DFG Schwerpunktprogramm / Priority Programme Compositionally Complex Alloys – High Entropy Alloys (CCA-HEA)

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Mechanical properties and hydrogen tolerance of particle-reinforced CCA produced by additive manufacturing (MarioCCArt)

In diesem Projekt werden partikelverstärkte HEA/CCA (High Entropy Alloys / Compositionally Complex Alloys) mit Partikeln unterschiedlicher Zusammensetzung und Größe verstärkt. Die Verarbeitbarkeit der verschiedenen Partikelarten und -größen auf verschiedenen in-situ und ex-situ Prozessrouten im L-PBF-Verfahren wird untersucht und die mechanischen Eigenschaften der resultierenden partikelverstärkten CCA werden ermittelt. Zudem wird der Einfluss von Wasserstoff und tiefen Temperaturen auf die mechanischen Eigenschaften und die Mikrostruktur untersucht. Das wesentliche Ziel dieser Untersuchungen ist es, einen bei niedrigen Temperaturen festen, bruchzähen, ermüdungsresistenten und wasserstofftoleranten Werkstoff zu erzeugen. Die Ergebnisse sollen die Grundlagen für die Nutzung von partikelverstärkten CCA in der Wasserstoffwirtschaft legen.

In the first funding period, the process chain for the synthesis of particle-reinforced HEA/CCA (High Entropy Alloys / Compositionally Complex Alloys) via gas atomization of powders and Laser Powder Bed Fusion (L-PBF) was established. We processed alloys in the family CoCrFeNi(-Al,-Mn) and investigated strengthening via spinodal decomposition, oxide and nitride precipitation. Continuing with this work, we will concentrate in the follow-up project on the most successful of these alloys (no crack formation in L-PBF, single-phase matrix) for more application-driven research. Two alloys will be investigated, both single-phase A1 (fcc), one HEA and one conventional alloy for reference. These alloys will be reinforced by particles of various chemical composition and size. The impact of these different particle sizes and compositions on processability in different ex-situ and in-situ process routes in L-PBF will be determined and the mechanical properties of the resulting particle-reinforced CCA (p-CCA) will be determined, including strength, fracture toughness and fatigue strength. Additionally, the influence of hydrogen and of low temperatures on the mechanical properties and on the microstructure will be a focus of the project. The goal of these analyses is to develop a strong, tough, fatigue- and hydrogen-resistant material. To this end, the mechanical properties and the mechanisms of plastic deformation of the p-CCA and reference alloys before and after gaseous hydrogen charging will be investigated at room temperature and at low temperatures. To understand the impact of hydrogen on plastic deformation and failure mechanisms, additionally a nanoindenter including an electrochemical charging cell will be used. The results lay the foundation of the application of p-CCA in the hydrogen economy.