

# DEVELOPMENT OF HIGH TEMPERATURE REFRACTORY-BASED MULTI-PRINCIPLE-COMPONENT ALLOYS BY THERMODYNAMIC CALCULATIONS AND RAPID ALLOY PROTOTYPING

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Recently, new refractory-based high entropy alloys (HEAs) have been investigated for potential use as high temperature structural alloys, and some alloys exhibit excellent high temperature strength and ductility. While the high entropy alloy community is generally concerned with obtaining single phase solid-solution phases, secondary strengthening phases are usually required to achieve an adequate balance of mechanical and physical properties for structural applications. This contribution will report on new Mo,Nb-based alloys that have been developed using HEA design guidelines, as well as new tools that enable thermodynamic property predictions and rapid alloy prototyping and assessment.

An elemental palette of Mo-Nb-Hf-Ta-Ti-V-W-Zr was chosen in order to promote the formation of a single body-centered cubic (BCC) solid-solution phase upon solidification, which facilitates homogenization heat treatments. Al, Cr, and Si were also included to promote secondary phase formation. These 11 elements were then used to calculate the phases present and their reaction temperatures of 3-, 4-, 5-, and 6-component alloy compositions from all of the available Pandat™ databases. Mo and Nb were required to be present in each alloy composition in order to maintain modest alloy costs and densities.

With the aforementioned elemental palette, approximately 100,000 unique 3- and 4-component alloys were rapidly assessed by thermodynamic calculations. Selected alloy compositions have been cast to verify the thermodynamic calculations. An overview of the screening procedures will be discussed, and preliminary results of mechanical testing of new 4-, 5-, and 6-component alloys will be presented.

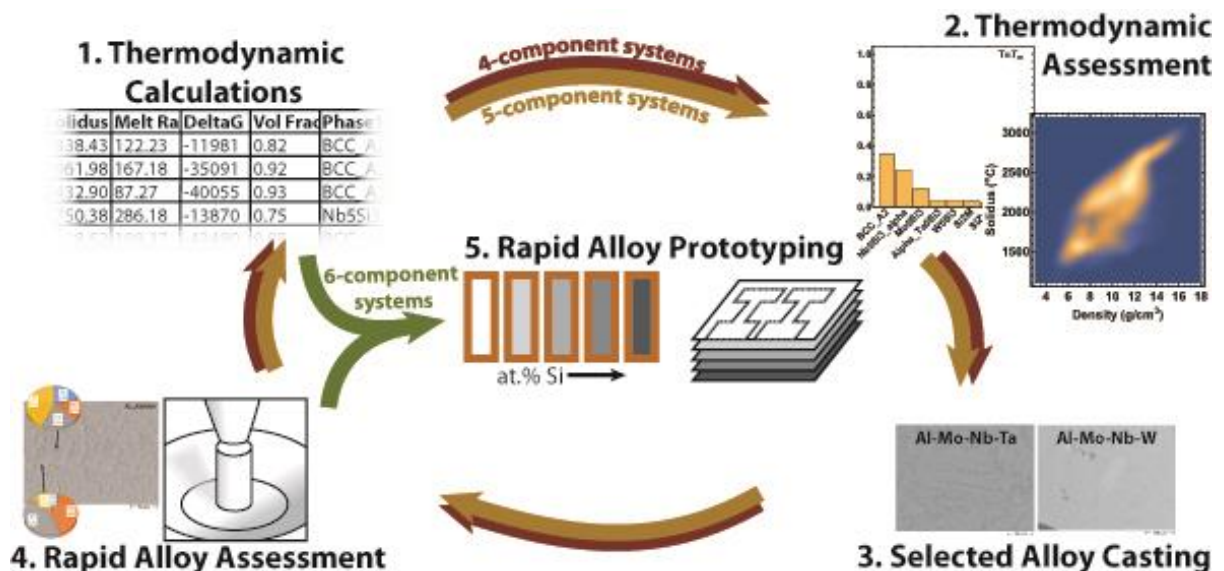


Figure 1 – Schematic of the alloy discovery and development process that iterates over 4-, 5-, and 6-component alloy systems. The process includes: (1) thermodynamic calculations over a broad range of composition space, (2) thermodynamic database assessment, (3) casting of selected alloys, (4) alloy assessment via microtesting and microanalysis, and (5) rapid alloy prototyping to investigate minor alloying additions, such as Si.