Daniel Salazar, BCMaterials; Alex Leary, NASA Glenn Research Center

Monday 2:00 PM
March 4, 2024
Room: Bayhill 22
Location: Hyatt

Session Chair: Jia Yan Law, University of Seville

2:00 PM Invited
Magnetocaloric Materials for the Liquefaction of Hhydrogen: *Tino Gottschall*[1]; Catalina Salazar-Mejía[1]; Timo Niehoff[1]; Marc Straßheim[1]; Eduard Bykov[1]; Yurii Skourski[1]; Jochen Wosnitza[1]; [1]Helmholtz-Zentrum Dresden-Rossendorf

Magnetic cooling is a refrigeration technique that is based on the so-called magnetocaloric effect, the change of temperature caused by a magnetic field. It can be utilized to construct environmentally friendly cooling devices, air conditioners, and heat pumps. Originally, magnetic cooling was used to achieve ultra-low temperatures by adiabatic demagnetization of magnetic salts. Recently, low temperatures have once again become the focus of attention as an area of application for magnetocaloric cooling namely for hydrogen liquefaction. In this work, we would like to discuss our current progress for the creation of a materials library for cryogenic applications. The basis for this is our characterization infrastructure for materials research at the Dresden High Magnetic Field Laboratory in static and pulsed fields. With this, we aim to understand these materials better to further optimize their magnetic cooling performance near the boiling temperature of hydrogen.

2:30 PM Invited
Assessing Rapid Solidification Processing to Produce Magnetocaloric Alloys for Gas Liquefaction: *Pablo Alvarez Alonso*[1]; Jonathan Zamora[2]; César Fidel Sánchez-Valdés[3]; Jose Luis Sánchez-Llamazares[2]; [1]Universidad de Oviedo; [2]Instituto Potosino de Investigación Científica y Tecnológica; [3]Universidad Autónoma de Ciudad Juárez

Magnetic liquefaction, based on the magnetocaloric effect (MC), is an emerging technology for improving energy efficiency in gas liquefaction. Extensive studies have been conducted on the MC properties of many magnetic materials families to identify MC refrigerants that can potentially be used in different cooling stages of gas liquefiers. The main technological target in this field is the development of liquefaction systems for specific gases such as natural gas (liquefaction temperature at 111 K), nitrogen (77 K), hydrogen (20 K), and He (4.2 K)). This study focuses on the synthesis and characterization of melt-spun ribbons made from intermetallic compounds with magnetic phase transitions near gas liquefaction temperatures. Comparative analyses with bulk counterparts highlight the influence of ribbon microstructure on magnetic properties. This research contributes to optimizing the performance of melt-spun ribbons in practical applications, advancing the field of magnetic liquefaction for efficient gas liquefaction systems.

3:00 PM Invited
Advances in Additive Manufacturing of Metamagnetic Shape Memory Alloys for Magnetocaloric Applications: *Daniel Salazar*[1]; [1]BCMaterials

The current social challenges demand new energy-efficient technologies and the ability of obtaining 3D

structures in a green and a cost-effective way. Recent progress in caloric materials (magneto- or elasto-caloric) as part of the next generation energy saving devices open new possibilities to explore future technological developments in additive manufacturing. In this way. metamagnetic shape memory alloys are promising candidates for magnetic refrigeration due to their high entropy change around the first-order martensitic transformation, but their crystalline phase is unstable at high temperatures. In this work, we develop original inks and pastes to be implemented in extrusion printing techniques at room temperature to fabricate complex 3D structures using high-performance NiMnSn-based magnetocaloric powders. Cellulose and water were used as green matrix and solvent, respectively. Ink containing more than 85 wt.% of powder was used to print a maximum number of layers of about 250.

3:30 PM Break

3:50 PM Invited
Advancements in the Development of Magnetic Refrigerators Operating at Near Room Temperature:
Jader Barbosa[1]; [1]Universidade Federal de Santa Catarina

The magnetocaloric effect (MCE) refers to the thermal response of a magnetic substance to a changing magnetic field. Magnetic refrigeration (MR) utilizes this effect in a thermodynamic cycle to transfer heat from a low-temperature source to a higher-temperature sink. MR offers advantages like MCE reversibility in certain materials, use of permanent magnets for magnetization work, and absence of hazardous substances. This paper presents recent findings on the development, implementation, and evaluation of two MR prototypes. The first is a compact wine cooler, while the second is a TRL-6 9000-BTU/h magnetic air conditioner. The key aspects are: 1. Advancement of AI-based methodologies for designing and optimizing magnetic circuit-AMR assemblies with high precision. 2. Optimization and integration of supplementary subsystems like heat exchangers, insulated cabinets, and hydraulic management systems.3. Establishment of standardized thermodynamic performance evaluation criteria and test procedures for magnetic refrigerators, inspired by existing standards for conventional systems.

4:20 PM
Effective Evaluation Setups for the Real Cooling Performance of Magnetocaloric Materials:
Jong-Woo Kim[1]; Ki Hoon Kang[1]; A Young Lee[1]; Kookchae Chung[1]; [1]Korea Institute of Materials Science

Magnetocaloric properties are generally characterized by thermodynamic calculations with well-known Maxwell relation. However, with this calculation, some crucial factors for the magnetic cooling applications, for instance, magnetic thermal hysteresis, heat conductivity, corrosion resistance, etc. cannot be properly considered. In order to study materials that can be used in the magnetic cooling system, the real cooling performance that can only be realized when the material is placed into the cooling system with cycle process should be investigated. For this purpose, the evaluation setups for the magnetic cooling performance in cycle process have been established. Through these evaluation methods, the results on whether the magnetocaloric materials can actually have better magnetic cooling performance in comparison with Gd in the magnetic cooling applications could be confirmed.In this presentation, the direct measurement setups as an effective evaluation method of magnetocaloric properties of Mn-Fe-P-Si and La(Fe,Si)13 in cyclic process will be discussed in detail.