Synthesis and Characterization of A-site and B-site Disordered High-Entropy Perovskites

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Introduction

Entropy-stabilized oxides are a new class of ceramic material inspired by high-entropy alloys. In entropy-stabilized oxides, many metallic elements in approximately equal amounts occupy one lattice site. The large number of atom types present in the crystal results in a high degree of disorder in the material. The purpose of this study was to determine if a single-phase samples of two entropy-stabilized oxides could be successfully created through solid-state synthesis. The first of these materials - $(Gd_{0.2}La_{0.2}Nd_{0.2}Sm_{0.2}Y_{0.2})MnO_3$ - has has 5 A-site elements creating a high degree of disorder. The second of these materials - $La(Co_{0.2}Cr_{0.2}Fe_{0.2}Mn_{0.2}Ni_{0.2})O_3$ - has 5 B-site elements creating a high degree of disorder. Successful synthesis of these two oxides proves that both sites of the perovskite structure can be used to create high-entropy oxides.

Experimental

Perovskite samples were obtained using solid-state synthesis. Stoichiometric ratios of the appropriate metal oxide powders were combined, ball milled for 30 minutes, pressed into 1/2" pellets, calcined at 950ºC for 10 hours, reground, repressed, and then sintered at 1250ºC for 10 hrs. The resultant pellet was ground into a powder and characterized using x-ray diffraction and scanning electron microscopy.

