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TEXTURE OF A 1H 800°C TREATED Ti-Al COMPOSITE

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INTRODUCTION

Intermetallic compounds such as titanium-aluminides and titanium-silicides have a special technological interest in high temperature applications. Therefore, in numerous papers recent investigations are described explaining the phase diagram, the constitution of special compositions and the mechanical behaviour. The aim of this preliminary study is to involve texture analysis in materials characterization especially in case of anisotropic behaviour. Hence, the texture of a well known initial sample will be correlated with a completely unknown sample after a well defined heat treatment. For realization, the programm was devided in two parts:

1. Texture analysis must be developed (pole figure measurement and pole figure inversion). The problem is the unknown number of intermetallic compounds with similar crystal structures.
2. Texture developement has to be regarded over some phase transformations.

EXPERIMENTAL

The initial material was a Ti-Al composite with an Al content of 37 wt.%. This composite was formed by a standard powder metallurgical technique starting with pure Ti and Al powders followed by powder mixing, by precompression and finally by cold extrusion (1). The phase analysis of this sample was performed with an X-ray diffractometer as well as with a neutron diffractometer, while the texture determination was carried out by with neutron diffraction. By that way, the bulk texture of the whole sample cylinder of 8 mm in high and 8 mm in diameter can be determined. Depending on the deformation mechanism a fibre texture resulted, so that the pole figure measurement was reduced to a χ-scan with $\Delta\chi = 5.0°$. The pole figures of Al (111), (200), (220) and Ti (010), (002), (011), (012), (110), (103) were measured. For these measurements the KARL diffractometer of the PTB at Braunschweig was used. The FMRB reactor of the PTB is a low flux reactor, so that the KARL diffractometer can only be used in the case of strong textures and in the case of a high sample symmetry.

A second sample was taken for a heat treatment (1h - 800°C) to form intermetallic compounds (2). It is well known that Ti-Al form different intermetallic compounds (3). Hence, a more complex and line-rich diffraction pattern was expected. Therefore, the neutron diffraction measurements were carried out at the high flux reactor at Grenoble (Institut Laue Langevin). The D1B instrument, used for this experiments, was arranged with a linear position sensitive detector of 80° in 2θ. Pole figure measurements with a linear position sensitive detector are different to a standard pole figure measurement using a single detector. For a detailed introduction in this technique reference should be made to one of the following overwies (4,5,6). The main advantage is that the whole diffraction pattern was measured for each pole figure point. Hence, it became possible to separate partly overlapping reflections and to perform a background correction extremely well. In contrast to the texture measurement of the initial material, complete pole figures were measured using an equal area scan with 667 different orientations. Figure 1 shows the sum-diagram of all 667 indiviual diagrams. By that way a rather good statistics was realised. Moreover, the sum-diagram presented a smoothing about the texture effect which occured in each indiviual diagram. In the following, the sum-diagram was used to analyse the phase composition and to identify the reflections.

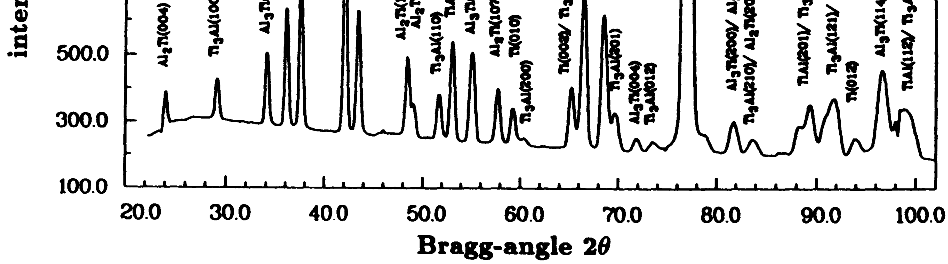

Figure 1 Sum-diagram of a Ti-Al sample

RESULTS AND DISCUSSION

In figure 1 a number of overlapping reflections can be observed. Hence, the evaluation of the sum-diagram requires a peak profile analysis. Using the ABFfit program (7), a total number of 39 reflections could be separated and identified. Table 1 gives the phase composition of the heated sample with the crystallographic data of each phase.

Table 1 Phase composition of the heated sample (1h - 800°)

phase	structure	a (Å)	c (Å)
Ti	hexagonal	2.951	4.679
Ti_3Al	hexagonal	5.789	4.669
TiAl	tetragonal	3.998	4.076
Al_2Ti	tetragonal	3.976	24.360
Al_3Ti	tetragonal	3.850	8.596

Table 1 points out, that some intermetallic compounds were formed. While the whole aluminium was transformed completely, remaining titanium can be observed.

