Structural-phase State of Cold Deformed Stainless Steel after Hight Power Pulsed Ion Beam Processing

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INTRODUCTION

Surface modification of metals and alloys by beams of accelerated ions is one of the promising directions for materials processing. It is known, that high-energy impact of high-power pulsed ion beams (HPPIB) can be accompanied by a number of processes, including: heating, melting and evaporation; excitation of compression waves in the target due to the recoil pulse; rapid cooling of the heated surface layer deep into the target at speeds of 10^9-10^{10} K/s [1,2]. Under the influence of these processes, structural and phase transformations occur in the material, as well as changes in the surface topography. This leads to modification of the surface layer of the material and improvement of its properties. An improvement in the hardness of the carbide tool by 2.5 times after HPPIB processing was shown in [3]. In works [4, 5], for high-speed steel W6Mo5Cr4V2 after exposure to ion beam, increased wear resistance and improved corrosion properties were found. Increasing the tribological properties of the magnesium alloy AZ31 is considered in [6].

For stainless steel, it was found that HPPIB processing leads to a decrease in the coefficient of friction and an increase in microhardness and corrosion resistance [7]. However, structural and phase transformations in near-surface layers of such stainless austenitic steels exposed by high-power pulsed ion beam have not been studied sufficiently.

EXPERIMENTAL SETUP

Material: AISI 321 stainless steel after cold deformation (ε=0.5, T=25°C)
Sample preparation: mechanically polishing
Surface treatment: TEMP accelerator under the following modes:

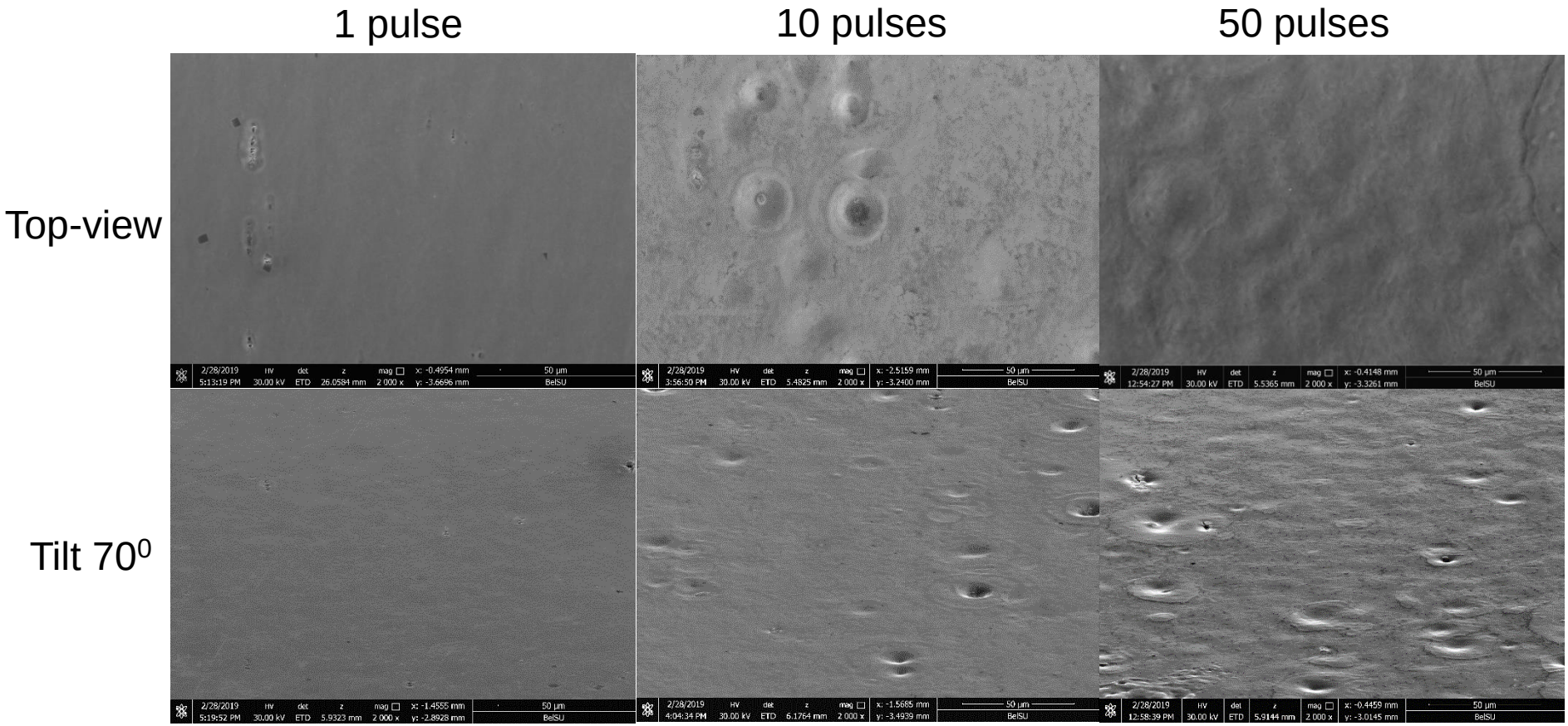
- the ion energy was 250 keV;
- the pulse duration was ~100 ns at the half-height;
- the pulse current density was 70 A/cm^2;
- the number of pulses was 1, 10, and 50.