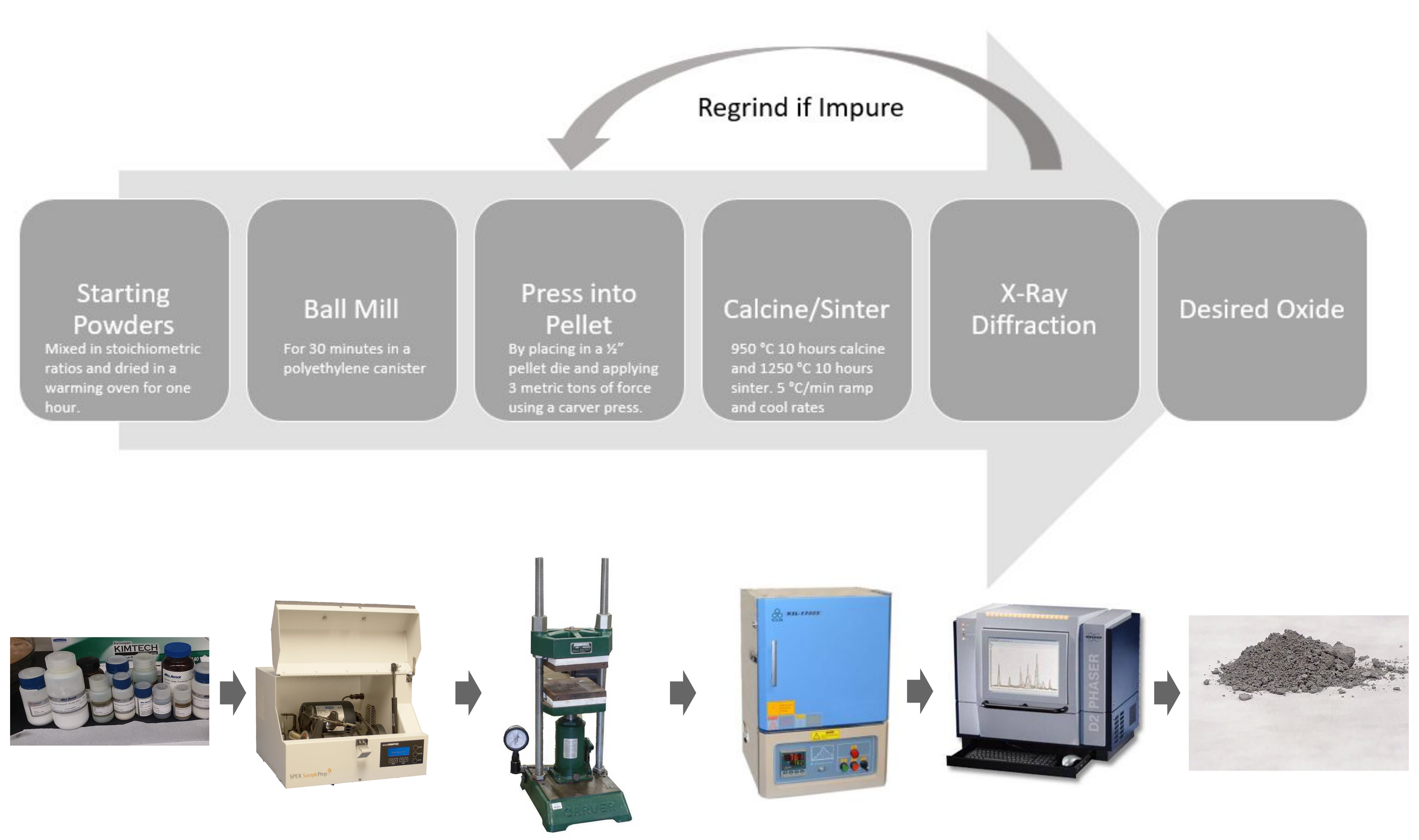


Figure 1. Diagram of Synthesis Process.

Results

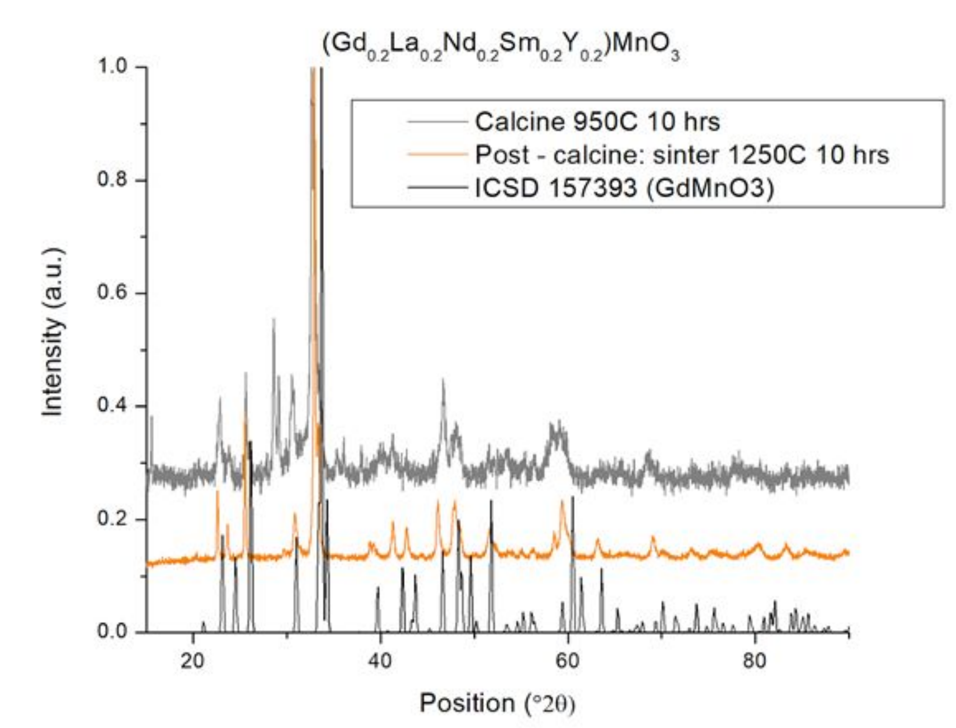


Figure 2. XRD of (GdLaNdSmY)MnO3 plotted against ICSD 157393 [2].

