Evaluation of Delamination Strength of Hard Film by Convex Edge Indent Method

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Introduction

To develop new coatings with superior mechanical properties, it is important not only to improve delamination strength of the coatings, but also to establish the evaluation method of the delamination strength of hard films. In this study, convex edge indent method is proposed by revising edge indent method(1) using a transparent model specimens, and the delamination strength of Cr$_3$C$_2$-NiCr and WC-Co films were measured by the method.

Experimental method

A Glass plate with a thickness $B_1$ of 0.5mm and acrylic resin with a thickness $B_2$ of 3.0mm was used as a model of coating and substrate. After ultrasonic cleaning, the glass plate and acrylic resin was bonded (CC-33A Kyowa electric instruments Co. LTD). Bonded plates were machined to a convex shape with a length and width of $l$ and $b$ as was shown in Fig.1.

Convex edge indent test was carried out by pressing a diamond conical indenter with an apex angle of $\alpha$ on the coating with a distance of $x$ from the edge until delamination. During the test, the interface was observed using a microscope.

The interfacial fracture toughness, $G_c$, was calculated using Eq.(1),

$$G_c = \frac{P_d^2 \sin^2 \theta}{2\pi E_1 b^2 B_1 \tan^2 \alpha}$$

, where $P_d$ is the load at delamination, $E_1$ is the Young’s modulus of coating, $\theta$ is the apex angle of delamination.

Experimental result

Figure 2 shows image of interfacial crack just before delamination. An interfacial crack propagates toward the edge of the specimen. Interfacial fracture toughness, $G_c$, calculated using Eq.(1) is shown as a function of normalized length, $l/b$. The interfacial fracture toughness increases with increasing normalized length and reaches a constant value.

The interfacial fracture toughness of the thermally sprayed Cr$_3$C$_2$-NiCr and WC-Co coatings measured by the convex edge indent method are around 25 and 14kJ/m$^2$, respectively.

Fig. 2 Propagation of interfacial crack during convex edge indent test.

Fig. 1 Schematic illustration of convex edge indent method.

References.