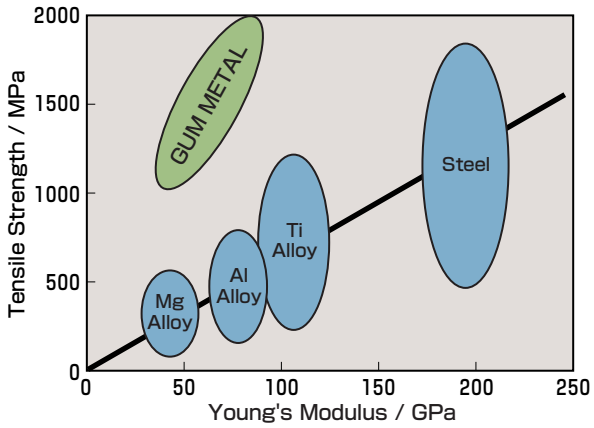
Super Elasto-plastic Titanium Alloy GUM METAL®

TOYOTA CENTRAL R&D LABS., INC.

1 Outline

Elasto-plastic metal is an entirely new titanium alloy having low Young's modulus and high strength that cannot be obtained from conventional metallic materials (Fig.1). This alloy has super-elastic nature one digit higher in elastic deformation (2.5%) compared to general metallic materials, and super-plastic nature permitting cold working to 99.9% or more at room temperature. Furthermore, its strength can be increased to the highest in the world (2,000 MPa in tensile strength) by applying a simple heat treatment process.

【Fig.1】Position of Young's Modulus and Strength of GUM METAL

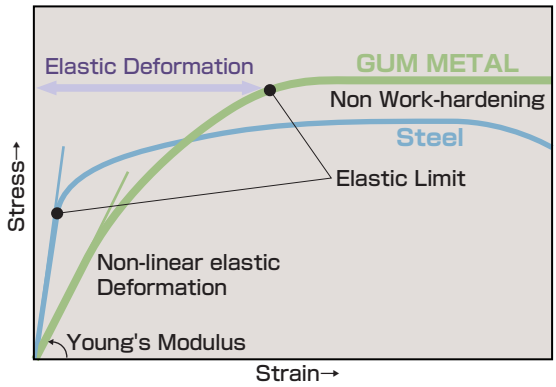


2 Features

GUM METAL belongs to the (β-type titanium alloy having a body-centered cubic structure and is basically expressed as Ti_3(Ta, Nb, V) + (Zr, Hf, O). Since this alloy is hard to be processed by the ordinary melting process because of excessive macro segregation making uniform structure extremely difficult, sintering is adopted for production.

While GUM METAL has considerably low Young's modulus (70 GPa) when applied with solution heat treatment, its Young's modulus drops further when cold working is applied so as to make the Hook's law as the common knowledge about metal inapplicable. In other words, its elastic coefficient is not constant and it shows non-linear elastic deformation, with Young's modulus changing greatly (60 to 20 GPa). As a result, the yield strength increases remarkably to show super-elastic

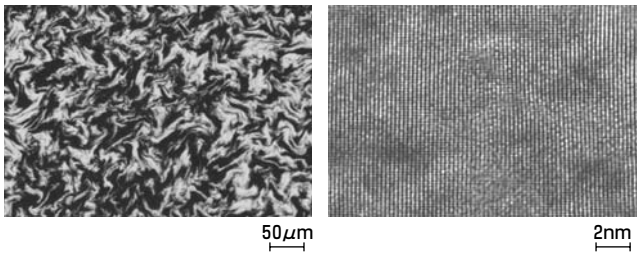
【Fig.2】Stress-Strain Curve of GUM METAL



nature (Fig.2). Since the alloy does not show work-hardening at all under any king of hard working, continuous deformation is possible to any desired level.

The unique characteristic of GUM METAL arises from its strange nano structure. As no dislocation or twin crystal is observed after hard cold-working, it changes to marble structure containing fractal, layered structure involving discrete strain field and its crystal lattice is curved greatly (Fig.3). It is estimated that an unknown plastic deformation mechanism completely different from those of other metallic materials is acting.

【Fig.3】Optical Microstructure (Left) and High-resolution Transmission Electron Microstructure of GUM METAL



3 Application

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

Kazuaki NISHINO (e0474@mosk.tytlabs.co.jp)