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Evolution of the Deformation Relief on the Surface of a Clad Aluminum Alloy at Random Cyclic Loads

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Abstract. *The deformation relief was revealed to be formed and evolved on the surface of a cladding layer of a D16AT aluminum alloy under random cyclic loading. The surface saturation, roughness, and microplastic deformation are found to be quantitative estimates of the deformation relief and damage levels. Experimental deformation relief characteristics-load cycle number relations are similar and can be employed for predicting the fatigue crack initiation in aircraft structure elements.*

Introduction.

Recent research and development efforts in the field of new nondestructive inspection methods create the basis for Structural Health Monitoring systems providing continuous aircraft damage monitoring.

Fatigue sensors [1-3] perform the function of monitoring the exhaustion of carrying capacity of structures under cyclic loading. Such sensors are built in or fixed on structure elements and respond to in-service loads. The sensor response to the variation of structure loads provides a means of estimating the damage level and predicting their residual fatigue life.

The development of sensors offers promise of their employment as diagnostic tools of fatigue damage accumulation through the deformation relief (DR) on the surface of easily deformable pure aluminium [4].

These sensors can be monocrystalline in the form of thin films from aluminum single crystals [5], or polycrystalline as a specially treated surface of the cladding layer from aluminum of commercial purity on the specimens from structural aluminum alloys [4, 6].

The loading history for such sensors is estimated by the time variation of surface DR characteristics.

It may be the DR saturation *D* [7] or its fractal dimension [8]. These parameters are determined automatically from the surface images with local microplastic deformation traces.

These 2D images are obtained using optical microscopes (x 200-400) fitted with a digital camera[6-9] (Fig. 1. a-c). The DR saturation is also assessed with other effective methods based on automatic analysis of digital images [4, 10].

The surface DR as a diagnostic tool of fatigue damage becomes more informative with its 3D representation (Fig. 1. d-f). Micron-Alpha noncontact