High Entropy Alloys (HEAs) are a modern group of Multi-Principal Element (MPEAs) engineering materials. Alloys characterized by high entropy differ significantly from classical engineering materials based on one main chemical element, to which other alloying elements are introduced, usually in small quantities. As a result HEAs exhibit unique physicochemical properties. The definition of HEAs is based on their chemical composition and high configurational entropy or entropy of mixing (ΔS_{conf} / ΔS_{mix}). In the context of solid solution formation in high entropy alloys, thermodynamic parameters have been proposed in the literature to support the selection of alloying elements. These parameters take into account differences in atomic radii, entropy of mixing, enthalpy of mixing, concentration of valence electrons. It is worth noting that the literature clearly indicates the need to study the effectiveness of these parameters in the study of new chemical compositions of alloys with high entropy, which is one of the research objectives of the dissertation.

High entropy alloys are characterized by four main effects (*core effects*), which are due to the multi-component nature of this group of materials, as well as to the physical and chemical properties of the selected alloying components and are not found in other groups of engineering materials. Due to these effects, high entropy materials show great application potential in various industries. One of the uses of HEAs indicated in the literature may include biomedical applications of HEAs (ang. *Biomedical High Entropy Alloys* - bio-HEAs). Their potential is related to good mechanical properties, high biocompatibility and corrosion resistance. Literature data extensively describe the study of bio-HEAs in solid form, as well as in the form of films applied to biomedical substrates. The chemical compositions contained in the literature contain mainly biocompatible elements Ti, Ta, Nb, Zr, Hf and/or Mo. In the case of high entropy biomedical alloys in solid form, these materials are mainly produced by arc melting from solid elements. The alloys produced are characterized by the presence of one or two phases with a body-centered cubic (BCC) structure. Literature data also indicate the presence of a dendritic microstructure. The chemical compositions described in the literature also show segregation of alloying elements in the microstructure based on their melting points.

Based on the current state of knowledge in the presented dissertation the effectivity of the literature-described thermodynamical parameters for the phase predictions was investigated for $Co_{15}Cr_{15}Mo_{25}Si_{15}Y_{15}Zr_{15}$ (at. %) high entropy alloys. Additionally, the influence of Hf, Mo and Zr on the phase formation, microstructure, selected mechanical properties and corrosion resistance of $Ti_{20}Ta_{20}Nb_{20}(ZrMo)_{20-x}Hf_x$, $Ti_{20}Ta_{20}Nb_{20}(ZrHf)_{20-x}Mo_x$ and

$Ti_{20}Ta_{20}Nb_{20}(HfMo)_{20-x}Zr_x$ (where: x = 0, 5, 10, 15, 20 at. %) for potential biomedical applications was also studied.

As mentioned above, the effectiveness of thermodynamic parameters was studied for $Co_{15}Cr_{15}Mo_{25}Si_{15}Y_{15}Zr_{15}$ alloy (% at.). The material was obtained by the arc melting method in order to obtain an amorphous structure immediately after formation. The chemical composition of the studied alloy was based on a large mismatch in the crystal lattice resulting from differences in atomic radii (δ) and the low enthalpy of mixing of the alloying elements (ΔH_{mix}). X-ray phase analysis (XRD) revealed the presence of a raised background in the experimental diffractogram, indicating the presence of an amorphous phase. Unambiguous confirmation of the presence of an amorphous phase was achieved using transmission electron microscopy (TEM), where the presence of fully amorphous areas was confirmed on the recorded electron diffraction patterns (SAED). In addition, amorphous areas were also revealed, in the vicinity of which nanocrystalline areas were present. Obtaining of such a microstructure in the case of arc melting without the use of increased cooling rates demonstrates high utility and correctness of the suggested thermodynamic parameters.

In the case of the samples with different Hf, Mo and Zr, the materials were produced from elemental powders. Powders were blended to obtain homogeneous distribution. As-blended powders were vacuum arc melted. The phase composition was determined using XRD measurements. Microstructure analysis included scanning electron microscopy (SEM) observation and chemical composition analysis by energy dispersive X-ray spectroscopy (SEM-EDS). Selected mechanical properties were determined using nano- and microhardness tests. Corrosion resistance measurements were performed using potentiodynamic polarization and electrochemical impedance spectroscopy (EIS) techniques in the Ringer's solution.

The results confirmed the prediction of the thermodynamic parameters, which suggested the presence of multi-phase microstructure and *BCC* solid solutions. All studied alloys confirmed the presence of dual-*BCC* phases, dendritic and interdendritic microstructure corresponding to *BCC1* and *BCC2* phases. Moreover, the segregation of the alloying elements based on their melting temperature was also revealed for all studied Hf, Mo and Zr-containing HEAs. The elemental segregation stays in agreement with the literature-described data. Microhardness of all studied HEAs oscillated from 427 HV1 to 557 HV1. Determined microhardness was higher than conventional biomedical alloys but lower compared to the literature-described NiTi after the plastic deformation process. All investigated materials also

exhibited high break-down potential (E_{BD}), highlighting the high corrosion resistance. It should be underlined that E_{BD} was significantly higher than commercial, biomedical Ti-based alloys.