Rockwell International

5

MATERIALS AND PROCESSES
FAILURE ANALYSIS LABORATORY

TEST REPORT

NUMBER PTN 027940

DATE REC'D IN LAB 9/24/92

NOMENCLATURE/SUBJECT Evaluation of Laser Marked Ti-6Al-4V
(Support to Vericode Laser Marking Development)

CONTRACT/LR LR 5941 SPECIFICATION none

REQUESTOR L. Burgess DEPT 284-204 LOCATION AB70 PHONE 2-3006

LABORATORY NOTEBOOK PAGES

BACKGROUND

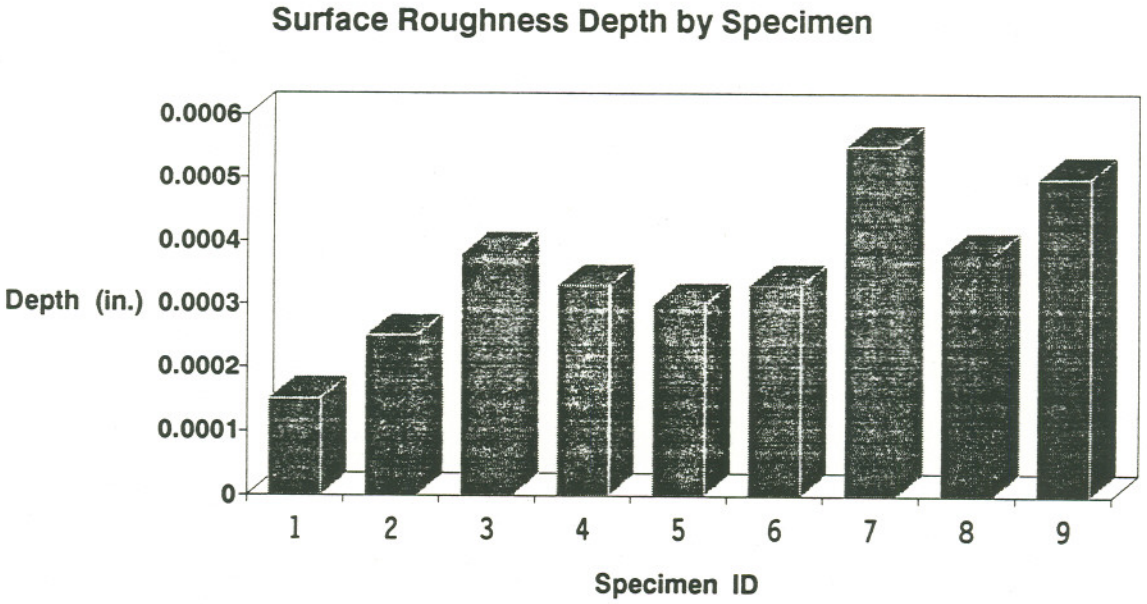
The Metallurgical Laboratory was provided a specimen of Ti-6Al-4V which had been Vericode marked using a laser. Each of the nine Vericodes was created using different parameters, such as pulse frequency, beam speed, and lamp current. (See Table I for specifics.)

Table I

Specimen ID	Lamp Current (amps.)	Beam Speed (mm/sec.)	Pulse Frequency (Hz)
1	165	450	4000
2	165	450	5000
3	165	450	6000
4	185	450	6000
5	195	450	7000
6	200	450	8000
7	210	350	8000
8	220	350	9000
9	220	250	10000

Veritec is currently developing the parameters for laser marking of titanium and the specimen was provided for destructive evaluation. The intent was to determine through optical, SEM, and metallographic techniques, which marking parameters produced the fewest artifacts detrimental to the integrity of the titanium substrate.

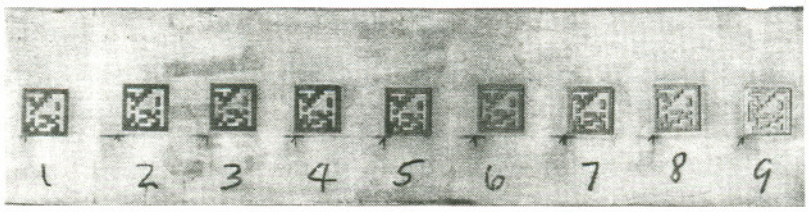
Determination of true alpha case development was somewhat difficult, as the primary structure of the parent material was alpha. The surface roughness induced by laser marking was measured and is plotted graphically below.



Each of the laser marked Vericode cross sections is illustrated in Figures 14 through 31.

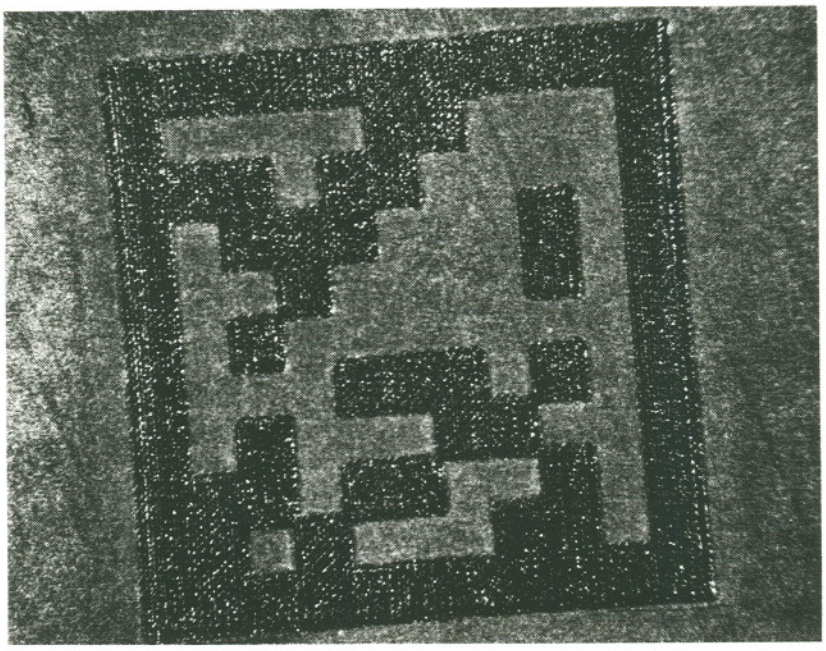
SUMMARY

Destructive evaluation of the laser marked Vericode specimens indicated very little substantial damage until the most severe marking parameters (>#7) were utilized. The harshest marking parameters did induce some fissuring which could be detrimental to the performance of a marked substrate. In addition, the microstructure of the specimen supplied made determination of the exact depth of the heat affected area difficult.



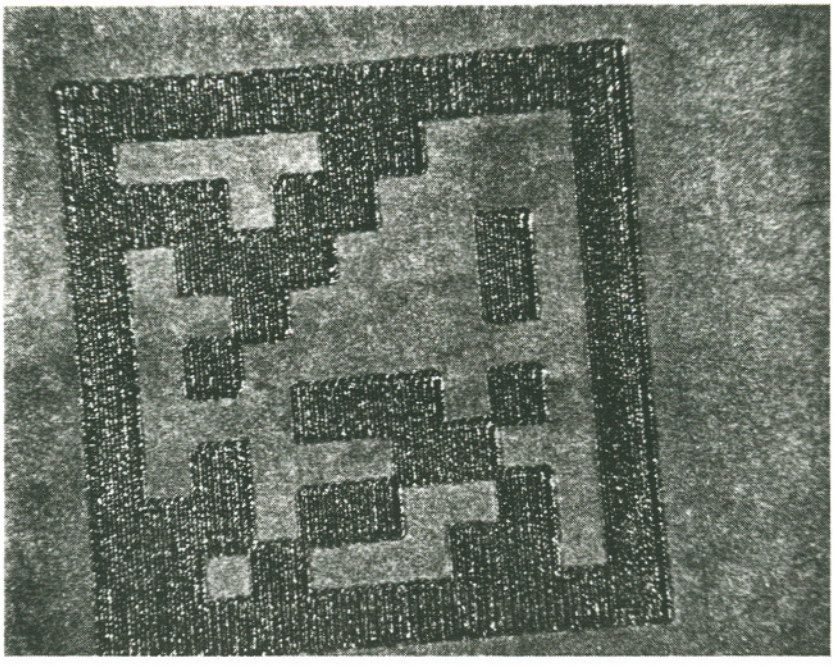
0.7X

Figure 1. Overall view of the Vericode marked specimen with each of the Vericode specimens identified.