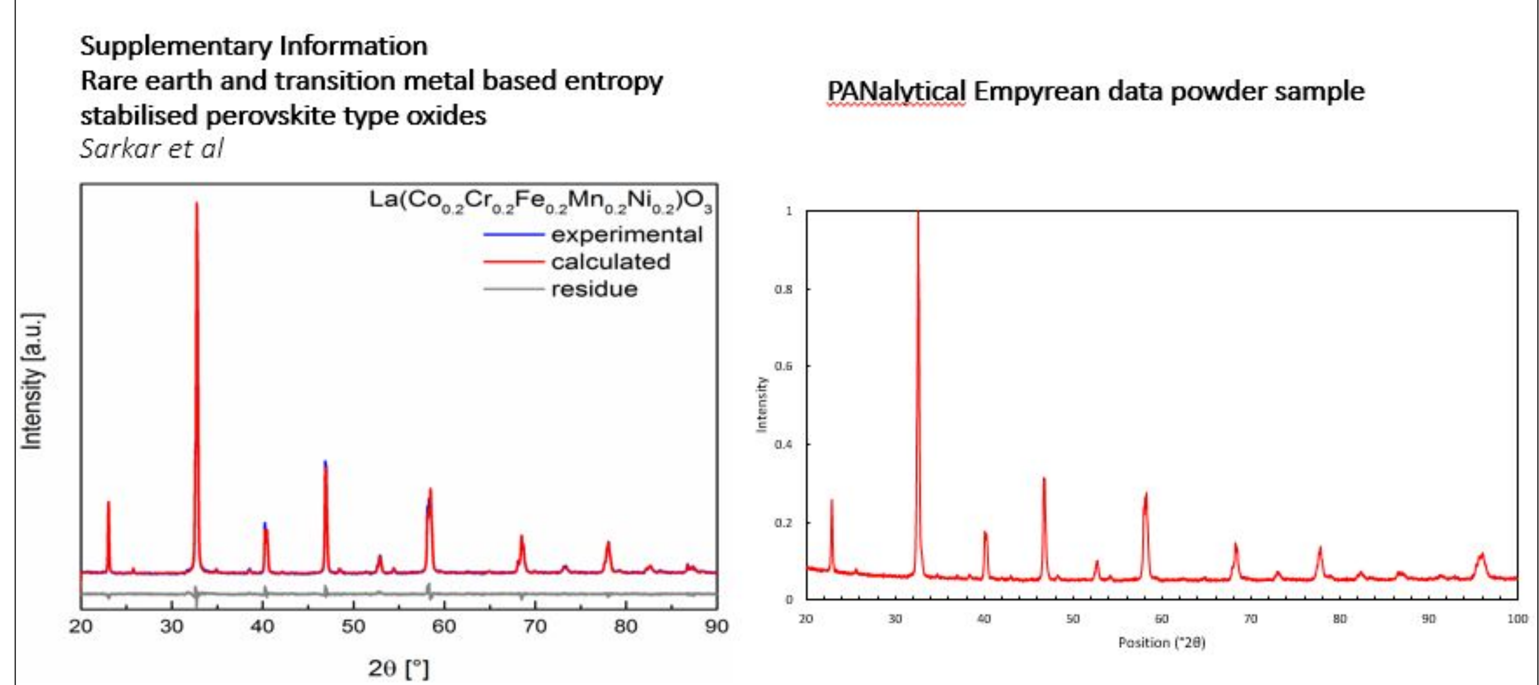


Figure 3. XRD data for La(CoCrFeMnNi)O3 compared to data from Sakar et al [3].

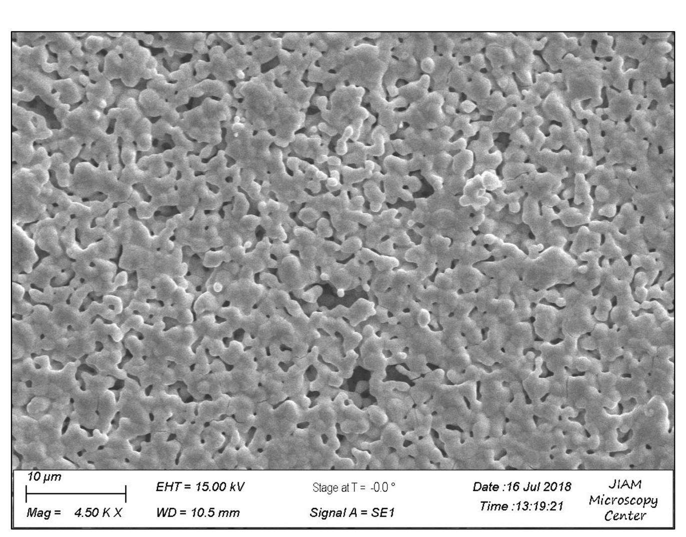


Figure 4. SEM image (GdLaNdSmY)MnO3. Magnification: 4,500x.

