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Investigation of Acoustic Emission under Scratch Motion

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Acoustic emission (AE) testing has been recognized as a well-established method for condition monitoring. Due to high sensitivity of the AE signal, it is possible to predict and diagnose a mechanical failure in the early stage. However, it is difficult to identify which wear phenomenon occurred between the contact surfaces with AE testing results. Also, since AE signals are easily affected by background noises, it is important to study the characteristics of the AE signals that are generated according to the wear mechanisms in developing an accurate AE testing method. In this study, to understand the AE phenomenon according to the wear mechanism, the AE tests on different materials were conducted under scratch motion. For the scratch test, the nano-scratch tester was used. The coating materials were fabricated by customized magnetron sputtering system. The AE signals were obtained by bandwidth type AE sensor attached below the specimen, and background noises were filtered based on the noise signals acquired before the experiment. After the experiments, the AE signals were analyzed in both frequency domain and time domain. The scratch tracks were observed using scanning electron microscope to identify the wear mechanisms. The experiment results demonstrated that the strength and frequency of AE signals changed according to different wear mechanisms. The results of this study will be helpful in designing the condition monitoring technique based on the AE test.

1. Introduction

Recently, the condition monitoring technique using AE testing has received great attention as an effective method for predicting and diagnosing material failure without optical inspection between mating surfaces. Since the AE signal is a phenomenon that occurs when a material is destroyed, AE testing has the advantage of being able to inspect the failure of mechanical parts in real-time [1-2]. Moreover, due to the high sensitivity of the AE signal, material failure can be detected in the early stage. Due to these advantages, the condition monitoring technique using AE testing has been widely studied [3-5].

Analysis of wear between mating surfaces is very important in condition monitoring in determining the severity of mechanical failure. However, it is very difficult to identify the wear mechanism by measuring AE signals that are affected severely by ambient noise. In this regard, it is highly required to study the relationship between the wear mechanism and the AE signal for an accurate condition monitoring technique [6-7].

In this research, the effects of the wear mechanisms on the AE signal were investigated by conducting scratch tests. During the scratch test, AE testing was performed to observe the changes in the AE signals. The results are expected to aid in the development of a better condition monitoring technique.

2. Experimental methods

Scratch tests were conducted on bare Cu plate, bare Si wafer, and DLC coatings deposited on Cu and Si substrates to simulate various wear mechanisms. For the experiments, the coating materials were fabricated using the PVD technique. Ti was used as an adhesion layer for each coating. Before the test, surface characterization was performed using a 3D confocal microscope. For the scratch test, a spherical tip was used, and the test conditions were determined through pretests. During the scratch tests, the friction force was measured in real-time.

During the scratch test, the experiments were conducted in the sound enclosure to minimize the effect of background noise. A bandwidth-type AE sensor was attached to the bottom of the specimen to measure the AE signal during the scratch test. The AE signal generated during the experiment was amplified. In addition, the measured AE signal was filtered to reduce the noise using a band-pass filter designed based on pre-measured background noise. Fig. 1. shows the schematic diagram of the scratch and AE tests.

After the tests, the scratch tracks were analyzed to determine the wear mechanism through SEM analysis. The filtered AE signal was analyzed and compared with the wear mechanism by observing changes in both time and frequency domains.

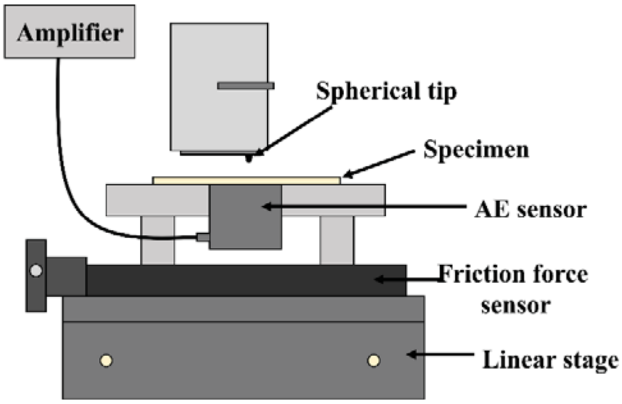

Fig. 1. Schematic diagram of the scratch test and AE test

3. Conclusions

The experiment results clearly showed the influence of the wear mechanism on the AE signal characteristics. Different wear mechanisms occurred depending on materials which resulted in different AE signals. However, it was difficult to analyze the relationship between the friction coefficient and the AE signal characteristics.

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