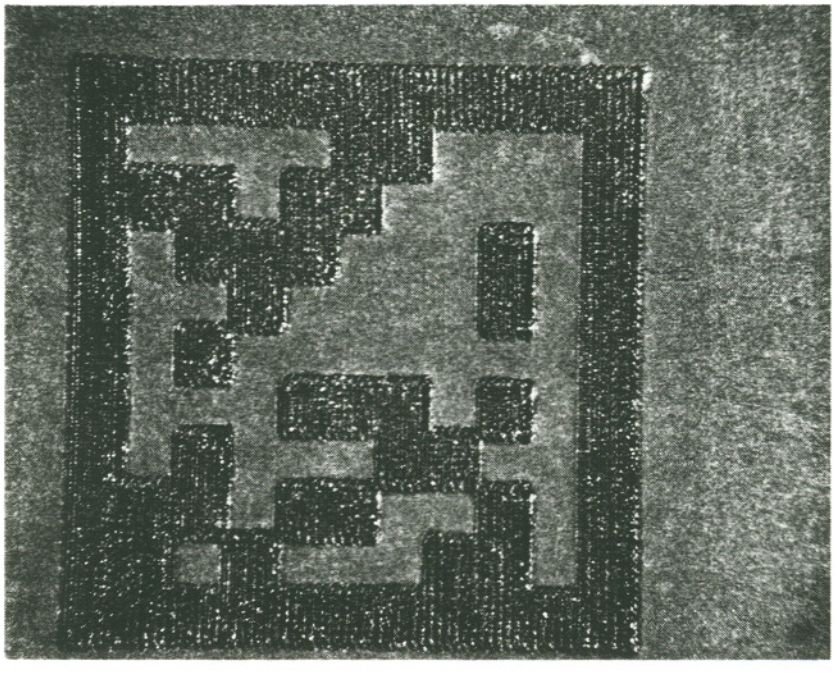
10X

Figure 2. Detail view of Vericode specimen #1.



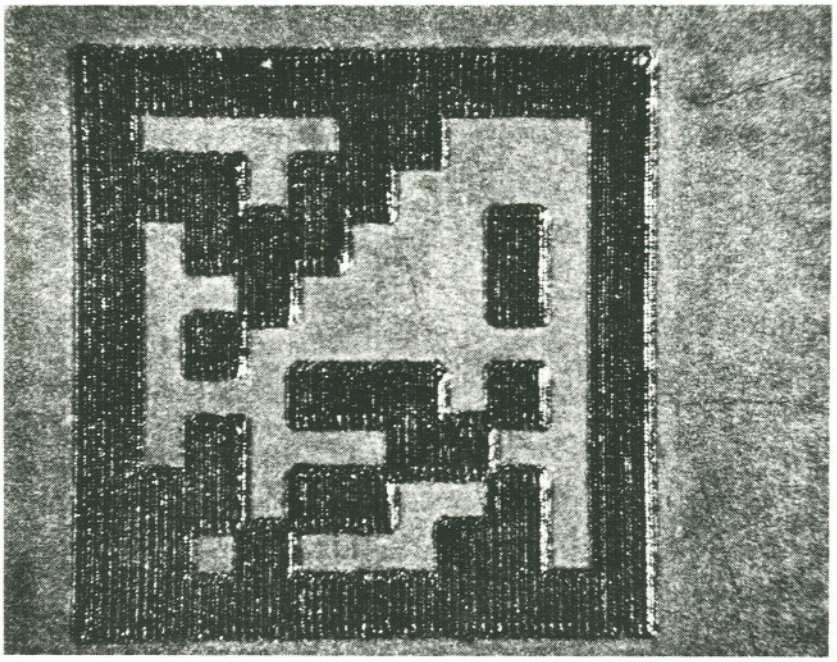
10X

Figure 3. Detail view of Vericode specimen #3.



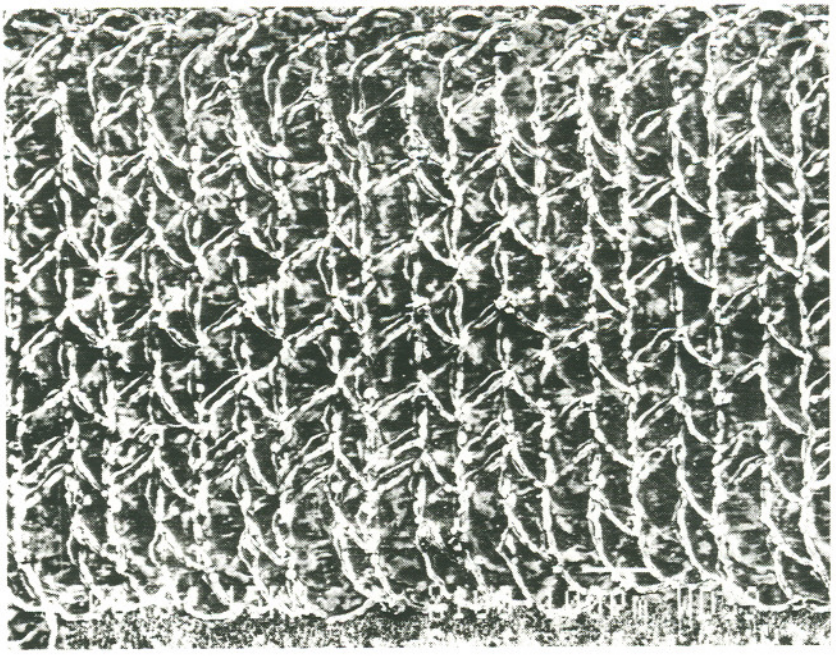
10X

Figure 4. Detail of Vericode specimen #6.



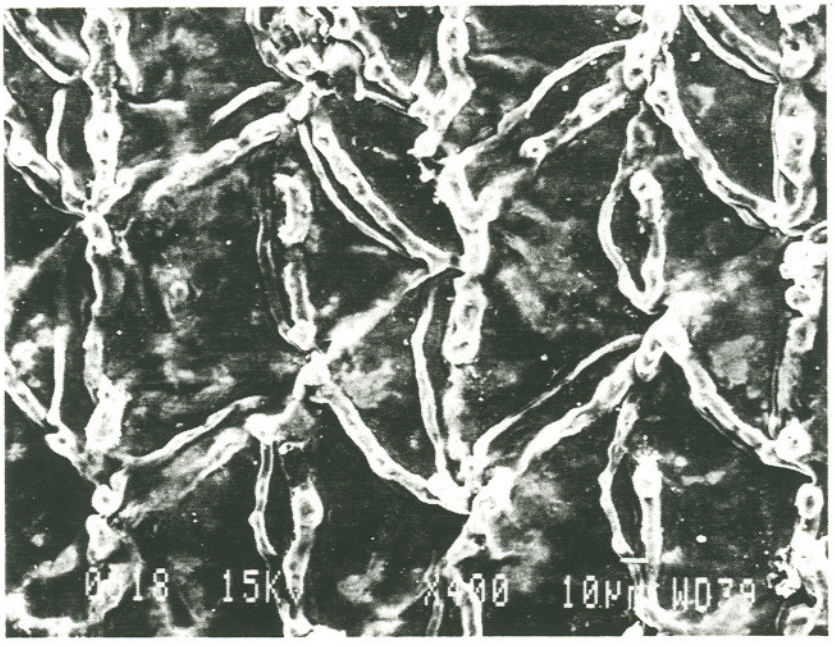
10X

Figure 5. Detail of Vericode specimen #9, the most heavily marked.