Investigations: scanning electron microscopy (Nova Nanosem 450), X-ray diffraction (ARL X'TRA)

TEMP accelerator (Tomsk Polytechnic University)

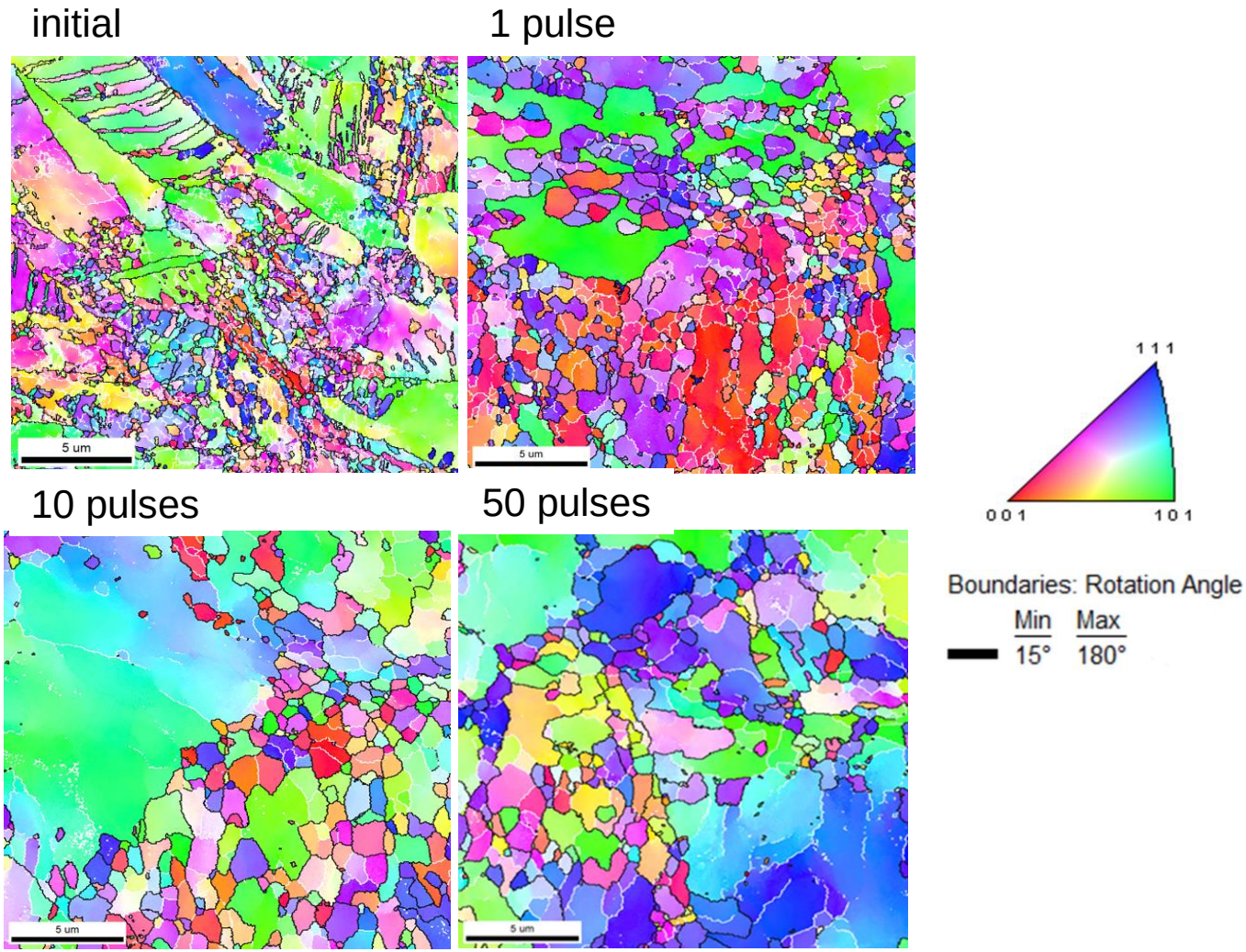
Surface Topography

- HPPIB processing leads to the formation of crater-type defects on the steel surface
- The average crater size, their surface density and surface roughness increase with increasing number of pulses.



