UT AUSTIN PORTUGAL ANNUAL CONFERENCE 2023
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Tailoring Thermomagnetic Properties of Co_2FeAl/(W,Ti) Heterostructures for Advanced Energy Conversion Devices

Nanotechnologies

Giorgia Siqueira[1], David Baptista[1], Cláudia Lopes[1,2] , Marcio A. Correa[1,3], Filipe Vaz[1,2] , and Armando Ferreira[1]

CONTEXT

Developing clean and efficient energy sources and electronic devices is vital for addressing environmental and energy challenges. Thermoelectric generation, which converts heat into electricity, holds significant promise.

This study investigates the impact of non-magnetic cap layer thickness on Co_2FeAl/NM (NM = W, Ti) heterostructures, focusing on the Longitudinal Spin Seebeck Effect (LSSE) and the Anomalous Nernst Effect (ANE). The choice of Co_2FeAl (CFA), a ferromagnetic material with tunable magnetic anisotropy, is crucial for spin-polarized current generation. Non-magnetic cap layers like W and Ti affect protection, hardness, and electrical characteristics. These findings advance our understanding of thermoelectric systems for enhanced efficiency.

THERMOMAGNETIC CHARACTERIZATION (ANE)

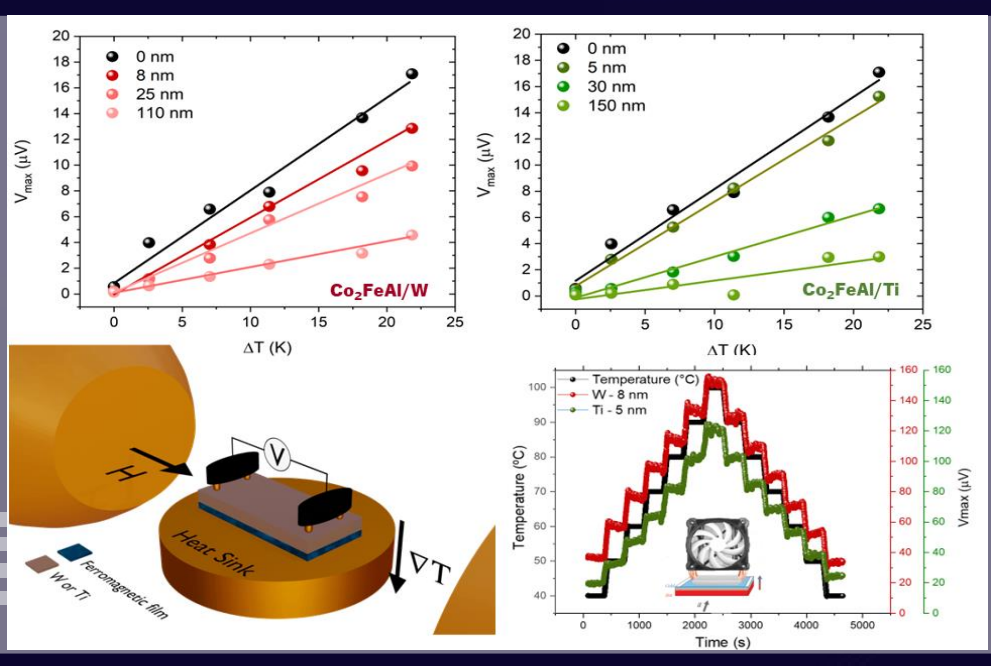
The thermomagnetic behavior of CFA films with varying non-magnetic metal thicknesses (W, Ti) was examined.

The results indicated that CFA films consistently exhibited ANE voltages, regardless of the presence of NM materials. However, the CFA/W and CFA/Ti samples displayed reduced ANE signals compared to pure CFA samples, measuring 12 μV, 15 μV, and 17 μV, respectively. The presence of the W layer introduced antiferromagnetic exchange coupling, resulting in an increased coercivity (from 40 Oe to approximately 50 Oe) and a diminished thermomagnetic response.

These results enabled the creation of a prototype that allowed us to assess the robustness of the optimized CFA/(W,Ti) heterostructures.

PROOF OF CONCEPT

- The thermomagnetic signal acquired using an ATmega328P microcontroller.
- The cooler system - recycled a commercial laptop cooler.
- The temperature was simulated in a controlled furnace Linkam model TMH 460.
- The external magnetic field (500 Oe) was maintained constant with two magnets



CONCLUSIONS

- Choosing a thinner NM cap layer affects thermomagnetic signals in both heterostructure types. Co_2FeAl/W and Co_2FeAl/Ti samples showed lower ANE voltages than Co_2FeAl thin film.
- Thinner NM layers, despite reducing thermoelectric signals, are preferable as they safeguard the FM layer from oxidation while preserving thermoelectric efficiency.

[1]Physics Centre of Minho and Porto Universities (CF-UM-UP), University of Minho, 4710057, Portugal;
[2]LaPMET - Laboratory of Physics for Materials and Emergent Technologies, University of Minho, 4710-057, Portugal;
[3]Physics Department, Federal University of Rio Grande do Norte, 59078-900 Natal, RN, Brazil

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