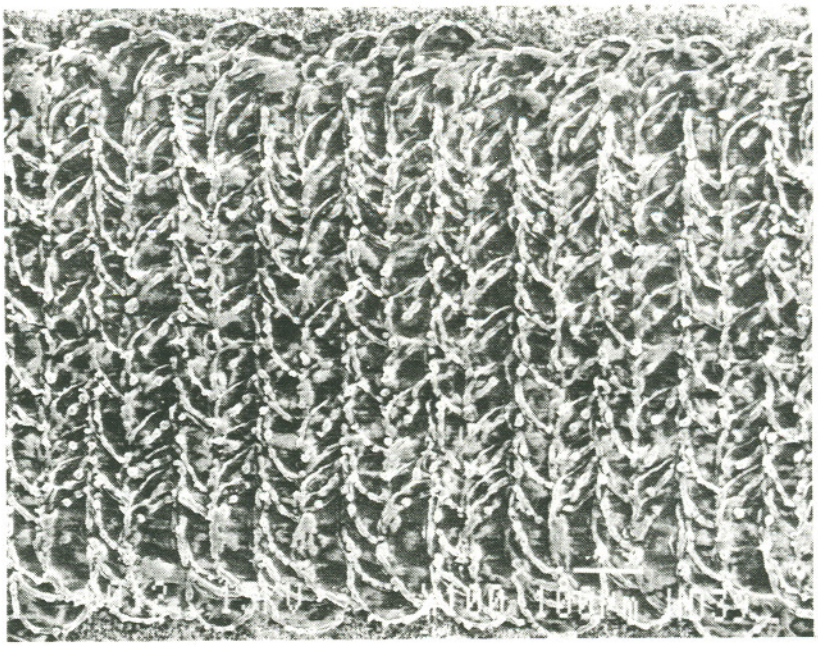
100X

Figure 6. Medium magnification of the typical laser marked texture of specimen #1. Compare with subsequent figures.



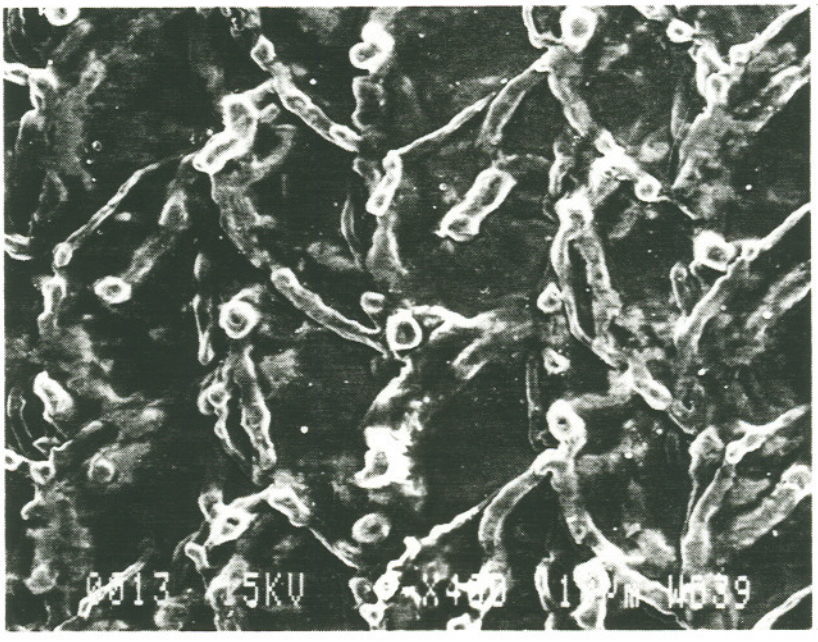
400X

Figure 7. Higher magnification of the typical laser marked surface of specimen #1.



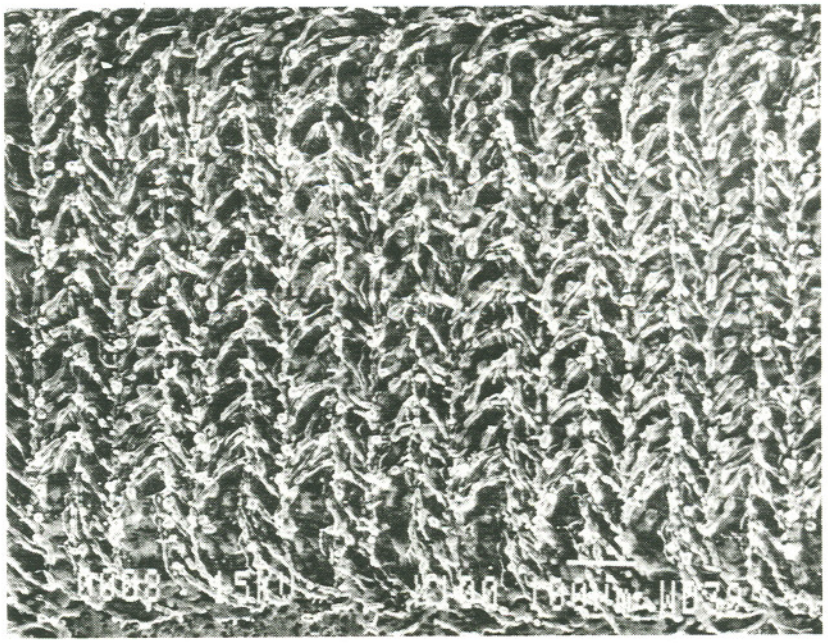
100X

Figure 8. Typical laser marked surface of specimen #3. Note the slightly higher pulse density when compared to specimen #1.



400X

Figure 9. Higher magnification view of the laser marked surface of specimen #3.

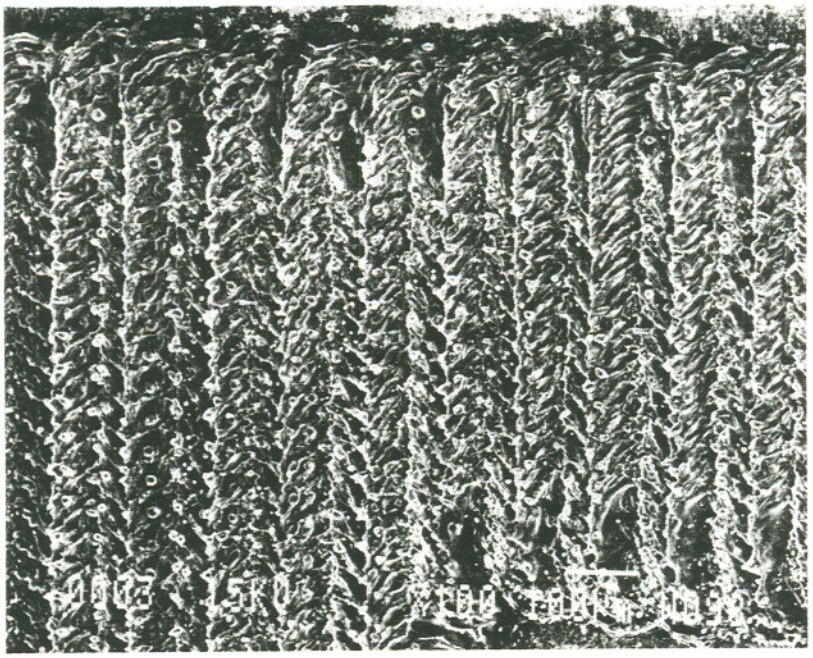


100X

Figure 10. Typical laser marked surface of specimen #6. Note the pulse density.

