Unlike the traditional strategy for alloy development which focuses on the corners of phase diagrams with one base element and several minor alloying elements, complex concentrated alloys (CCAs) or multi-principal element alloys (MPEAs) explore the central regions of multi-dimensional phase diagrams. This strategy has led to the development of high entropy alloys (HEAs) that are associated with finding single phase solid solutions stabilized by configurational entropy, and now evolves to the design of complex multiphase microstructures.

Development of CCAs mainly rely on a trial-and-error approach where most of the alloys are engineered by starting with a mixture of four or five 3d transition metals, such as the Cantor alloy (CoCrFeMnNi), and adding an element, such as Al, that leads to the enhancement of certain mechanical properties, typical strength and ductility, and continuing to add that element until the best compromise is obtained. This often occurs with little knowledge of the microstructure and the corresponding phase fields of operation.

In this presentation, we will utilize computational thermodynamics and various Calphad databases to gain a better understanding of the effect of given elements on phase stability and more generally on the relationships between composition, processing and microstructure. To illustrate the value of these predictive thermodynamic approaches, we calculate equilibrium and non-equilibrium (via the Scheil-Gulliver solidification path model) phase diagrams for several alloys that have been well characterized experimentally. By comparing not only the phases present but also volume fractions and compositions in both equilibrium and as-cast states, the predictive capabilities of these models are highlighted and discussed. The ability to anticipate the phases present and their volume fractions and transformation temperatures provides a useful tool prior to the production and testing of actual samples.

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His research is focused on two principle areas: the microstructure genesis and evolution in the metallic solid state, and the relationship between functional properties and microstructure of metallic alloys and semiconductors. His work contains both experimental and modeling approaches. Until 2015, his research activities were related to the metallurgy of functional materials with a special emphasis on thermoelectrics. He now moved to the field of high entropy alloys during a sabbatical at Wright State University and the Air Force Research Laboratory.