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Effects of ternary ω-Phase on the Deformed Microstructures of Two-Phase Zr-2.5Nb Alloy

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ABSTRACT

The present study involved uniaxial cold compression of two samples – generically termed as samples A and B (see figure 1). Both had a microstructure of hcp (hexagonal closed packed) α grains with grain boundary and tri-junction bcc (body centered cubic) β . The two structures, however, had distinct differences: (i) α grains in sample B were approximately 1.5 times larger than α grains in sample A and (ii) hardness of β in sample A was more than twice that of β in sample B. (ii) was due to fine ω precipitates present in the β phase of sample A. Plastic deformation, in these two samples, had clear differences in microstructural developments. These are summarized below:

- Softer β, i.e. β phase in sample B, had more fragmentation and stronger developments in GAM (grain average misorientation). Similarly, softer α, i.e. α phase in sample A, had more lattice strain and GAM. Such trends can be justified from the expected patterns of strain partitioning – more strain partitioning being expected in the softer phase.
- Only $\{10\bar{1}2\} < \bar{1}011 >$ type of tensile twins were observed in α grains of both samples. The amount of twinning was more in sample B. Hence the α grain size refinement in sample B was more. Sample B also had stronger developments deformation texture – i.e. increased presence of basal orientation, a generalized twinning product.
- More extensive twinning in sample B can be justified due to larger grain size and/or softer second phase. Though larger grains, in general, are expected to promote deformation twinning, recent study in single phase Zr had shown that $\{10\bar{1}2\} < \bar{1}011 >$ type of tensile twins are affected more by crystallographic orientations than by moderate differences (similar to the present study) in grain size. Presence of soft β in sample B is expected to restrict strain partitioning and slip. This, on the other hand, does provide an explanation for the more extensive deformation twinning in sample B.

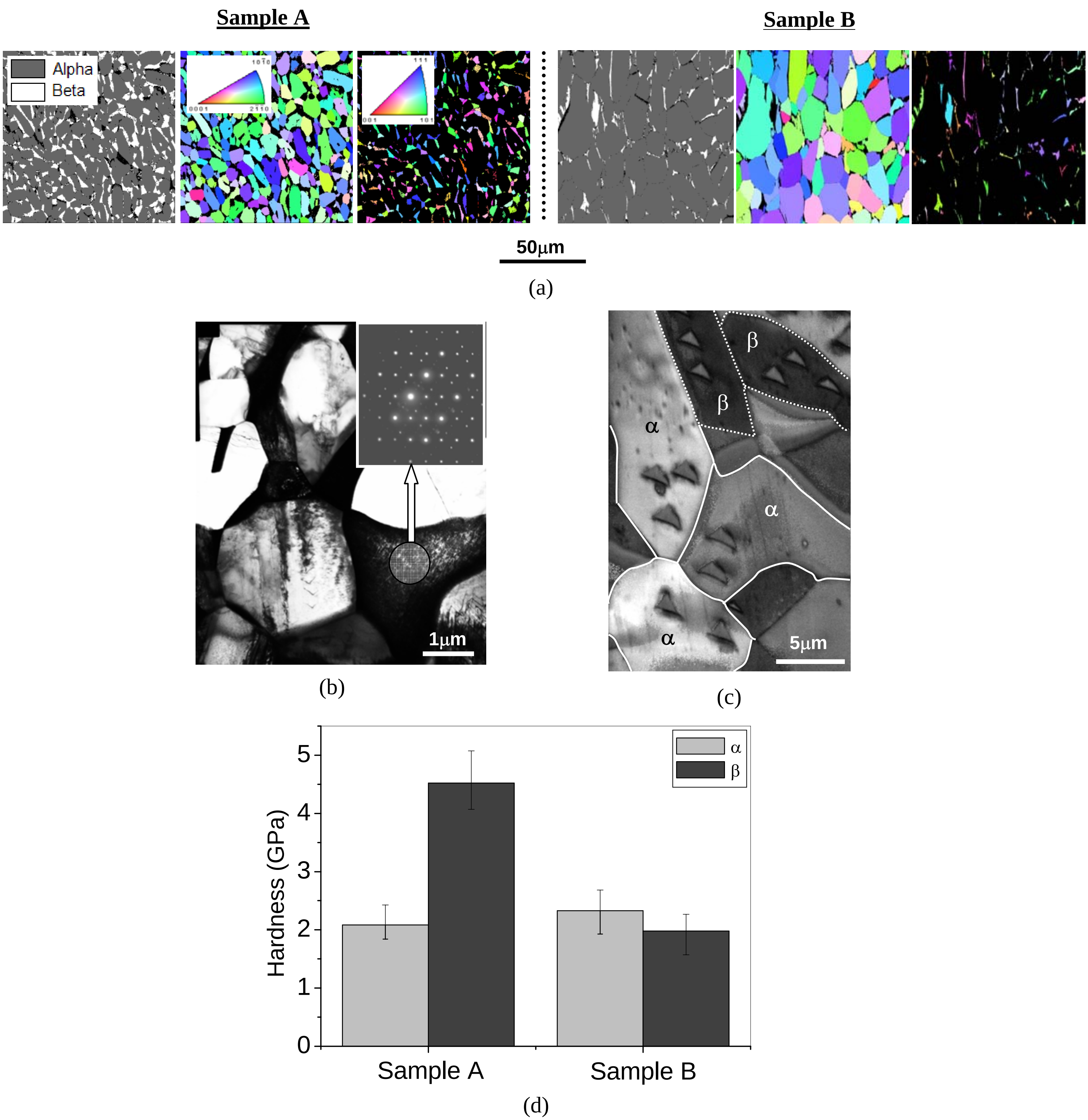

Figure 1. (a) Starting microstructures of Sample A and Sample B. Included are phase maps and IPF (inverse pole figure) maps. The later represented respectively the α & β phases. (b) TEM microstructure of Sample A, showing visible presence of ω phase in β. This was confirmed through electron diffraction. ω was not observed in the β of sample B. (c) Image quality (IQ) map of Sample A after nano-indentation. (d) Nano-hardness of both α and β phases in sample A & B. Error bars represent the standard deviations estimated from multiple hardness measurements.