TOPICS

Super Multifunctional Alloy "GUM METAL"

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The super multifunctional titanium alloy "GUM METAL" has been developed. This alloy has (a) ultra-low elastic modulus with high strength (**Fig. 1**), (b)super-elastic like nature; one digit higher in elastic deformation (2.5%) compared to general metallic materials, (c)super-plastic nature permitting cold plastic working to 99.9% or more with no work hardening at room temperature, (d)ultra-high strength of more than 2000 MPa by applying a heat-treatment, (e)a near-zero linear expansion coefficient (Invar property) and a constant elastic modulus (Elinvar property) over a wide temperature range from -200°C to +250°C. All these unique properties are achieved by cold working. The typical properties of the alloy are summarized in **Fig. 2**.

GUM METAL belongs to a beta-type titanium alloy having a body-centered-cubic structure and is fundamentally expressed as $Ti_3(Ta+Nb+V)+(Zr, Hf)+O$, and has a compositional average valence electron number (electron/atom ratio) of approximately 4.24. **Figure 3** shows the changes in elastic modulus, attainable elasticity and work hardening ratio of several alloys with the valence electron number. Each property takes a specificity around the common valence electron number of about 4.24. The value of the "ideal shear stress" has been estimated as 0.11G for bcc metals; such values for conventional metals are several times the actual strength, whereas that for GUM METAL is estimated to be so low as the actual strength as seen in Fig. 1.

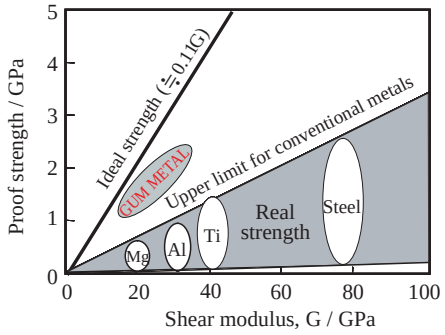

Fig. 1 Position of elastic modulus and strength of GUM METAL.

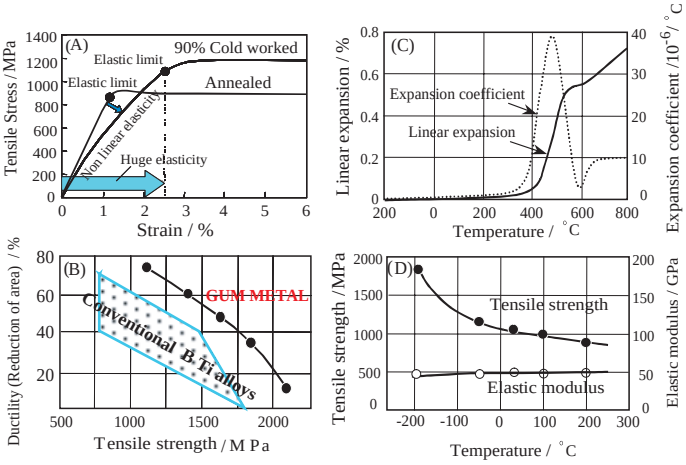

Fig. 2 Typical properties of GUM METAL.
(A) Stress-strain curve, (B) Relation between strength and ductility, (C) Invar and (D) Elinvar property.

The unique characteristics of GUM METAL are attributable to an arcane feature in relation to the plastic deformation of the alloy; they result from a dislocation-free plastic deformation mechanism. In the cold worked alloy, this plastic deformation mechanism forms elastic strain fields of a hierarchical structure that range in size from nanometers to several tens of micrometers. The resultant elastic energy leads to a number of unique properties.

GUM METAL named after its various unique characteristics unlike other metals is a new material having infinite possibilities in practical applications. In addition to its already commercialized applications including spectacle frames and precision screws, it is considered to be applicable in a wide range for automotive parts, medical equipments, sporting goods, decorative materials and in the aerospace industry.

Reference

1) Saito, T., et al. : Science, **300**(2003), 464

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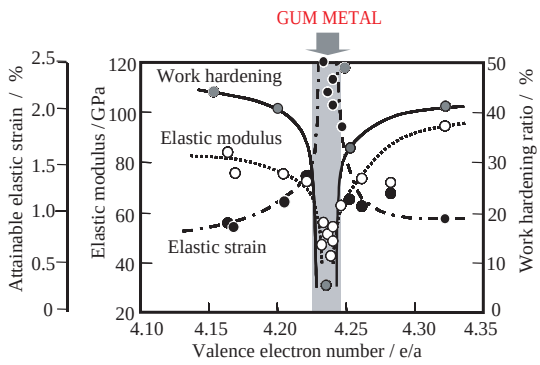

Fig. 3 Anomaly in properties of Ti-Nb-Ta-Zr-O alloys.