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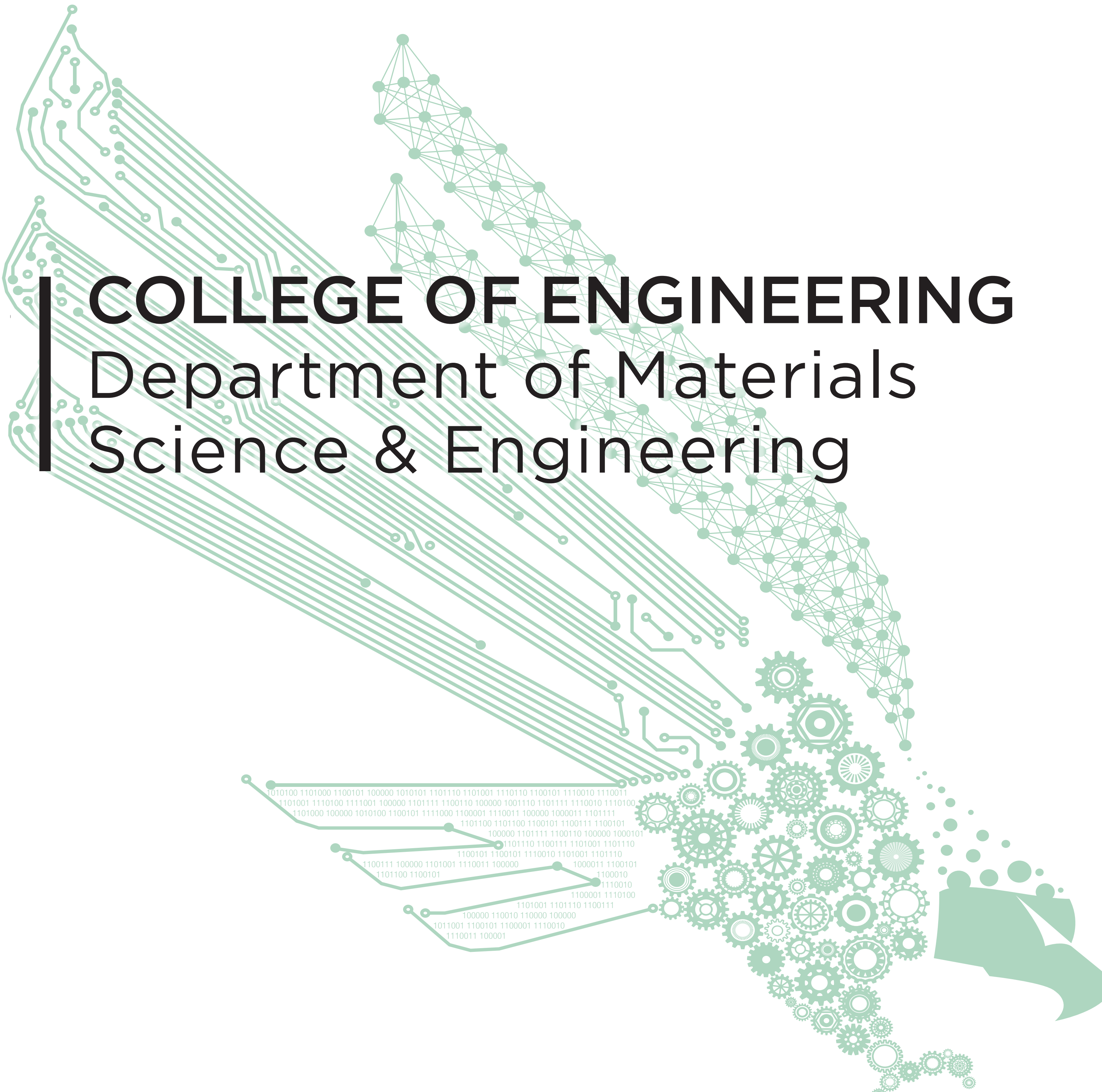

Senior Design Abstracts
Spring 2024

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Al-Ce Alloys

Team Members

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External Sponsors/Mentors

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Dr. Vijay Vasudevan
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Abstract