Not all of the 39 separated reflections have shown a sufficiant accuracy for a texture analysis. A selection of 16 pole figures was made, which are shown in Table 2. Table 2 gives also the pole figures of the initial sample used for the pole figure inversion. Some of the pole figures are shown in figure 2.

Table 2 Measured pole figures for both samples

phase	sample	pole figures	
		number	type
Ti	initial	6	(010),(002),(011),(012), (110),(103)
Al	initial	3	(111),(200),(220)
Ti_3Al	heated	6	(100),(101),(110),(200) (201),(210)
Al_3Ti	heated	4	(002),(101),(110), (112/103)
TiAl	heated	3	(001),(110),(201)
Ti	heated	1	(010)
Al_2Ti	heated	2	(004),(101)

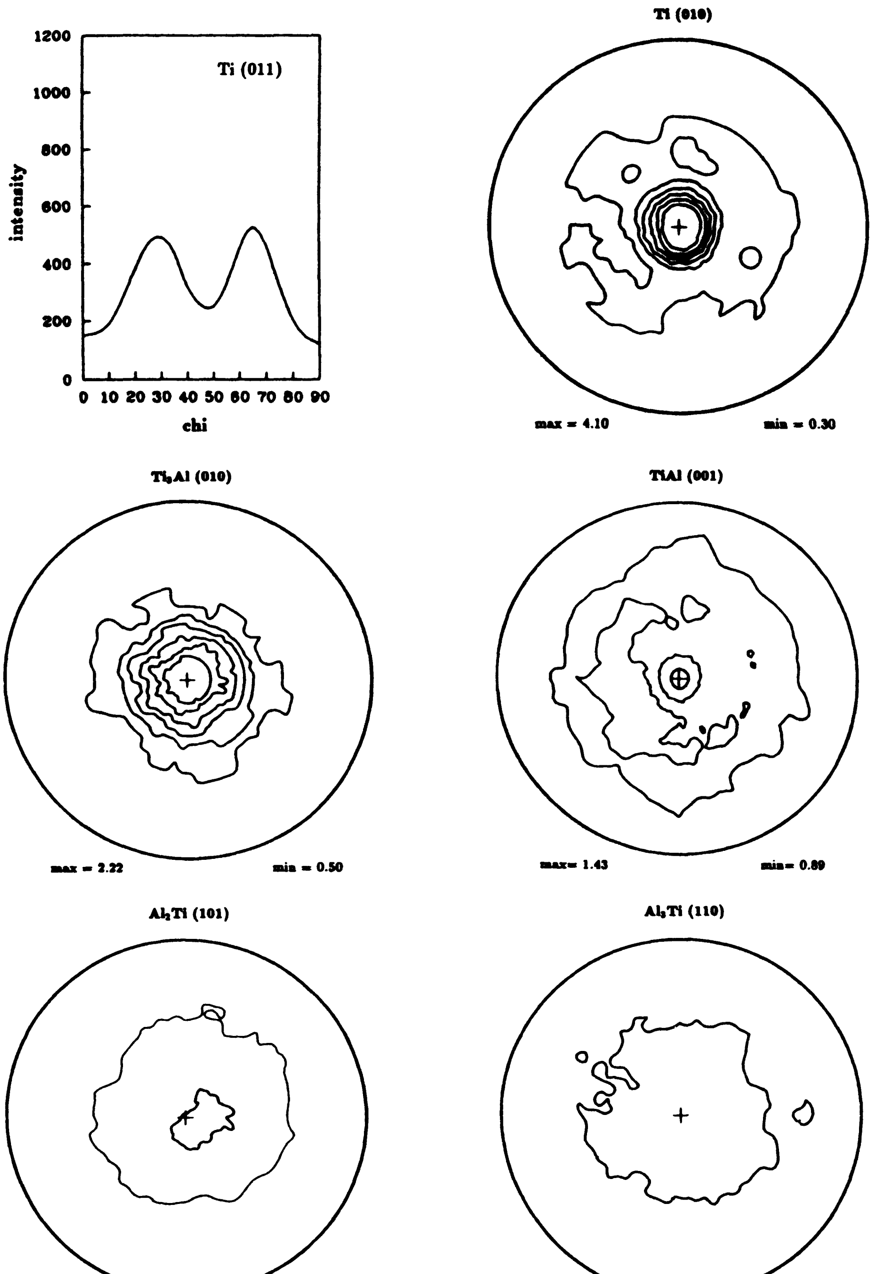

Figure 2 Selection of 6 measured pole figures
a) Ti (011) initial sample b) Ti (010) heated sample
c) Ti_3Al (010) heated sample d) TiAl heated sample (001)
e) Al_2Ti heated sample (101) f) Al_3Ti heated sample (110)

