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The structure and properties of nano titanium obtained by cryogenic quasi-hydrostatic extrusion

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Titanium and its alloys are widely used in various fields of engineering and medicine [1]. For some applications, in particular, for manufacture of medical implants pure titanium is most preferable due to its high biocompatibility and lack of toxic elements. Improving the strength of titanium up to the strength level of heavily doped alloys is possible by different extreme effects on bulk material [2]. The aim of this study was to investigate the influence of quasi-hydrostatic extrusion (QHE) of submicrocrystalline titanium on its microstructure and mechanical properties.

Submicrocrystalline high-purity iodide titanium was obtained by severe plastic deformation (SPD) in a swaging-extrusion-drawing regime. Commercial titanium VT1-0 was subjected to a combination of twist extrusion with subsequent extrusion and drawing. All these samples were subjected to quasi-hydrostatic extrusion at liquid nitrogen temperature (QHE77) and room temperature (QHE300) as described in [3]. The degree of QHE deformation was about 45% (true strain $e \approx 0.86$).

The results of measuring the average grain size (d), microhardness (H_{μ}), yield strength ($\sigma_{0.2}$), tensile strength (σ_b), and elongation to fracture (δ) are presented in the Table.

Titanium grade and method of obtaining	d, nm	H_{μ}, MPa	$\sigma_{0.2}$, MPa	σ_b, MPa	δ, %
Iodide Ti, SPD	150	2300	670	780	6,7
Iodide Ti, SPD + QHE300	130	1870	610	840	12,6
Iodide Ti, SPD + QHE77	75	2650	750	930	12,3
VT1-0, SPD	100	2750	820	1050	5
VT1-0, SPD + QHE300	90	2900	1080	1200	7
VT1-0, SPD + QHE77	65	3780	1140	1220	8

Analysis of the results shows that quasi-hydrostatic extrusion at nitrogen temperature more effectively refines structure as compared to quasi-hydrostatic extrusion at room temperature, allowing to obtain high-strength titanium with sufficient plasticity. It opens new possibilities of using titanium, particularly in medicine.