## 1. Introduction

"SP-700"[1–3] is a high-strength, high-formability titanium alloy for general-purpose applications, developed by JFE Steel in 1990. The alloy has excellent superplastic formability (**Fig. 1**) and fatigue strength (**Fig. 2**) compared to the general-purpose titanium alloy Ti-6Al-4V. Taking advantage of these properties, SP-700 is used to fabricate airframe parts and high-performance auto engine parts. SP-700 is also well recognized and widely used as a representative material for today's highly popular titanium golf clubs. The light weight, low Young's modulus, and high durability of the alloy make it ideal as a face material.

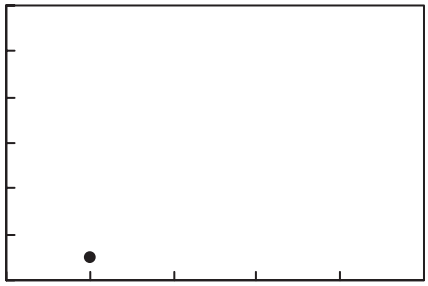

Fig.1 Superplastic elongation of SP-700 and Ti-6Al-4V

Fig.2 Fatigue strength of SP-700 and Ti-6Al-4V

Recently adopted rules, however, restrict the use of golf clubs with face materials designed to deliver spring-like effects. Instead, the face materials now adopted must provide light weight and high stiffness. With the materials of these characteristics, engineers can design golf clubs in which the center of gravity of the head is positioned in a rear part to ensure high inertia, and with properties to facilitate the striking of the ball by the club. To respond, JFE Steel has developed SP-700HM, a new material ideal for golf club heads with high stiffness. SP-700HM maintains the excellent properties of the conventional SP-700 while complying with the spring-like effect (SLE) rule. This article describes this new material, SP-700HM.

## 2. Properties of SP-700HM

### 2.1 Tensile Properties and Physical Properties

SP-700HM has a chemical composition of Ti-4.5Al-3V-2Fe-2Mo, the same composition as the general-purpose SP-700. But SP-700HM is designed to confer higher stiffness for the faces of golf clubs (the face stiffness) by controlling the texture formed by rolling. The face stiffness is proportional to the cube of the plate thickness and to the modulus of longitudinal elasticity (Young's modulus). **Table 1** shows examples of the room-temperature tensile properties of SP-700HM and SP-700.

In SP-700, the tensile properties and the Young's modulus in the final rolling direction, hereinafter referred to as "the longitudinal direction," are more or less equal to

Table 1 Tensile properties of SP-700 and SP-700HM

made from SP-700HM (courtesy of YONEX Co., Ltd.).

## 5. Concluding Remarks

This report presented the properties of SP-700HM, an alloy well suited for golf club faces. By using this material it becomes possible to increase stiffness, with the face plate thickness kept small, without any changes in the chemical composition or handiness. SP-700HM is expected for use in wider applications as a new, lightweight material capable of conforming to the spring-like effect (SLE) rule of golf club heads. New applications are also likely to be developed to fully exploit the excellent fatigue strength, the strength-reinforcement via texture control, and the anisotropy of stiffness of this new material.

### References

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3) JFE Technical Report. 2005, no. 5, p. 74.
4) YONEX Co., Ltd. Private communication.

### For Further Information, Please Contact :

Titanium Sec., Plate Sales Dept., JFE Steel
Phone: (81) 3-3597-3364 Fax: (81) 3-3597-3533
Website: http://www.jfe-steel.co.jp/en/products/titanium/