Comparison of the 6 pole figures (see figure 2) shows a decrease of the preferred orientation for the new intermetallic compounds. The initial material has a strong fibre texture (see figure 2a). In the heated sample, the small amount of pure titanium also shows a relatively strong fibre texture (see figure 2b). Ti_3Al, a superstructure of Ti, also forms a fibre texture. That means, that the texture symmetry of pure Ti was transformed to Ti_3Al. The other three phases are more or less random, although some of their pole figures show a fibre texture which is realtively weak. A more detailed texture describtion needs quantitative texture analysis.

Because of the total overlapping of Al (111) and Ti (002) the pole figure inversion of both phases (initial sample) was calculated simultaneously as done before in the case of Al-Cu composites, see Dahms et al. (8). The program developement takes into account the overlapping of cubic phase (Al) and a hexagonal phase (Ti). The result is shown in figure 3.

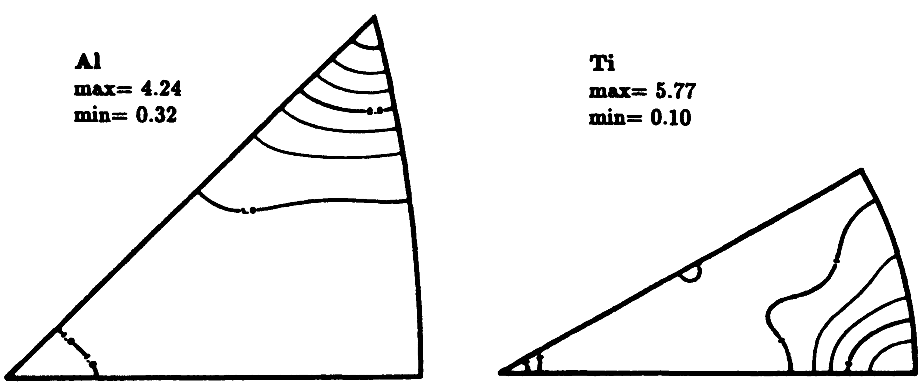

Figure 3 Inverse pole figures for Ti and Al (initial sample)

In the case of the heated sample a pole figure inversion was carried out for Ti_3Al, TiAl and Al_3Ti. Based on the different number of pole figures, the different accuracy of the pole figures and the different orientation degree, the pole figure inversion works with different success. Hence, the pole figure inversion of Ti_3Al was performed with (001),(110),(101),(201) and (210). The series expension goes up to L_{max}=20. Thereafter, the inverse pole figure was calculated and correlated with the initial Ti values. In both cases a rather similar texture type was observed, a (100) fibre texture . Only the degree of the preferred orientation decreases during phase transformation from 5.77 * random (see figure 3a) down to 1.98 * random (see figure 4). Texture similarity is evident because Ti_3Al is a supersturucture of Ti.

The pole figure inversions of the two tetragonal phases (TiAl and Al_3Ti) were calculated with three reflections and L_{max}=16. In both cases a very weak fibre texture was obtained. The orientation distribution function shows a maximum of

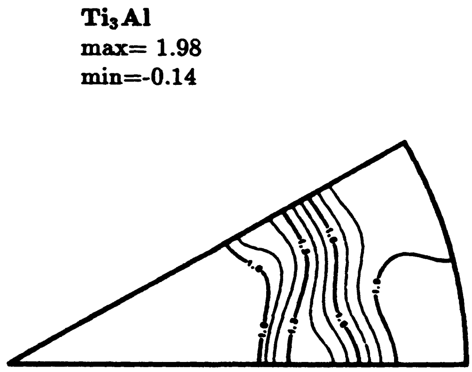

Figure 4 Inverse pole figure for Ti_3Al

F_{TiAl}=1.38 and of F_{Ti_3Al}=1.33. A correlation between the texture of the cubic Al (initial material) and the two analysed tetragonal phases can not be done.

Finally it can be remarked,

1. that the texture symmetry of the extrusion experiment can be observed after some phase transformations.
2. that the texture type of pure Ti goes to the superstructure Ti_3Al.
3. that the degree of preferred orientation (bulk texture) decreases during phase transformation.

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