Topography of the surface of steel after HPPIB processing

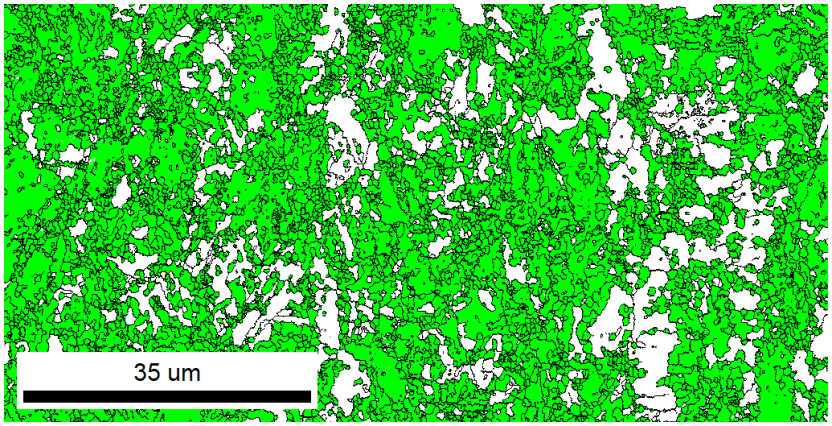
Structure and phase composition



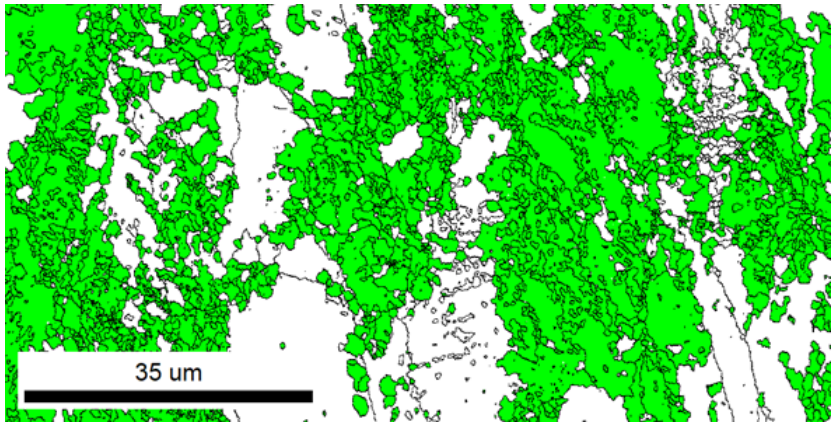
Orientation image maps of stainless steel in the initial state and after irradiation by HPPIB

