High Temperature Testing of Passivated Metal Thin Films

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1. Introduction

Almost all of the microelectromechanical systems (MEMS)-based devices are designed with passivation layer which changes the mechanical behavior of micro- and nanoscale materials dramatically, unlike their bulk counterparts. These micro-scale and nano-scale devices are often operated in harsh environments such as elevated temperatures. However, the thermomechanical behavior of passivated thin films is seldom reported, and the deformation mechanism is not well understood. This is mainly due to technical difficulties related to fabrication and handling of thin film specimens. In addition, at elevated temperatures, accurate temperature control of the specimen requires development of advanced experimental techniques.

2. Body of abstract

In this presentation, I will introduce two experimental techniques that can be used to understand the strain hardening behavior in passivated metal thin films at various temperatures.

The first experimental method that will be introduced utilizes a custom-built *in-situ* scanning electron microscope (SEM) micro-tensile tester. The apparatus has a stroke of 250μm with a displacement resolution of 10nm and a load resolution of 9.7μN. Measurements at elevated temperatures up to 740°C can be performed through use of two silicon-based micromachined heaters that support the sample. Each heater consists of a tungsten heating element that also serves as a temperature gauge [1, 2].

The second method is based on an *in-situ* SEM nanoindenter equipped with a customized diamond gripper, which is manufactured using focused ion beam (FIB) milling. Independent heating of both the indenter tip and sample is used for mechanical testing at elevated temperatures. Thermocouples are located next to the tip and sample, and the temperatures are precisely controlled to reduce contact thermal drift due to temperature difference.

Measurements at room temperature are performed through use of microfabricated tensile specimens with and without a passivation layer. Metallic thin films with a passivation layer exhibit significant strain hardening at room temperature because the passivation layer forms a strong interface, which acts as an obstacle to dislocation motion. As temperature increases, passivated metal thin films exhibit lower strain hardening rate due to thermally activated recovery mechanisms. We will also present ongoing efforts to understand the recovery processes by means of tensile and relaxation/creep experiments at a range of temperatures.

3. Equations, figures, and tables

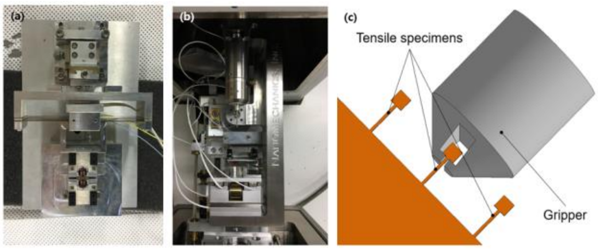

Fig.1 Image of (a) the custom-built *in-situ* SEM micro-tensile tester, (b) the *in-situ* SEM nanoindenter and (c) the schematic representation of tensile test using customized gripper and microfabricated specimens

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References

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