Search for New High-Entropy Superconductors with High Upper Critical Fields

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High-entropy alloy (HEA) superconductors have attracted considerable attention owing to their remarkable tolerance to chemical disorder and promising superconducting properties. However, most reported type-A HEA superconductors exhibit upper critical fields, $\mu_0 H_{c2}(0)$, below 12 T, limiting their potential for high-field applications [1, 2]. In this work, we present a systematic search for new NbTi-based and Ti-rich HEA superconductors designed to enhance the upper critical field by exploiting the favorable superconducting properties of the Nb-Ti system. Polycrystalline alloys were synthesized by arc melting and characterized using X-ray diffraction, electron microscopy, electrical resistivity, magnetic susceptibility, and specific heat measurements.

The first stage of this study led to the discovery of the $Nb_{0.34}Ti_{0.33}Zr_{0.14}Ta_{0.11}Hf_{0.08}$ HEA, which crystallizes in a single-phase bcc structure and exhibits bulk type-II superconductivity with a critical temperature of 7.5 K and an upper critical field $\mu_0 H_{c2}(0)$ = 12.2 T, among the highest values reported for conventional type-A HEA superconductors [3].

Building on this result, a new family of Ti-rich HEA superconductors, $Ti_{0.5}(ZrNbHfTa)_{0.5}$ and $Ti_{0.5}(VNbHfTa)_{0.5}$, was developed. Despite containing a majority of elements that crystallize in the hcp structure, both alloys form a single-phase bcc solid solution and display robust bulk superconductivity with $T_c \approx 6$ K. Specific heat measurements combined with Werthamer-Helfand-Hohenberg analysis yielded exceptionally high upper critical fields of 13.5 T and 12.8 T, respectively [4]. The value of 13.5 T observed for $Ti_{0.5}(ZrNbHfTa)_{0.5}$ represents one of the highest reliably determined upper critical fields among HEA superconductors and approaches those of commercial Nb-Ti alloys.

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References

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