Application of Scanning Probe Microscopy to the Research Field of Metal Fatigue.

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Choi Song Jong

By using SPM(Scanning Probe Microscope) such as STM(Scanning Tunneling Microscope) and AFM(Atomic Force Microscope) three-dimensional atomic level resolution can be obtained easily even in an ambient or a liquid environment, and the SPM is becoming used for various research fields including the mechanical behavior of materials. Such studies as nucleation of fatigue slip bands and microcracks, nucleation and growth of the pit in corrosion fatigue and the growth of SCC were performed. However, no systematic investigations on the fatigue fracture surface and slip bands of fatigued single crystals are made so far using the SPM.

In the present study STM was used to study the formation of fatigue damage in Cu and CuAl single crystals. Observations were made in air after applying constant cyclic total strain amplitude for various numbers of cycles. The surface became proportionately rough as the number of cycles increased. Although morphology of the slip bands was different depending on the material(or stacking fault energy), the slip steps with the heights of 100 to 200nm and the widths of 1000 to 2000nm were prevailing. Nucleation of micro-cracks was resulted from concentrated deformation at some of the hills and valleys. The slipped distance on the surface in one slip system was not uniform along the slip line, and formation of the extrusions or intrusions was assumed to occur such place. By comparing the morphological change caused by crystallographic orientation, strain amplitude, number of cycles or stacking fault energy, some interesting results which help to clarify the basic mechanism of fatigue damage were obtained, and applicability of the STM to fatigue damage is discussed.

While, AFM was used to study cross sectional profiles and dimensions of fatigue striations for 2017-T351 aluminum alloy. The widths (*SW*) and the hights (*SH*) of fatigue striations were measured from their cross sectional profiles of the three-dimensional AFM images. The following results that will be helpful to understand the fatigue crack growth mechanism were obtained. (1) Crack growth rate was the same as a striation width down to the 10^{-5}mm/cycle. (2) The striation height SH increased at the ratio of $(SW)^{1.2}$, and it is independent of the stress ratio $R(=P_{min}/P_{max}=K_{min}/K_{max})$. (3) The ratio of the striation height to its width *SH/SW* is independent of the stress intensity factor range ΔK and the stress ratio R. (4) The fractal dimension *D* of the cross sectional profile of striations also independent of these factors. (5) Effect of a precipitate on the morphology of striation was changed by the relative dimensional difference between the striation width *SW* and the precipitates. From these results, the applicability of the AFM to nano-fractography is discussed.