Project ID 8529 High-Entropy Ceramic Coatings

New high-entropy ceramics with reduced thermal conductivity

1. Impact

We have discovered a new class of single-phase high-entropy ceramics (HECs) with reduced thermal conductivity and highly tunable properties.

2. Project Goal

This project aimed at developing HECs as a new class of materials for thermally-insulating, high-temperature protective coating materials against heat transfer media for concentrated solar thermal power applications. We have shown that the phenomenon of reduced thermal conductivity occurs for a range of formulations, investigated the temperature dependence of the thermal conductivity, and examined the stability of HECs against molten chloride salts.

3. Method(s)

A large number of HECs have been fabricated through a high-throughput high-energy ball milling process, followed by conventional sintering at 1600 °C for 24 hours. XRD and SEM-EDS were performed to screen for single-phase HECs. We have measured the density, lattice parameter, elastic modulus, temperature-dependent thermal conductivity of the single-phase HEC specimens. Subsequently, we screened 42 compositions for molten-salt corrosion, studied the kinetics of corrosion in molten salts, and completed the long-term stability test for three selected compositions to show that our HECs can outperform the benchmark H230 alloy at >500 h.

4. Outcome(s)

We have identified a large number (~100) of single-phase compositions with $k < 2$ W/m-K from room temperature to 1000°C. We proposed a new descriptor (size disorder) for designing HECs of reduced thermal conductivity. Furthermore, we showed reduced thermal conductivity can be attained via maintaining high modulus and hardness (breaking a common trade-off in materials science). We have also developed a fast screen method for testing molten salt corrosion resistance, and we proposed and tested a new criterion for forecasting corrosion resistance.

5. Conclusion/Risks

A new class of single-phase HECs with reduced thermal conductivity, along with a vast compositional space for tailoring various properties, has been developed. This opens a new window for developing thermally-insulating, high-temperature protective coating materials.

6. Team

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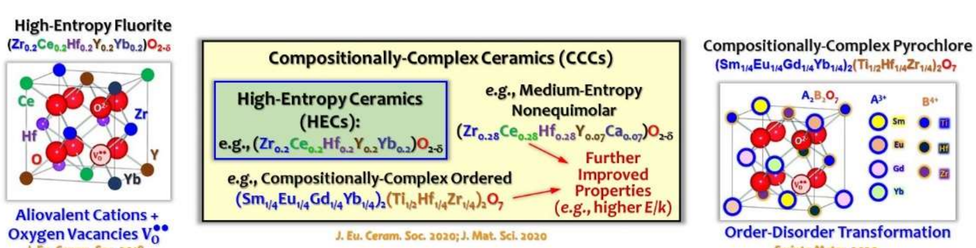

Figure 1. Examples of high-entropy ceramics (HECs) and compositionally complex ceramics (CCCs).