ROBL-CRG	**Experiment title:** Depth distribution of nitrides in Ti64 after N implantation	**Experiment number**: 20_02_010
Beamline: BM 20	**Date of experiment**: from: 6.11.98 to: 11.11.99	**Date of report**: 24.8.99
Shifts: 10	**Local contact(s)**: N. Schell	*Received at ROBL:* 31.8.99

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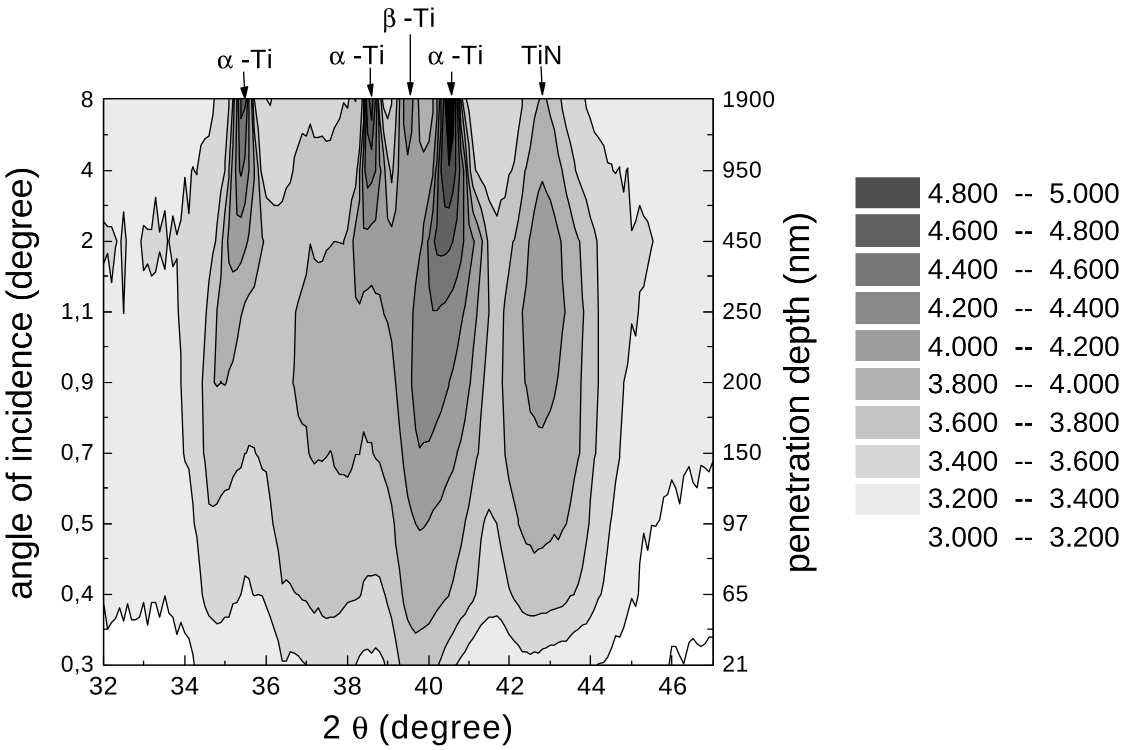
Report:

The technical alloy Ti-6Al-4V (wt.-%) was implanted with nitrogen in order to enhance surface hardness. The as-received alloy has a duplex structure, where the main component is the hexagonal α-phase. The cubic β-phase as the minor component is stabilised by V. The beam line implantation of N at 80 keV produces a Gaussian depth distribution with the centre at 130 nm and a FWHM of about 120 nm. From laboratory X-ray diffraction it was found that for doses $>3x10^{17}$ N^+/cm^2 the TiN phase is formed. The aim of the experiment was to check the correlation between nitrogen depth distribution and formation range of TiN. Because of the shallow profile one needs low incidence angles and low divergence of the beam.
A sample implanted with a dose of $6x10^{17}$ N^+/cm^2 was investigated in grazing incidence technique with incidence angles from 0.3° to 8°. At λ = 0.154 nm the intensity in the angular range 2θ = 32°-47° was recorded. Bragg reflections from all 3 interesting phases are located in this range. The figure shows the 2D intensity plot of the measurements. Note, that the angle / depth -scales are not linear.

We were not successful in correcting the data for the penetration depth. The intensity is always the accumulated scattering for the given angle of incidence. For this reason the calculated penetration depth of the X-rays using the density of Ti6Al4V of 4.43 g/cm3 is given as the right scale of the figure. Existing correction procedures [1,2] assume a multilayer structure with flat, sharp interfaces. In the case of the implantation profile one has a smooth change in the concentration and obviously also in the phase content.

The following conclusions can be drawn from the obtained data.

- The ion implantation destroys most of the crystallinity of the alloy near the surface.
- The lattice of the α-Ti-phase is expanded in the implantation region. At greater depth (bulk region) the peak positions are shifted to higher Bragg angles.
- The TiN phase is formed in the region of partially amorphous material. The maximum of the Bragg reflections of the base alloy were observed in a depth three times higher than the maximum if TiN. The destroyed lattice of the alloy is one prerequisite for forming crystalline TiN directly during implantation without further annealing.
- The strong line broadening for TiN peaks indicates small crystallites in all depths. The estimated crystallite size is about 5-6 nm.
- The apparent maximum of TiN phase is about two times deeper than the maximum of N implantation. This is an effect of the accumulation of intensity. It is necessary to adapt depth correction procedures to smooth distribution functions rather than step like functions.



[1] P. Predecki, Powder Diffraction, **8** (1993) 122

[2] Jian Luo, Kun Tao, Thin Solid Films, **279** (1996) 53