Available online at www.sciencedirect.com
ScienceDirect
Vacuum 81 (2007) 1252–1255
VACUUM
SURFACE ENGINEERING, SURFACE INSTRUMENTATION & VACUUM TECHNOLOGY
www.elsevier.com/locate/vacuum

Ion implantation effect on atomic structure of deformed Si, Ir, W, Ni and Cu

Rostyslav Shalayev[a,*], Vladimir Ivchenko[b], Borys Efros[a], Andrzej Misiuk[c]

[a]*Physics and Technology Institute of NASc of Ukraine, St. R. Luxemburg 72, 83114 Donetsk, Ukraine*
[b]*Institute of Electrophysics of Ural Branch of RAS, St. Amundsen 106, 620016 Ekaterinburg, Russia*
[c]*Institute of Electron Technology, Al. Lotnikow 32/46, 02-668 Warsaw, Poland*

Abstract

It has been revealed, that in Ir subjected to severe plastic deformation, an ultrafine grained structure (UFG) is formed (the grain size of 20–30 nm). Practically no defects have been detected within the grains, while, in the case of Ar^+ implantation, the subgrain structure with characteristic sizes of about 3–5 nm is formed; defects have been detected within subgrains.

The subgrain structure was also revealed in UFG Ni and Cu after severe plastic deformation (SPD) (subgrain size of 3–15 nm), but in the latter case the observed boundary region is broader and subgrain is highly disoriented.
© 2007 Elsevier Ltd. All rights reserved.

Keywords: Severe plastic deformation; Field ion microscopy; Ultrafine grained structure

1. Introduction

Producing ultrafine grained materials with 10–200 nm grain sizes, among which there are sub microcrystalline (the average grain size ~100–200 nm) and nanocrystalline (the average grain size ~10 ⩽ 100 nm) is one of the most actively investigated problems at present. It is known that such materials indicate unique physical and mechanical characteristics [1–4].

The UFG materials are produced by quick cooling of the melt, powder methods, ball milling and by SPD. The latter methods [3,5,6] are well suited for the production of UFG specimens that have no contaminations. Such specimens are very suitable for defect-structure investigations. Besides, from the strain-hardening point of view, of interest are experimental studies of radiation-induced defects in irradiated materials when there are no radiation-stimulated phase transitions, and the increased density of implantation defects can result in essential changes in structure state and properties.

The field ion microscopy (FIM), providing direct observation of individual atoms constituting the samples, has been applied as the basic measurement tool in this work. The FIM method potentially makes it possible to investigate the real structure of the crystal lattice of solids, at the atomic level and at the same time to analyze the atomic structure of an object in the volume by a controllable consecutive removal of surface atoms by the electric field.

2. Materials and experimental methods

The objects investigated in this work are: polycrystalline Ir, W, Ni and Cu of 99.95–99.99% purity, with the initial grain size ≈20–50 μm, single-crystalline Si subjected to self-implantation with Si^+. Some metallic samples were pretreated using Ar^+ implantation and severe plastic deformation.

The atomic structure of defects of different *n*-dimensionality (preferentially the in-plane type) was studied after SPD and ion irradiation of the metals. The UFG structures in Ir, W and Cu were formed by the SPD method of shear (logarithmic deformation $e \approx 7$) under quasi-hydrostatic pressure by using a plant of the Bridgman anvils type [5].

SPD of Ni, aimed at obtaining UFG structure, was carried out by the method of packet hydroextrusion (PHE)

*Corresponding author. Tel.: +380 501614272; fax: +380 623377608.
E-mail addresses: sharos@mail.ru (R. Shalayev), voca_2000@mail.ru (V. Ivchenko), b_efros@mail.ru (B. Efros), misiuk@ite.waw.pl (A. Misiuk).

0042-207X/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.vacuum.2007.01.024

(with the maximal logarithmic deformation $e \approx 12$) under the room-temperature conditions [7].

The Ir samples also were irradiated by argon ions with the energy $E = 20$–24 keV, the irradiation dose $D = 10^{18}$ ion/cm^2 and the current density $j = 300\,\mu$A/cm^2.

The samples of metals to be investigated by the FIM method were in the form of needle-like emitters, prepared from the radiated and SPD-treated billets by electrochemical polishing, with the curvature radius of 30–50 nm. The plant for FIM investigation consisted of a field ion microscope fitted with a micro-channel ion–electron converter providing a 10^4 times gain in brightness of micro-images. Liquid nitrogen ($T = 78$ K) was the coolant and the image-making gas was neon of spectral purity [8].

3. Experimental results and discussion

The sample of pure Ir preliminarily certified in the field ion microscope (the initial state) had atomically smooth surface in situ prepared by the field evaporation of the surface atoms. The ion images of the certified field emitters (Ir samples) fixed a truly ring-like pattern typical of single crystals pointing to the absence of the atomic lever structure defects in the grain body.

