Materials Letters 132 (2014) 157–161

Contents lists available at ScienceDirect

Materials Letters

journal homepage: www.elsevier.com/locate/matlet

Microstructure and phase transformation on milled and unmilled Ti induced by water quenching

A.S. Bolokang [a,b,*], M.J. Phasha [c], D.E. Motaung [b], F.R. Cummings [a,d], T.F.G. Muller [a], C.J. Arendse [a]

[a] Department of Physics, University of the Western Cape, Private Bag x17, Bellville 7535, South Africa
[b] DST/CSIR Nanotechnology Innovation Centre, National Centre for Nano-Structured Materials, Council for Scientific and Industrial Research, P.O. Box 395, Pretoria 0001, South Africa
[c] Transnet Engineering, Product Development, Private Bag X 528, Kilnerpark, Pretoria 0127, South Africa
[d] Electron Microscope Unit, University of the Western Cape, Private Bag x17, Bellville 7535, South Africa

ARTICLE INFO

Article history:
Received 10 March 2014
Accepted 11 June 2014
Available online 18 June 2014

Keywords:
Microstructures
Twinning
Phase transformation
Orthorhombic
Crystal orientation
FCC

ABSTRACT

Water quenching of unmilled Ti compact has yielded martensitic-type laths and fishbone-type twinned microstructures, with α′, α′′ and FCC phases induced. Upon quenching 30 h milled and (0+30) h mixed powders at 1200 °C, α′, FCC, tetragonal and BCC phases were detected using XRD.

1. Introduction

Titanium (Ti) belongs to group IV 3d transition metals with a hexagonal-closed packed (HCP) α phase at room temperature. It is widely used in structural applications due to its attractive properties such as high strength-to-density ratio, good formability and excellent corrosion resistance. These properties render Ti as a material of choice in aerospace and other fields of engineering [1,2]. Its physical and mechanical properties are greatly influenced by the preferred crystal orientations and microstructure [3]. In a quest to improve the mechanical properties of commercially pure (CP) Ti, many studies have been carried out on the deformation mechanisms [4,5]. Most experimental studies on the specific plastic deformation mechanism of pure Ti have been performed using a number of processing routes such as electropulse quenching [6–8], water quenching (WQ) [7–9], severe plastic deformation (SPD) techniques such equal channel angular pressing (ECAP) or rolling [10–12]. They are non-equilibrium processes that are capable of inducing excellent mechanical properties by altering surface microstructures. This behavior is shown by the fishbone-type microstructure induced by ECAP in pure Ti [13]. Despite such processes being capable of inducing interesting microstructures, the structural transformation induced by deformation remains unclear. One of the old cost-effective traditional methods of achieving novel microstructures is WQ. So far, it is not clear, how high temperature water-quenching (above 1000 °C) can vary the surface structures of pure Ti which is very crucial for biomedical application.

2. Experimental procedure

Unmilled Ti with an average particle size of about 45 μm was milled for 30 h under argon atmosphere. The average size of Ti particles after milling was reduced to 32 μm. Both powders were compacted into discs of 17 mm in diameter and 3 mm thickness at a pressure of 20 MPa in a uniaxial press. The discs were sintered in a carbolite tube furnace at 1200 °C under argon atmosphere for 2 h. WQ was carried out at 1000 and 1200 °C. The discs compositions were 0, 30 and a mixture of 0 and 30 h Ti powders. Quenched samples were grounded with 200 to 320 grit silicon carbide papers and final polishing was done with colloidal silica suspension. Etching was done using a solution of 10 ml hydrofluoric acid, 20 ml nitric acid and 50 ml distilled water. Microstructures

* Corresponding author at. Transnet Engineering, Product Development, Private Bag X 528, Kilnerpark, Pretoria 0127, South Africa.
E-mail addresses: Sylvester.bolokang@transnet.net, Bolokang.sylvester@yahoo.co.uk (A.S. Bolokang).

