PHASE TRANSFORMATION OF TITANIUM AND ZIRCONIUM IN SHOCK WAVES

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The metals of the IVa group of the periodic table – titanium and zirconium – have a hexagonal close-packed lattice (α phase) at normal temperatures and pressures. The high-temperature β phases of these metals have body-centered cubic lattices. The properties of titanium and zirconium at high pressures were first studied by Bridgman [1-3], who inferred in the abrupt changes in volume and resistance in titanium and zirconium the existence in them of a high-pressure phase. Jamieson [4] determined the structure of these phases by x-ray structural investigations under pressure. It was found that the high-pressure phases of these metals continue to exist after the pressure is relieved and have hexagonal lattices of a new type under normal conditions (with crystallographic constants of a = 4.625, c = 2.813 Å and a = 5.036, c = 3.109 Å for titanium and zirconium, respectively). Three atoms entering into the composition of the unit cell are found at lattice points with coordinates (0, 0, 0), (2/3, 1/3, 1/2), and 1/3, 2/3, 1/2). The high-pressure phase was called the ω phase. X-ray investigations performed by the authors [5] confirmed the presence in zirconium of an ω phase. Table 1 gives the constants of unit cells of the α, β, and ω phases of the metals studied.

We studied in the present investigations samples of titanium and zirconium subjected to short-term pulsed loading by shock waves with amplitudes of 120, 200, 350, and 500 kbar. The method of loading and preserving the samples is that of Al'tshuler et al. [6]. After the shock the titanium and zirconium samples underwent x-ray investigation on a URS-50 IM diffractometer.

The lines of a new phase were observed in zirconium samples for all shock-pressure amplitudes. The maximum amount of the new phase, which exceeded the content of the initial phase, was obtained at pressures of 350 kbar. Table 2 shows the results of calculating the interplanar distances of a zirconium sample under a pressure P = 350 kbar. Values of the interplanar distances of original zirconium according to Mirkin [7], interplanar distances and relative line intensities of the ω phase calculated from the data of Jamieson [4], and also interplanar distances and relative intensities for a lattice we shall discuss below are given in the table for comparison. The relative intensities were calculated taking into account the polarization, Lorentz geometric (form), structure, and multiplicity factors.

TABLE 1. Parameters of Known Polymorphous Phases of Titanium and Zirconium

	α phase		ω phase		β phase*		New phase
	a, Å	c, Å	a, Å	c, Å	t, °C	a, Å	a, Å
Ti	2.95	4.69	4.625	2.813	882	3.28	3.276
Zr	3.23	5.14	5.036	3.109	862	3.59	3.568

Note. *Parameters of the β phase were determined by extrapolation of data obtained at high temperatures to normal temperatures.