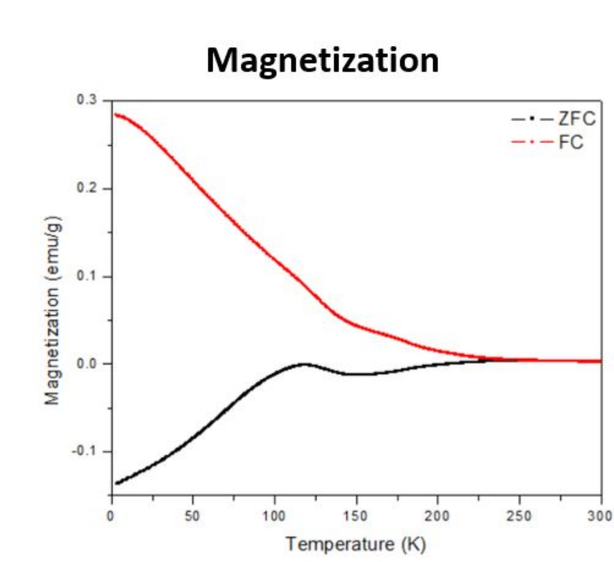
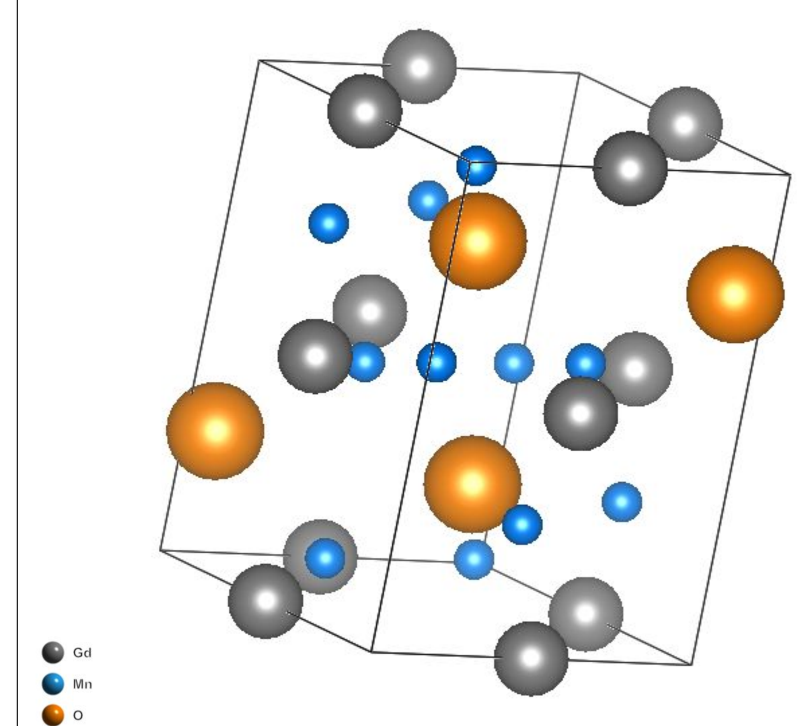


Figure 5. Magnetization data for La(CoCrFeMnNi)O3

Conclusion

X-ray diffraction and scanning electron microscopy confirm that single-phase samples of both perovskites were successfully synthesized through the method of solid state synthesis. The XRD scan of the sintered $(Gd_{0.2}La_{0.2}Nd_{0.2}Sm_{0.2}Y_{0.2})MnO_3$ shows that it is forming a single-phase orthorhombic perovskite crystal structure similar to $GdMnO_3$. The XRD scan of the sintered $La(Co_{0.2}Cr_{0.2}Fe_{0.2}Mn_{0.2}Ni_{0.2})O_3$ is very simlar to the XRD scan of the same material that appeared in the Sakar et al paper [3]. These results prove that a high-entropy perovskite can be successfully synthesized by creating disorder on either the A-site or B-site.

Future Work



Future research should investigate the properties of these new materials in order to determine potential applications. Future research within the Keppens group will attempt to determine if these perovskites have desirable properties for dielectric applications.

Figure 6. Crystal structure of (Gd)MnO3.

Acknowledgements:

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References:
[1] **WITTE, R., SAKAR, A., KRUK, R., EGGERT, B., BRAND, R., WENDE, H. AND HAHN, H.**
High entropy oxides: An emerging prospect for magnetic rare earth - transition metal perovskites
[2] **YAN, C. Y., HONGMING, Y., GUANGHUA, L., GE, T. AND SHOUHUA, F.**
Crystal growth and magnetic property of orthorhombic R Mn O3 (R = Sm - Ho) perovskites by mild hydrothermal synthesis
[3] **SAKAR, A., DJENADIC, R., WANG, D., HEIN, C.,KAUTENBURGER, R., CLEMENS O. AND HAHN, H.**
Rare earth and transition metal based entropy stabilized perovskite type oxides

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