Structure and phase composition

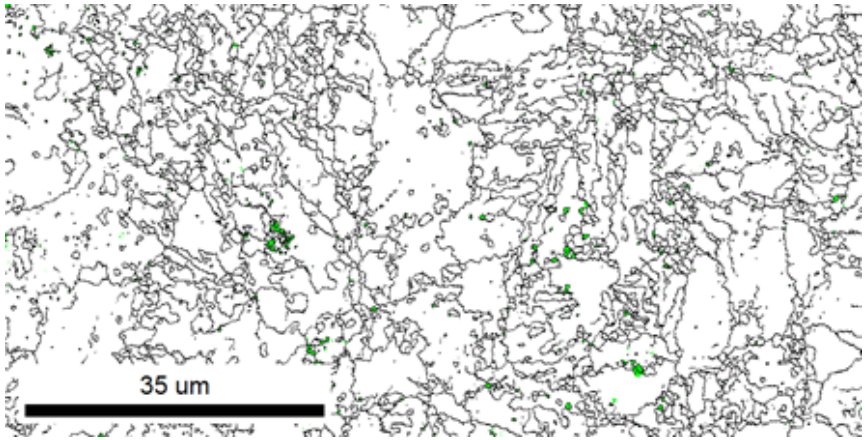
1 pulse



10 pulses



50 pulses

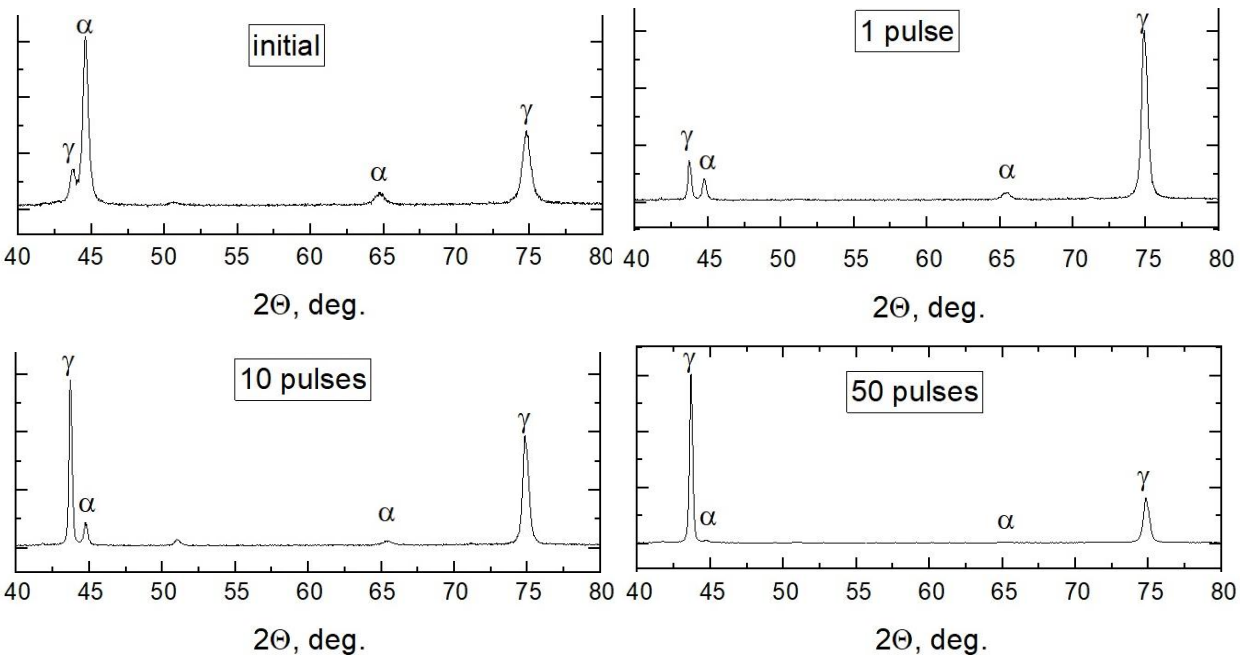


Phase
Austenite
Ferrite

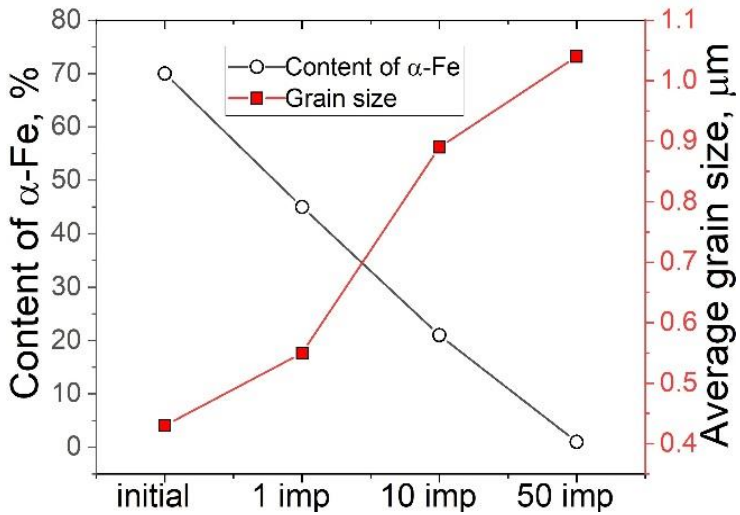
Boundaries: Rotation Angle
Min Max
15° 180°

Phase-distibution maps of stainless steel after irradiation by HPPIB

Structure and phase composition



XRD patterns of steel in the initial state and after irradiation by HPPIB



α-Fe content and average grain size in the stainless steel before and after irradiation by HPPIB

CONCLUSION

1. The surface irradiation of stainless steel by the high power pulsed ion beam (HPPIB) leads to the formation of surface defects in the forms of craters.

2. The average grain size increases with the number of pulses.

3. HPPIB processing changes the phase composition of the surface layers of stainless steel. The ferrite content in the near surface layer decreases with increasing number of pulses.

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