Alloy of Improved Magnetocaloric Effect for Magnetic Refrigeration Applications

1. Technology:

Energy-efficient and energy-harvesting materials are in high demand now than ever before. The existing technologies, based on vapor compression and expansion are highly energy-demanding, and in addition to that they contribute to greenhouse gases. Magnetic refrigeration is an alternative eco-friendly technology in contrast to compressor-based refrigeration. Magnetic refrigeration is an environmentally friendly technology rather than compressor-based refrigeration. The working cost is 20 % less, maintenance-free (because of no moving parts) in magnetic refrigeration, and Carnot's efficiency is about 60-70 % (higher) when compared to compressor-based one (40 %). Magnetic refrigeration works under the magnetocaloric effect (MCE) principle. The temperature of a magnetic material changes in response to an applied magnetic field. When a magnetic material is subjected to a magnetic field, its magnetic moments align with the field, resulting in a temperature rise. Conversely, when the magnetic field is removed, the material's magnetic moments become disordered, causing a decrease in temperature.

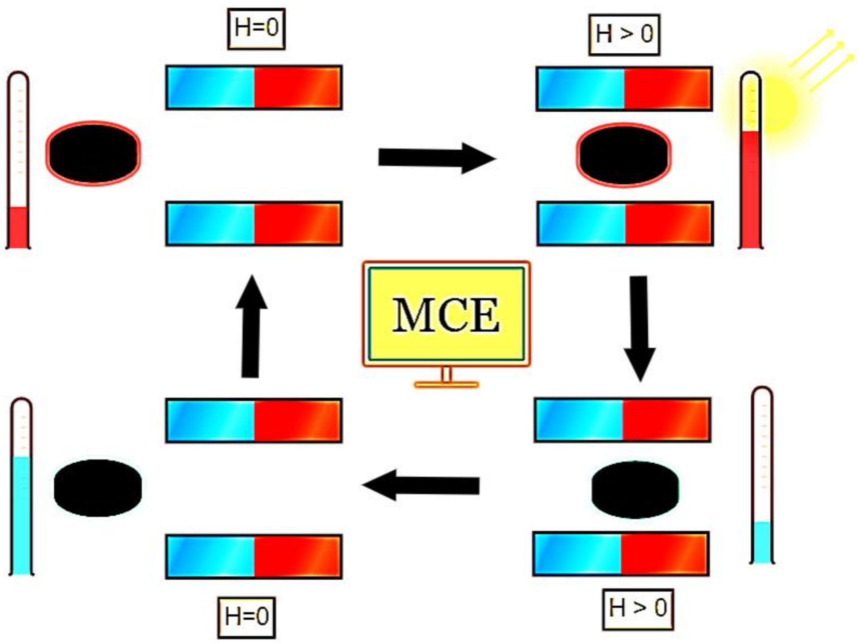

Fig. 1 Principle diagram of Magnetocaloric Effect (MCE)

2. Problem Addressed:

Research on Fe_2MnSb Heusler alloys for magnetic refrigeration has been limited, with most studies focusing on multicomponent Heusler alloys. Our study aims to address this gap in the literature by exploring the potential for achieving a large magnetocaloric effect using low-cost Fe_2MnSb alloys. The Fe_2MnSb system makes a promising candidate for various applications such as spintronic, sensors, and magnetocaloric applications where high magnetization, spin polarization, and structural and magnetic phase transition near room temperature are required.

The solution to the problem:

- ✓ The synthesized alloy is novel and has not been reported so far.
- ✓ The room temperature transition (260 K <T_c > 350 K) is achieved with no hysteresis loss.
- ✓ Second-order magnetic phase transition behavior.
- ✓ Significant relative cooling power (RCP) observed for magnetic refrigeration application successfully. The value is comparatively higher than the other Fe-based alloys.
- ✓ Our findings allowed us to identify the research gap and achieve a noteworthy magnetocaloric efficiency at room temperature.

3. Industrial Applications:

i. **Magnetic Refrigeration:** Magnetocaloric material (MCM)--based refrigerators can operate more efficiently and quietly than conventional systems, leading to energy savings and reduced noise pollution. MCMs can be used to cool large-scale processes, such as data centers and manufacturing facilities, where energy efficiency and reliability are critical.

ii. **Thermomagnetic Generator (TMG):** These materials can also be used in Thermomagnetic generators because of the room temperature T_c. MCMs can be used to recover waste heat from industrial processes and convert it into useful energy.

iii. **Magnetic Actuation:** MCMs can be used in various sensors and actuators, such as magnetic valves and switches.

iv. **Magnetic recording media:** Fe_2MnSb alloys have high magnetic anisotropy and low magnetic noise, making them suitable for use in hard disk drives, magnetic tapes, and other recording media.

4. Patent Application Number: 202441067434