マテリアル先端リサーチインフラ利用報告書
ARIM User's Report

【Release：2024.07.25】　【Update：2024.06.24】

課題データ / Project Data

課題番号 Project Issue Number	23NU0214
利用課題名 Title	Elucidation of Heat Transfer Characteristics of Magnetic Refrigeration System
利用した実施機関 Support Institute	名古屋大学 / Nagoya Univ.
機関外・機関内の利用 External or Internal Use	内部利用（ARIM事業参画者以外）/Internal Use (by non ARIM members)
横断技術領域 Cross-Technology Area	加工・デバイスプロセス/Nanofabrication
重要技術領域 Important Technology Area	革新的なエネルギー変換を可能とするマテリアル/Materials enabling innovative energy conversion
キーワード Keywords	熱電材料/ Thermoelectric material,蒸着・成膜/ Vapor deposition/film formation, スパッタリング/ Sputtering,光リソグラフィ / Photolithgraphy,環境発電/ Energy Harvesting

利用者と利用形態 / User and Support Type

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ARIM実施機関支援担当者 Names of Collaborators in The Hub and Spoke Institutes	
利用形態 Support Type	機器利用/Equipment Utilization

利用した主な設備 / Equipment Used in This Project

利用した主な設備 Equipment ID & Name	NU-245：スパッタリング装置 NU-208：両面露光用マスクアライナ

報告書データ / Report

概要（目的・用途・実施内容） Abstract (Aim, Use Applications and Contents)	This study focus on the analysis of the heat transfer characteristics of a magnetic refrigeration system, a promising technology for energy-efficient cooling. The magnetic refrigeration system employs the magnetocaloric effect, where the temperature of a magnetic material changes in response to a varying magnetic field. The heat transfer mechanisms is investigated, including conduction, convection, and adiabatic demagnetization, that govern the performance of the system. The impact of key parameters such as magnetic field strength, magnetocaloric material properties, and heat exchanger design on the overall efficiency and cooling capacity is thoroughly explored. Through experimental and numerical methods, we elucidate the thermal behavior of the system under various operating conditions. This study aid into optimizing magnetic refrigeration systems for practical applications, offering a pathway towards environmentally friendly and energy-efficient cooling solutions.
実験 Experimental	In the experimental investigation of the magnetic refrigeration system, the NU-245 sputtering system and the NU-208 mask aligner were used to create an Au-micro heater structure on a SiO_2 substrate. This Au-micro heater was then utilized to measure the thermophysical properties of heat transfer fluids, such as thermal conductivity and heat capacity by analyzing the temperature response of the micro heater when exposed to the fluid. The fabrication process involved the following steps. A SOi2 substrate was cleaned to ensure proper adhesion and to prevent contamination during the fabrication process. A photoresist layer was then spin-coated onto the substrate to define the micro heater pattern. The photoresist was exposed to UV light through a mask designed with the micro heater pattern using the NU-208 mask aligner, and the exposed areas were developed to create the desired heater structure. Subsequently, a thin layer of Cr and Au (10+40 nm) was deposited over the patterned substrate using the NU-245 sputtering system, ensuring a uniform and adherent gold layer on the exposed areas. Finally, the photoresist and excess metallic layer were removed through the lift-off process, resulting in the Au-micro heater structure on the substrate. For evaluation, a prototype was constructed using gadolinium as the magnetocaloric material, known for its significant temperature change under magnetic field variation. The experimental setup included a magnetic field source, a regenerative chamber filled with gadolinium particles, and a heat exchange mechanism. Thermal camera and thermocouples were utilized to measure the temperature distribution within the system. The magnetic field strength was systematically varied, and the resulting temperature changes in the magnetocaloric material were recorded. The heat transfer characteristics, such as the cooling capacity and coefficient of performance (COP), were evaluated under different operating conditions.

結果と考察 Results and Discussion	The experimental results demonstrated a significant temperature change in the gadolinium-based magnetocaloric material upon the application of a magnetic field, confirming the potential of magnetic refrigeration for cooling applications. The maximum temperature span achieved was observed to be strongly dependent on the magnetic field strength, with higher fields resulting in larger temperature changes. The cooling capacity of the system was evaluated under various operating conditions, and it was found that the efficiency of the heat exchange process played a crucial role in determining the overall performance of the magnetic refrigeration system.Discussions focused on the relationship between the magnetic field strength and the temperature change in the magnetocaloric material, highlighting the importance of optimizing the magnetic field distribution for improved heat transfer characteristics. The impact of the regenerative heat exchanger design, including the size and arrangement of the magnetocaloric material particles, on the system's performance was also examined. The experimental findings were compared with theoretical models, showing good agreement and validating the predictive capability of the models. The study concluded with suggestions for future research, such as exploring alternative magnetocaloric materials and enhancing the heat exchange mechanism, to further advance the development of efficient and environmentally friendly magnetic refrigeration systems.
図・表・数式 Figures, Tables and Equations	
その他・特記事項（参考文献・謝辞等） Remarks(References and Acknowledgements)	

成果発表・成果利用 / Publication and Patents

DOI（論文・プロシーディング） DOI (Publication and Proceedings)	
口頭発表、ポスター発表および、その他の論文 Oral Presentations etc.	
特許出願件数 Number of Patent Applications	0件
特許登録件数 Number of Registered Patents	0件