Al-Ce alloys are promising for high-temperature structural aerospace applications due to their thermal stability and low density. In this study, three Al-Ce eutectic compositions (Al-12Ce-3Mg-0.45Sc, Al-9Ce-3Mg-0.45Sc, and Al-12Ce-3Mg-1Er (wt. %)) are examined to evaluate their suitability for low-pressure compressor casings in gas turbines. The mechanical properties of these alloys were improved at both room and elevated temperatures through microstructure design and the use of additive friction stir deposition (AFSD). Magnesium, scandium, and erbium were selected as alloying elements for their strengthening capabilities in Al alloys. AFSD was employed to further refine the microstructure and ensure a uniform distribution of intermetallic particles. The study concluded that combining microstructure design with processing methods such as AFSD resulted in mechanical properties comparable to those of current state-of-the-art materials used in low-pressure compressor casings (LPCs).

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The Search for Better Elastocaloric Shape Memory Alloys for Near Room Temperature Cooling Devices

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Abstract

The rise in global demand for space cooling is leading to an increase in energy consumption and a rise in greenhouse gas emissions. These issues can be combatted by developing higher efficiency cooling technologies such as solid-state elastocaloric cooling. Elastocaloric cooling ranks amongst the most affordable and efficient cooling technologies, exploiting the heat exchange associated with phase transformations in shape memory alloys. Shape memory alloys are difficult to optimize for elastocaloric cooling because of the competition between thermal properties, the necessity for low transformation stress, and the targeted affordability. Our team synthesized, processed, and characterized affordable shape memory alloys with excellent characteristics for room temperature elastocaloric cooling. The alloys were melted in a vacuum arc melter and heat treated in a high temperature furnace. Thermal analysis of the alloys was performed via differential scanning calorimetry (DSC), microstructural examinations were carried out using scanning electron microscopy (SEM), and mechanical properties were evaluated through compression testing.

We would like to thank graduate students Faith Gantz and Gerardo Gamboa for their assistance with characterization.

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Low Energy Alloy Production: Rotary Hydrogen Furnace to Reduce Iron Oxide.

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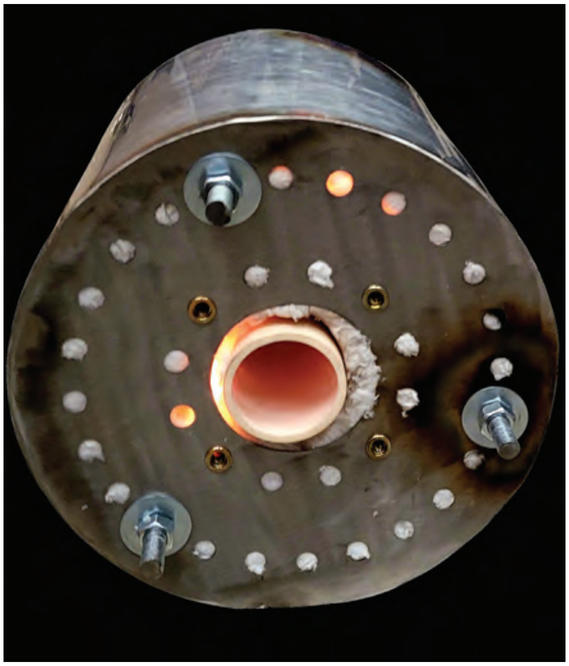
Abstract

The Low-energy Efficient Alloy Production System (LEAPS) was designed to reduce both terrestrial and lunar ores to produce metal powders using hydrogen gas. This was obtained through alkaline electrolysis of water, creating a self-sustaining system. The proposed lunar design is heated by concentrated solar thermal energy, however, due to time, scale, and resource limitations, only the terrestrial design was constructed. Both the terrestrial and lunar designs use a rotary kiln style furnace as opposed to the traditional fluidized bed reactor, eliminating the hydrogen required by 30%, as well as eliminating the energy needed for gas preheating. Ilmenite ($FeTiO_3$), Chromite ($FeCr_2O_4$), and lunar regolith simulant powders were characterized by Energy-dispersive X-ray spectroscopy (EDX) before and after reduction in the furnace to measure the percent metalization of the ore, with an expected minimum metalization of 20% to show concept feasibility.



The LEAP team would like to acknowledge and thank the Advanced Material and Manufacturing Processes Institute and Richard Brannock.

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