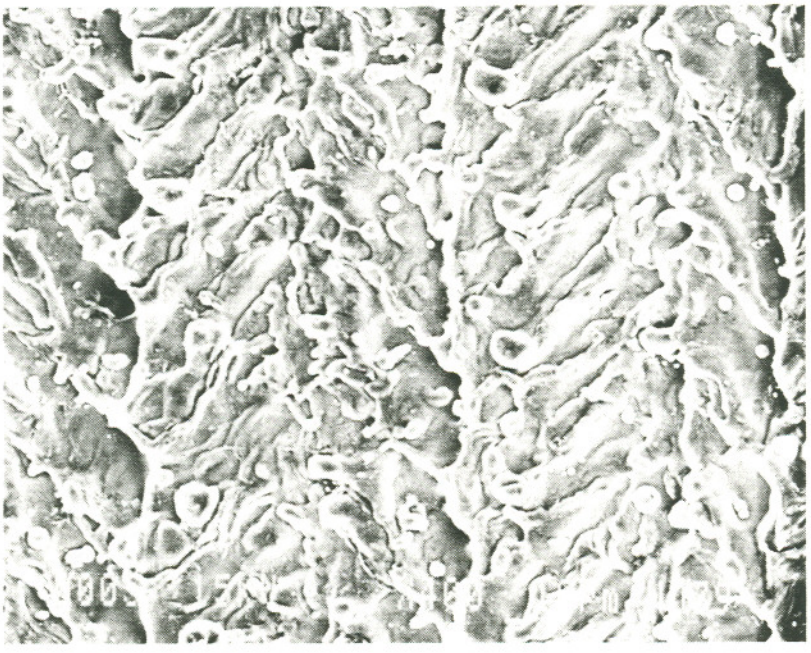
400X

Figure 11. Higher magnification of the typical surface of specimen #6.



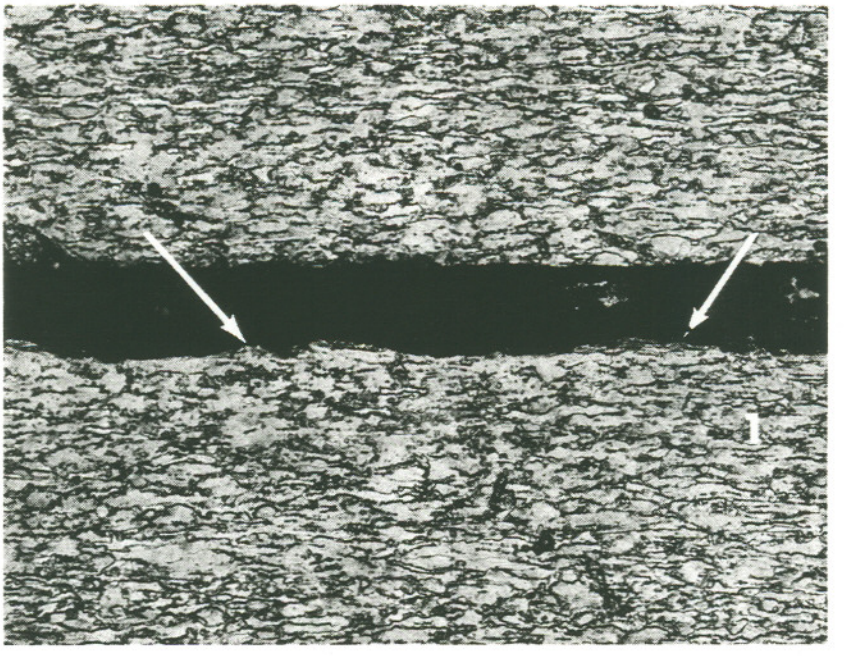
100X

Figure 12. Typical surface of laser marked specimen #9. Note the high pulse density.



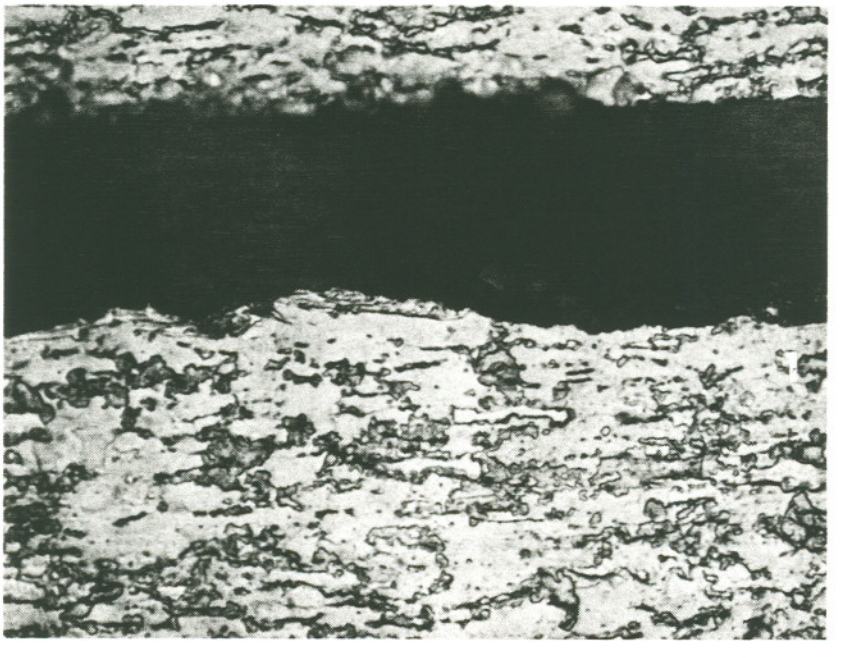
400X

Figure 13. Higher magnification of the typical laser marked surface of specimen #9.



