

Icosahedral quasicrystal, 1/1 and 2/1 approximants in Zn-Au-L (L=Yb, Tb) alloys

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It is well known that isomorphic substitution is an effective way to reach new quasicrystalline alloys. In particular, in the case of Tsai-type quasicrystals, Cu, Ag and Au-based quasicrystals were found by using the Cd-Yb or Zn-Mg-Sc quasicrystal as a starting material. In this report, we introduce recent experimental results on new Zn-based alloys. The formation of 1/1 approximant is known in Zn-Yb system, but no icosahedral quasicrystal has been observed in Zn-based alloys containing Yb except for the metastable Zn-Mg-Yb quasicrystal (Mitani and Ishimasa, 2006). The purpose of this study is to find new materials that exhibit interesting properties related to magnetism and valence-fluctuations.

The results are summarized in the following Table. A new icosahedral quasicrystal is found in the quenched Zn-Au-Yb alloy, and this quasicrystal appears to be metastable. The quasicrystal survived after aging at 602°C for 108 hours, but was not formed by slow cooling from the melt. Instead, a 2/1 approximant crystal is formed as a stable phase near the same composition range. Interestingly, a new 1/1 approximant is found in Zn-Au-Tb system, which appears to be a stable phase. (Note that there is no cubic approximant in the binary Zn-Tb system.)

These experimental results show that Cd in Cd-based quasicrystals and approximant crystals may be replaced by Zn/Au. The ratio of Zn/Au can be between 0.8 and 0.9. Considering the rich variety of Cd-based alloys, this substitution method may contribute to reaching a deeper understanding of the physical properties of quasicrystal-related materials.

Nominal composition	Heat treatment	Structure	Analyzed Composition [#]	Minor phase
Zn _{72.5} Au _{11.8} Yb _{15.7}	quenched from 882°C	P-type icosahedral QC $a_{6D}=7.384(1) \text{ \AA} *$	Zn ₇₃ Au ₁₁ Yb ₁₆	ZnAuYb-type (<i>Pnma</i>)
Zn _{76.0} Au _{9.0} Yb _{15.0}	annealed at 533°C, 67h	2/1 approximant (<i>Pa</i> $\bar{3}$) $a_{2/1}=23.29(2) \text{ \AA} **$	Zn ₇₆ Au ₈ Yb ₁₆	unidentified
Zn _{70.5} Au _{15.0} Tb _{14.5}	annealed at 524°C, 92h	1/1 approximant (<i>Im</i> $\bar{3}$) $a_{1/1}=14.318(3) \text{ \AA} **$	Zn ₆₉ Au ₁₅ Tb ₁₆	Zn ₅₈ Tb ₁₃ -type (<i>P63/mmc</i>)

Table. New Zn-based quasicrystal-related phases containing Au and lanthanoids.
#: composition analyzed by EDS method. * and **: lattice parameters estimated by extrapolation method and Rietveld method, respectively.