http://dx.doi.org/10.1016/j.matlet.2014.06.063
0167-577X/

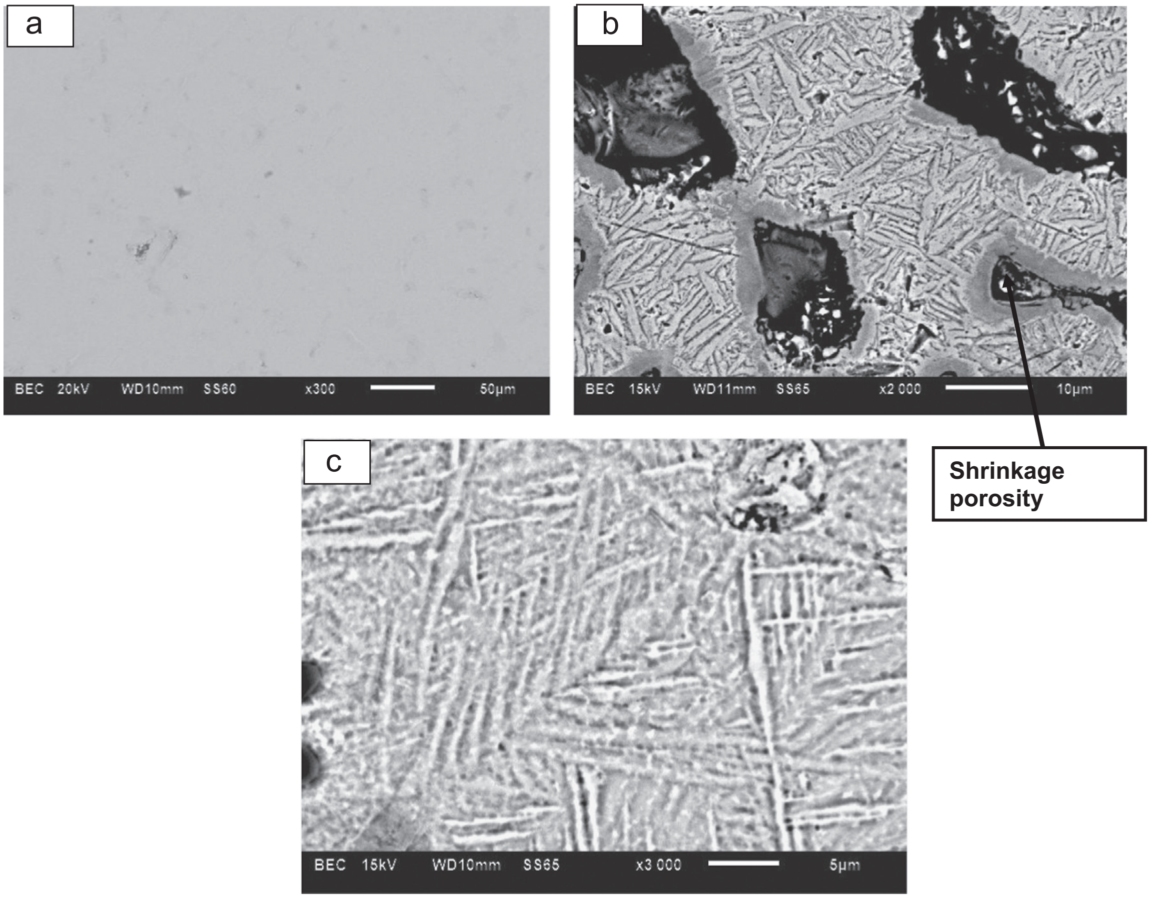

Fig. 1. SEM images of pure Ti (a) sintered at 1200 °C, (b) WQ-1000 °C, and (c) WQ-1200 °C.

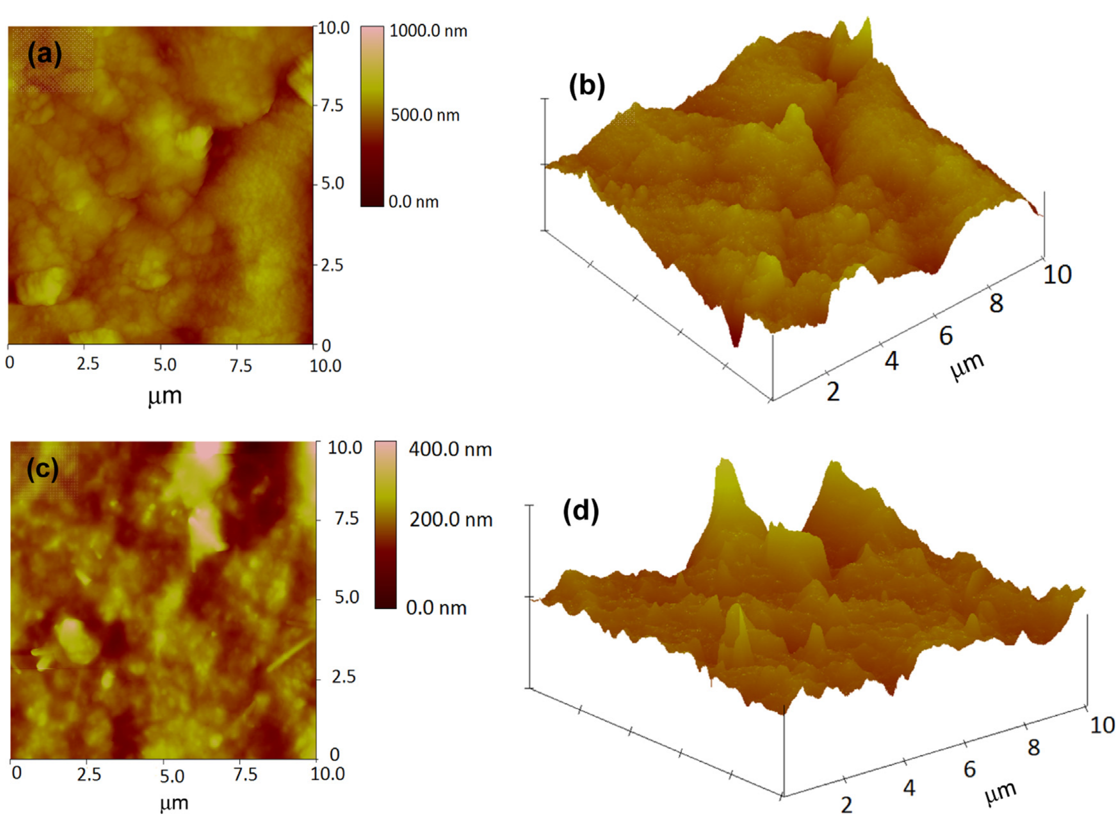

Fig. 2. AFM height and 3D images of the (a) pure sintered and (b) WQ-1200 °C.