Development of new-type of superconductors having "high-entropy-alloy site"

Since the discovery of superconductivity in (Ta,Nb,Hf,Zr,Ti) in 2014 [1], the field of high-entropy-alloy (HEA) superconductors have been activated. HEA is an alloy containing five or more elements and typically satisfies $\Delta S_{\mathrm{mix}} > 1.5R$, where ΔS_{mix} and R are configurational mixing entropy and gas constant, respectively. The development of HEA superconductors are reviewed in Ref. 2 by Prof. Sun and Prof. Cava. The purposes of the field are to achieve superconductors available under extreme conditions and that has superior superconducting properties than non-HEA superconductors.

Since the target phases were simple alloy with a single crystallographic site in the first stage, we have applied the concept of HEA to more complicated compounds [3-7]. Those shown in the figure have a HEA-type site where the site is in HEA state with a solution of five or more different elements. Notably, in (C) BiS_2-based layered system, superconducting properties were improved by increasing ΔS_{mix}; the increase in ΔS_{mix} caused the suppression inn-plane structural disorder in $REO_{0.5}F_{0.5}BiS_2$ [8]. Therefore, further development of HEA-type superconductors with a complicated structure will open new ways to improve superconducting properties. Very recently, we proposed an efficient way to achieve very high ΔS_{mix} by alloying two different sites [10]. In a series of MCh (M: metal, Ch: chalcogen), (Ag,In,Pb,Bi)Te1-xSex shows superconductivity and very high ΔS_{mix} close to $2R$. Using those concepts and methods, we will try to develop HEA-type superconductors to achieve high T_c, high H_{c2} (upper critical field), large J_c (critical current density), and high resistance to extreme conditions.

References

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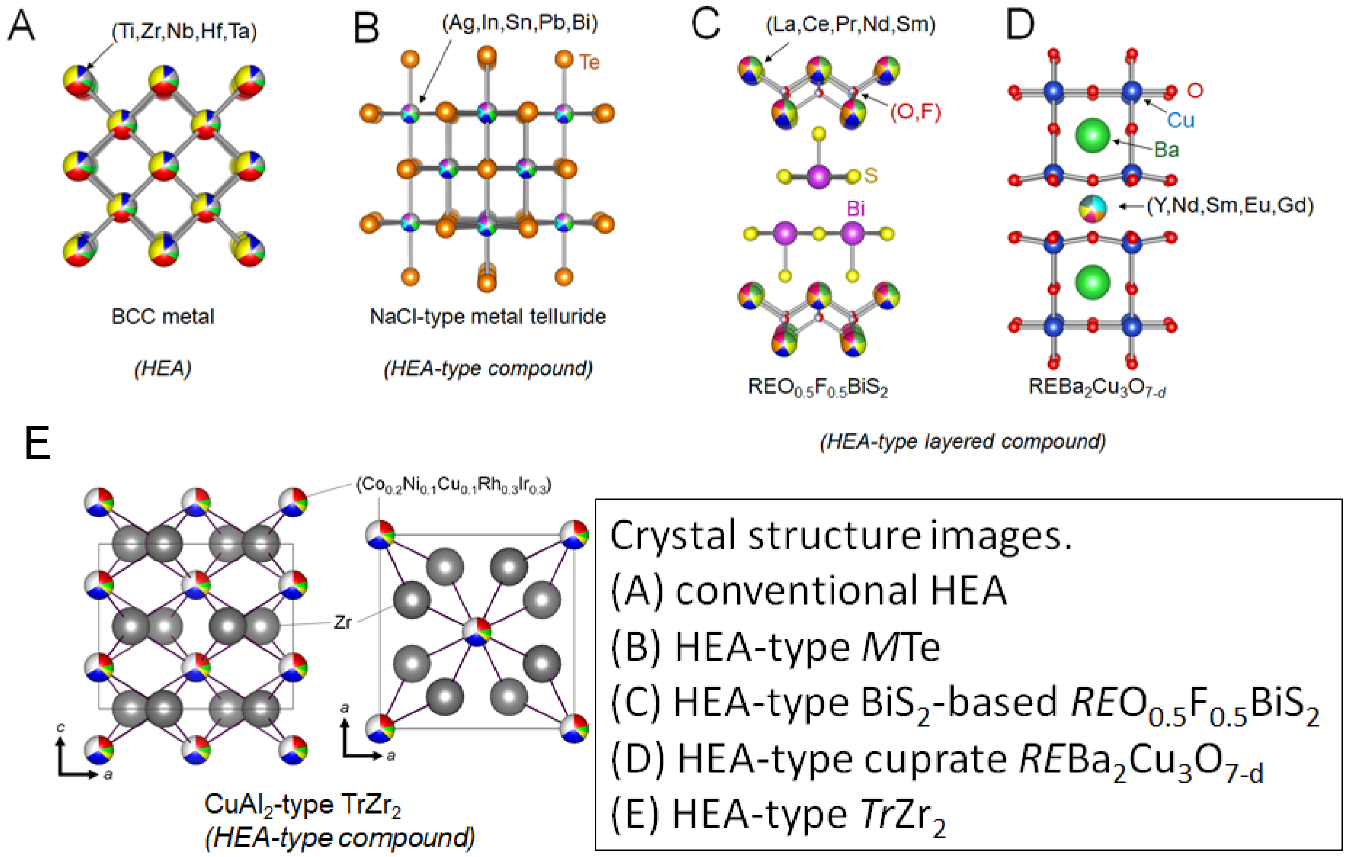

Crystal structure images.
(A) conventional HEA
(B) HEA-type *M*Te
(C) HEA-type BiS_2-based $REO_{0.5}F_{0.5}BiS_2$
(D) HEA-type cuprate $REBa_2Cu_3O_{7-d}$
(E) HEA-type $TrZr_2$