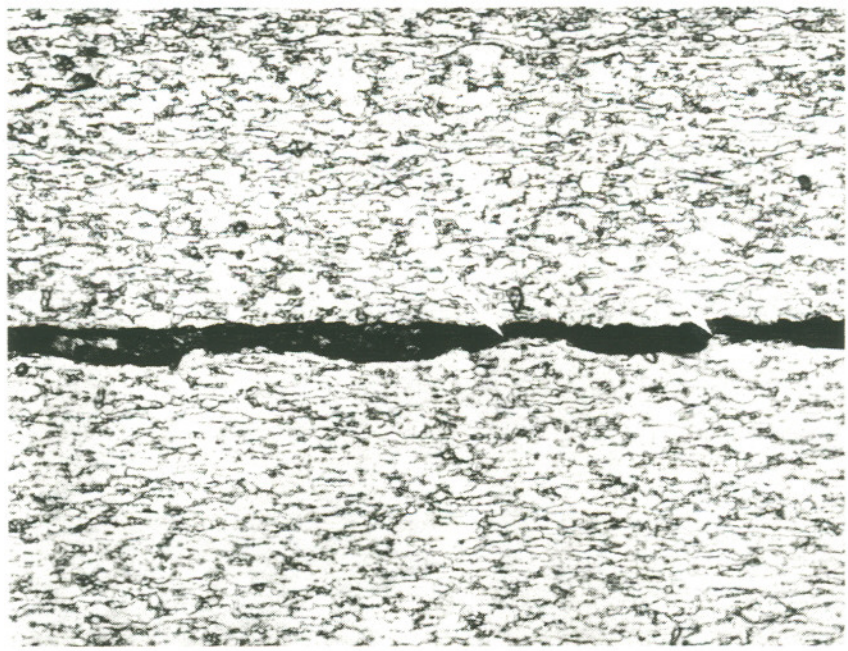
400X

Figure 14. Metallographic cross section through the laser marked area of specimen #1. The surface roughness is not great, compared to the other specimens (subsequent figures).



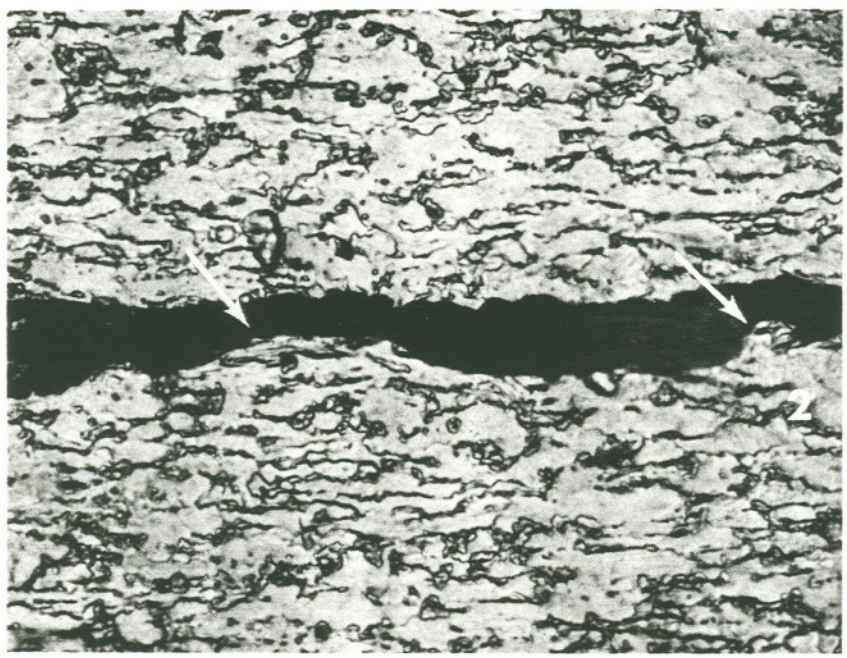
1000X

Figure 15. Higher magnification of the typical laser marked area of specimen #1.



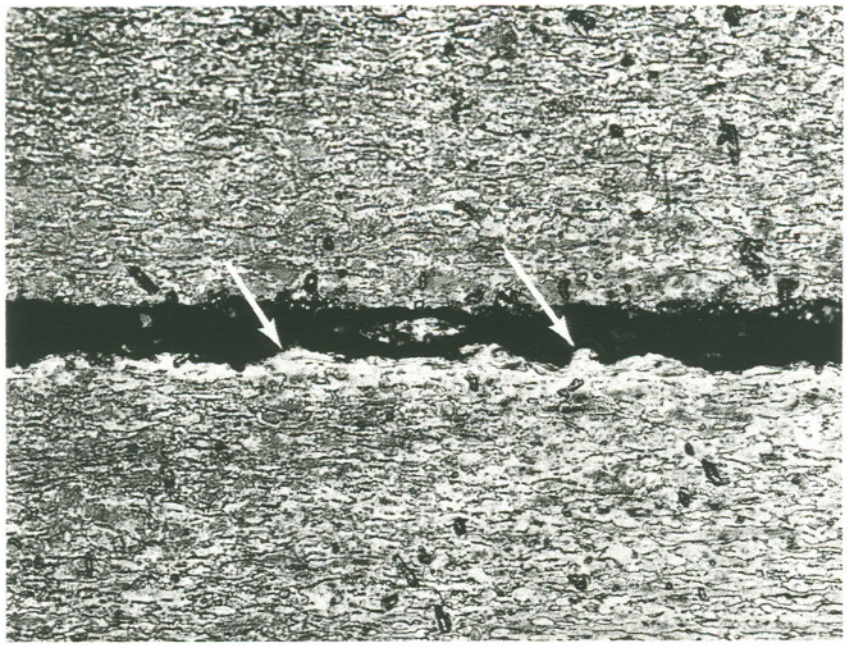
400X

Figure 16. Typical metallographic cross section through the laser marked area of specimen #2.



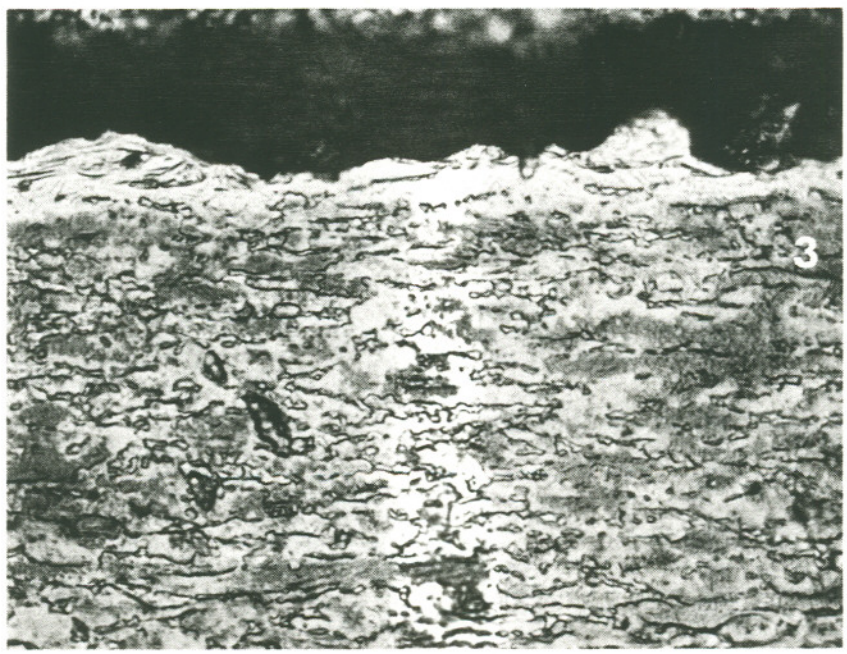
1000X

Figure 17. Higher magnification of the laser marked area of specimen #2 shown above.