After the ion irradiation, the implanted samples were placed in the FIM once again. The field ion images of the surface were registered by a video or a photographic camera under a controllable removal of one atomic layer after another; next, the state of metal in the near-surface layer was analyzed. As a result, in the implanted pure Ir there was a high density of point, linear and volume structure defects (Fig. 1).

A comparative analysis of structure defects revealed in Ir after SPD ($e \approx 6$) and in implanted Ir (see Figs. 1a–c) has shown their structure to be essentially different and dependent on external influence type. In the UFG Ir there were the deformation grain boundaries, $d_g \approx 20$–30 nm, and in the grain bodies there were practically no crystal structure defects (Fig. 1b). On the contrary, in the irradiated UFG Ir (Figs. 2a–c), a subgrain structure (subgrain size $d_{sg} \approx 3$–5 nm) was revealed. The angular misorientation ω of subgrain was approximately equal to

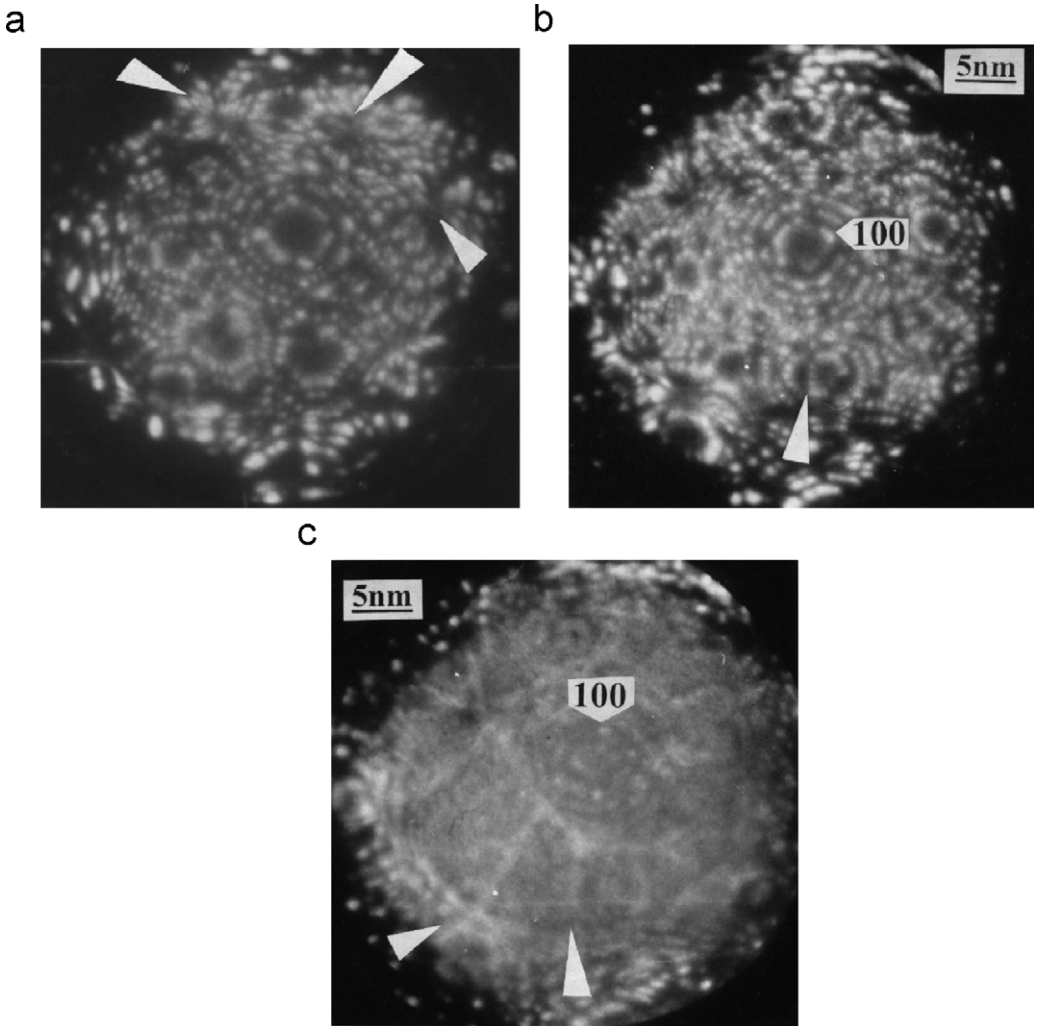

Fig. 1. Field ion image of Ir surface after the argon ion implantation ($E = 20$ keV, $D = 10^{18}$ ion/cm^2, $j = 300\,\mu$A/cm^2): (a) $V = 7.2$ kV (a micro-pore is shown), (b) $V = 8.4$ kV (the arrows show the crystal-lattice defects), and (c) $V = 8.9$ kV.

Download English Version:

https://daneshyari.com/en/article/1689325

Download Persian Version:

https://daneshyari.com/article/1689325

Daneshyari.com