Lüders Band Formation in Steel

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Introduction

This video was presented at the National Educator's Workshop, Update-2001, held at College Park, Maryland from November 15-21. Detailed descriptions of how we made it and how it has been used in our courses are given in the paper, "Lüders Band Formation in Steel – Video" which was published in the proceedings. The paper is also available on-line at:

www.kstreetstudio.com/MatSci/NEW/NEW-Update-2001.htm

Background

Lüders bands formation and propagation are fascinating aspects of the deformation of a number of materials and is well-known in steel. This phenomenon can be seen in stress-strain curves as the curious upper and lower yield strengths and yield point extension feature. This behavior is characterized by an initially high yield stress followed immediately by a sudden drop in stress. With continued straining the stress stays nearly constant for several percent strain before normal strain hardening behavior begins. A full explanation of this behavior involves a discussion of the density and velocity of mobile dislocations, how dislocations break free of the solute atoms, and how this results in a localized process which produces the Lüders bands which in turn propagate until they cover the whole specimen. The abstractness of this explanation can be helped by viewing this video.

The material shown in this video is a 1018 steel which had been annealed then polished to a metallographic (mirror) finish. During tensile testing a video camera, VCR, and PC was used to record the action taking place on the surface of the specimen. Lighting was a challenge which was eventually solved by using a ring illuminator and a stereo-zoom microscope. The resulting video clips looked like microstructures viewed under a microscope using dark-field illumination. The specimen itself appears dark with bright edges and the Lüders bands showed up as bright streaks.

Title screens, micron bars and all rendering was done using Adobe Premiere. The video was exported in three formats: 640x480x24-bits, 320x240x24-bits and 160x120x24 bits, all at a frame rate of 15 fps. These videos were also accelerated so that their runtimes would be less than the recommended three minutes.

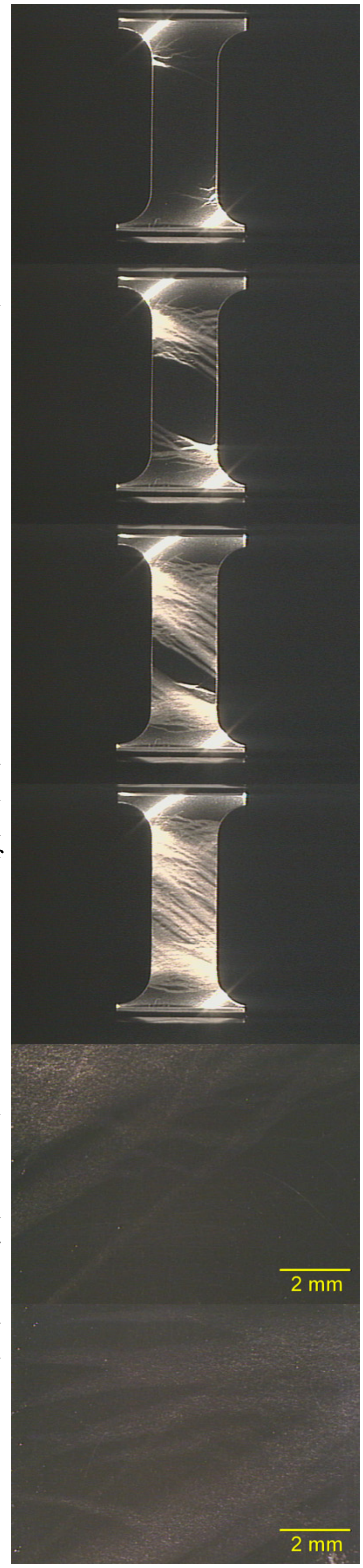

Figure 1 Selected frames from the video.

The final video is made up from the best clips from the nine tensile tests conducted. It starts by showing the whole specimen as it is deformed. Note how the Lüders band start at two opposite corners of the specimen, indicating that the sample was not fully aligned with the tensile axis. About half way through the video there are two segments showing the close-up views of individual Lüders bands growing and branching.

Feedback

We'd appreciate hearing from anyone who has viewed these videos and especially from those who have used them in their courses. You can contact Mike Meier at:

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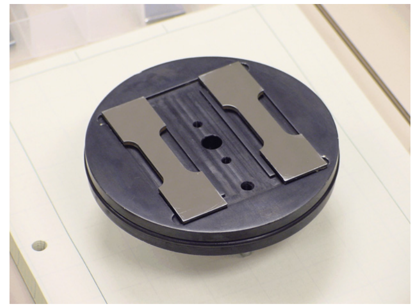

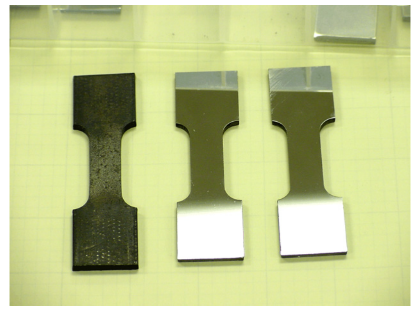

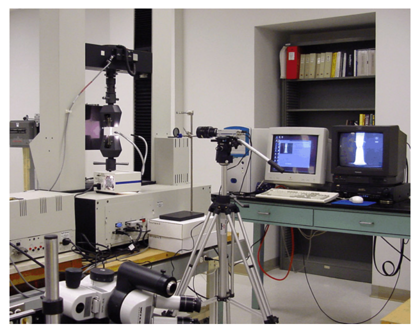

Figure 2
Top: the fixture used to hold the tensile samples during polishing. Grinding and polishing was done using a Buehler Ecomet 3 with Automet power head and a Buehler Vibromet 2 vibrator polisher.

Second: The tensile samples, before and after polishing.

Third: The original set up using a camera and zoom lens, polarizer and fiber optic light pipes for illumination. The computer and VCR are also shown.

Bottom: The final arrangement using a stereo-zoom microscope and ring illumination.