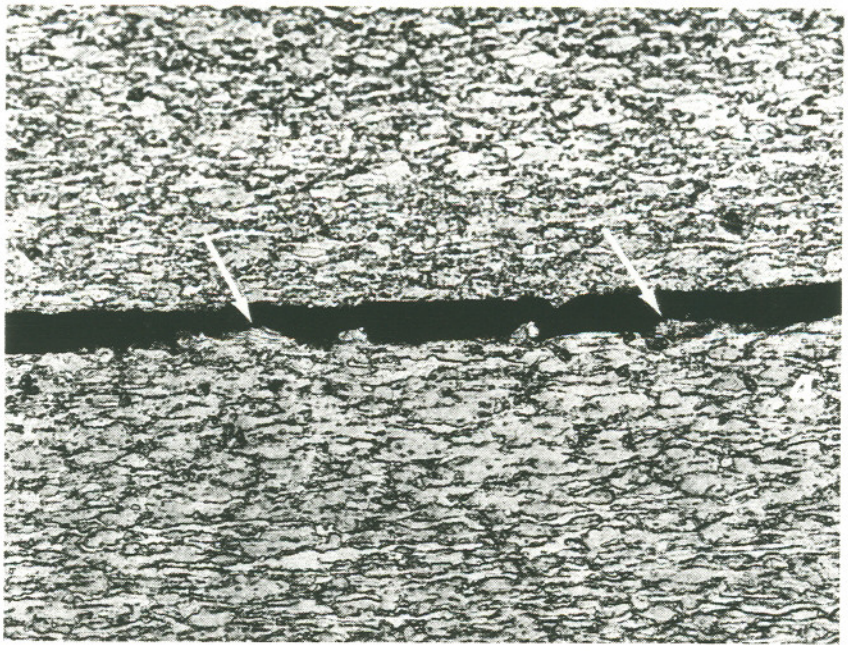
400X

Figure 18. Typical metallographic cross section through the laser marked area of specimen #3.



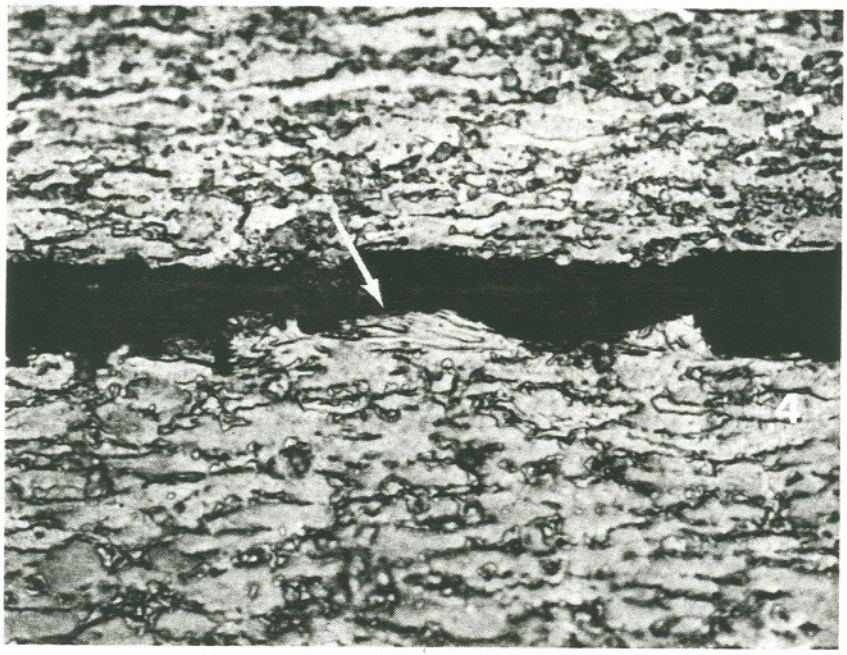
1000X

Figure 19. Higher magnification of the laser marked area of specimen #3 shown above.



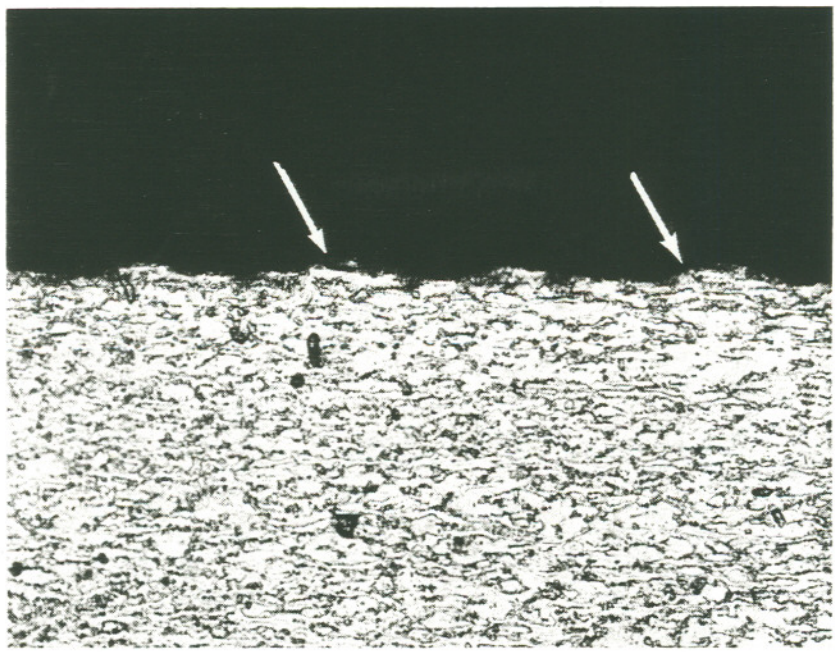
400X

Figure 20. Typical cross section through the laser marked area of specimen #4.



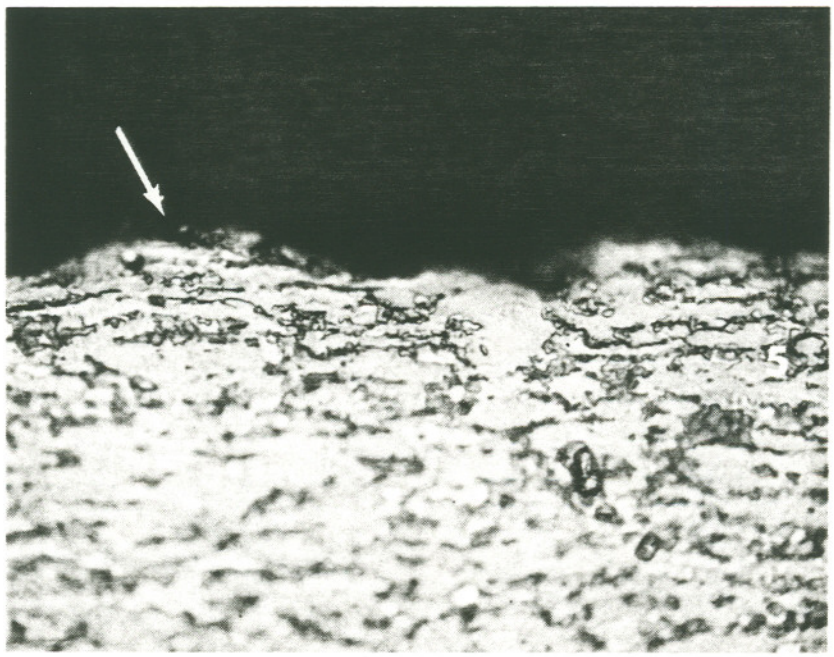
1000X

Figure 21. Higher magnification view of the laser marked area of specimen #4 shown above.



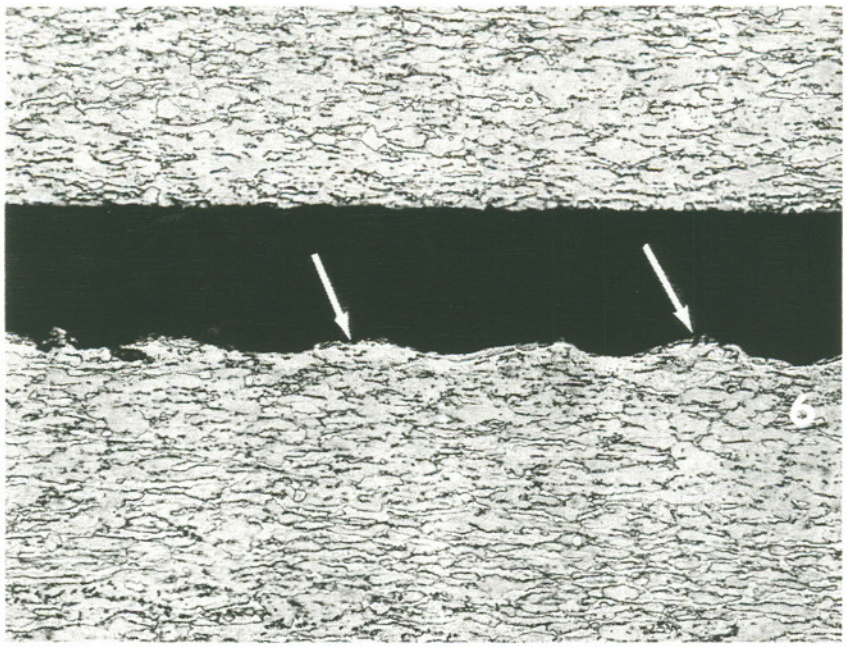
400X

Figure 22. Typical metallographic cross section through the laser marked area of specimen #5.



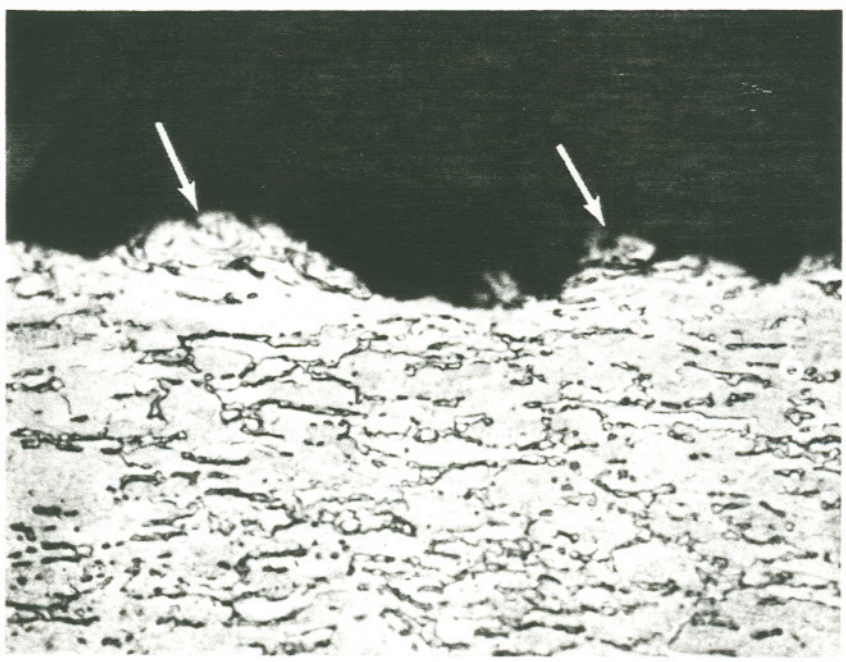
1000X

Figure 23. Higher magnification of the laser marked area of specimen #5 shown above.



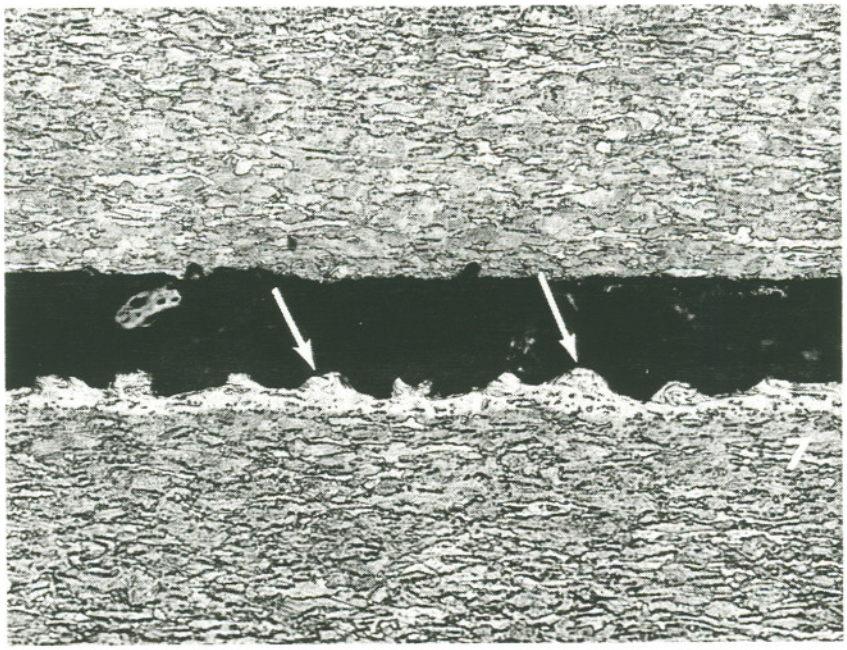
400X

Figure 24. Typical cross section through the laser marked area of specimen #6.



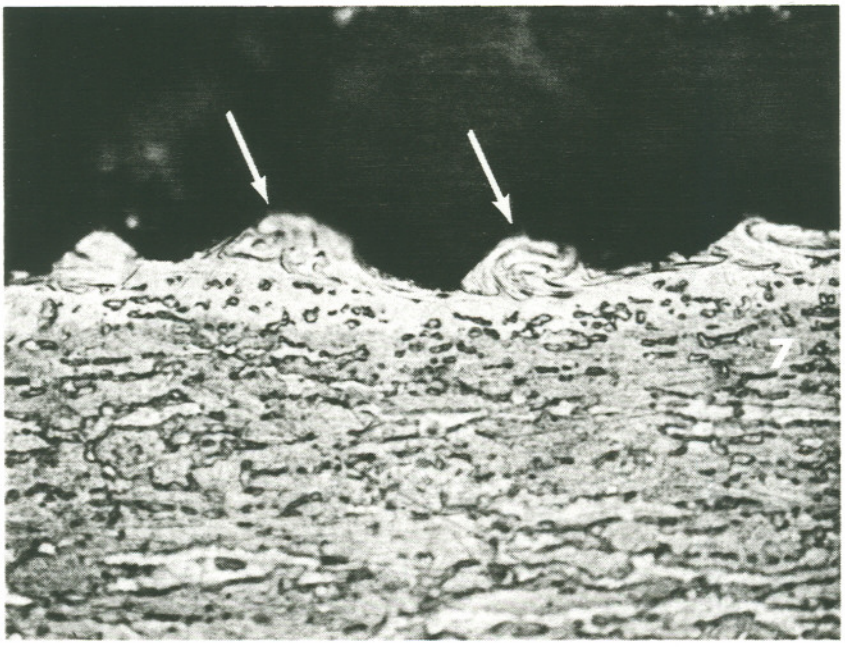
1000X

Figure 25. Higher magnification of the laser marked cross section of specimen #6 shown above.



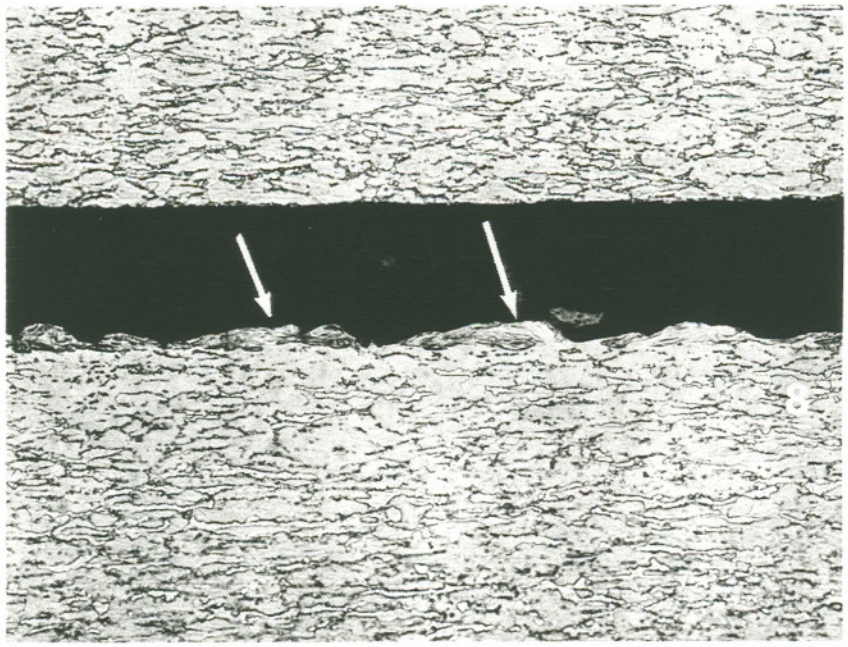
400X

Figure 26. Typical cross section through the laser marked area of specimen #7.



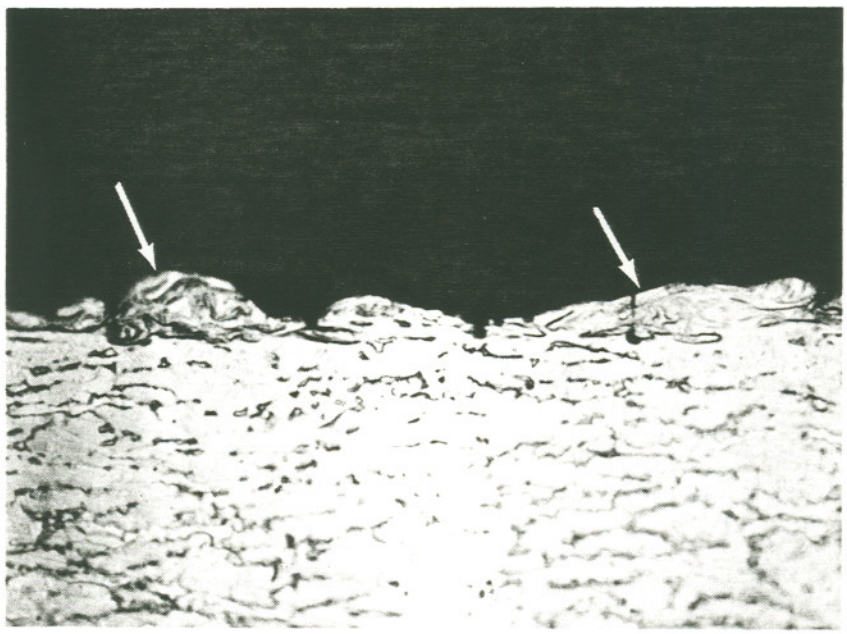
1000X

Figure 27. Higher magnification of the laser marked region of specimen #7 shown above.



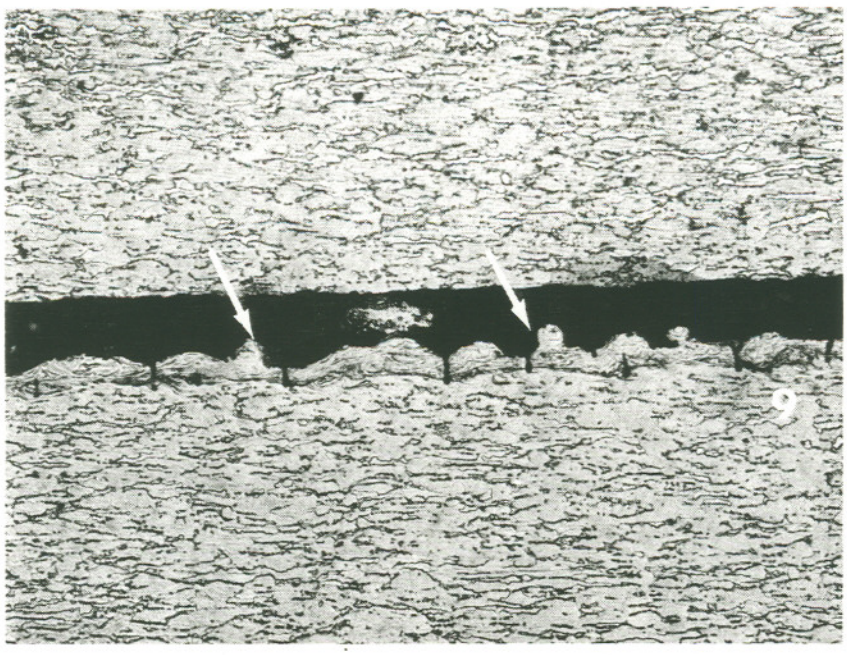
400X

Figure 28. Typical cross section through the laser marked area of specimen #8.



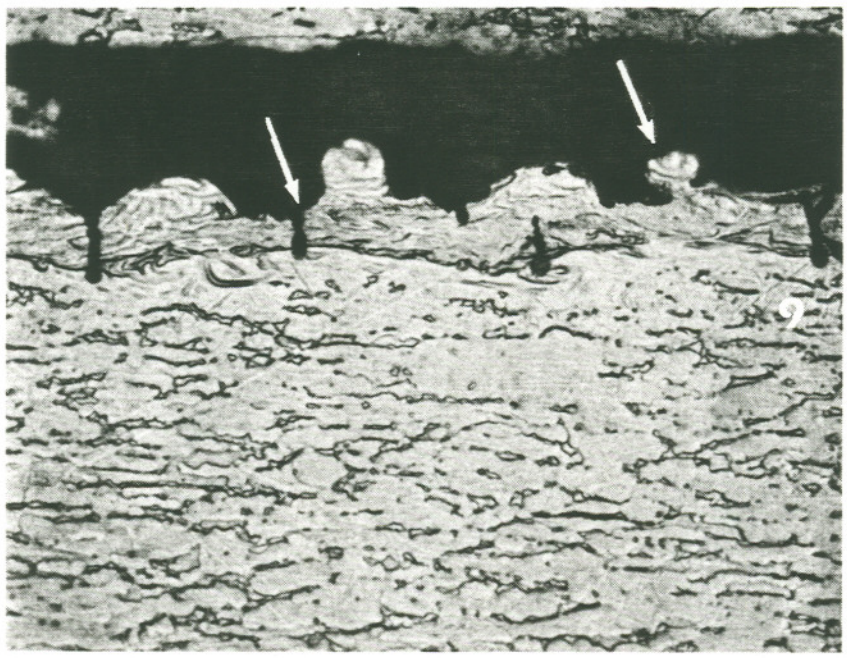
1000X

Figure 29. Higher magnification of the laser marked region of specimen #8 shown above.



400X

Figure 30. Typical cross section through the laser marked area of specimen #9, showing fissuring at the base of most of the resolidified nuggets.



1000X

Figure 31. Higher magnification of the recast and fissured area of specimen #9 shown above.