Towards the thermodynamic equilibrium of titanium aluminides after consolidation by back pressure equal channel angular processing

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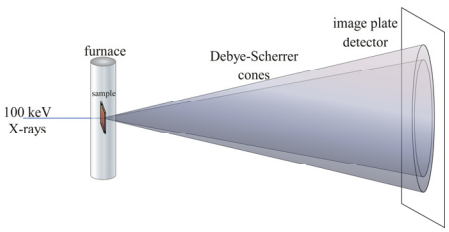
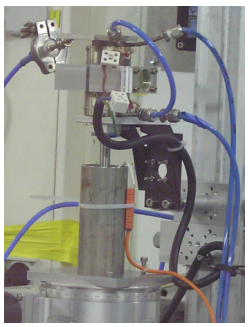
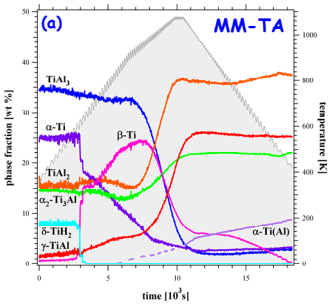
Upon heating up from 300 to 1075 K under helium flow, in-situ high-energy synchrotron X-ray diffraction was employed to investigate phase transformations in two Ti-47Al (at.%) samples produced by back pressure equal channel angular (BP-ECA) consolidation (903 K, one pass, 200 MPa). The two samples are: 1) a fully mechanically mixed Ti-47Al (MM-TA) elemental particles (Ti~80 μm, Al~30 μm) ; 2) a ball-milled Ti-47Al (BM-TA) particles without identified reactions. X-ray analysis indicated the grain sizes of Ti and Al were refined to 90 and 40 nm, respectively, after ball milling, in contrast to the coarse grain size in the mechanically mixed particles.

High energy synchrotron X-ray, Beamline ID15B (88.95 keV), ESRF, Grenoble, France

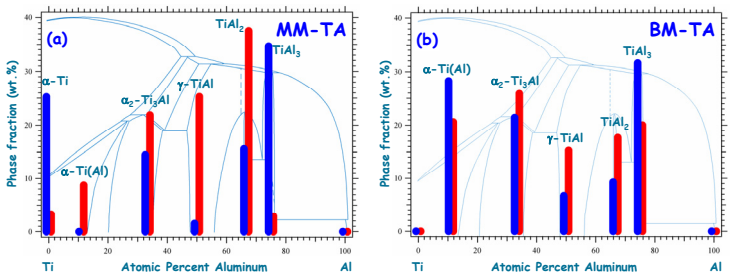




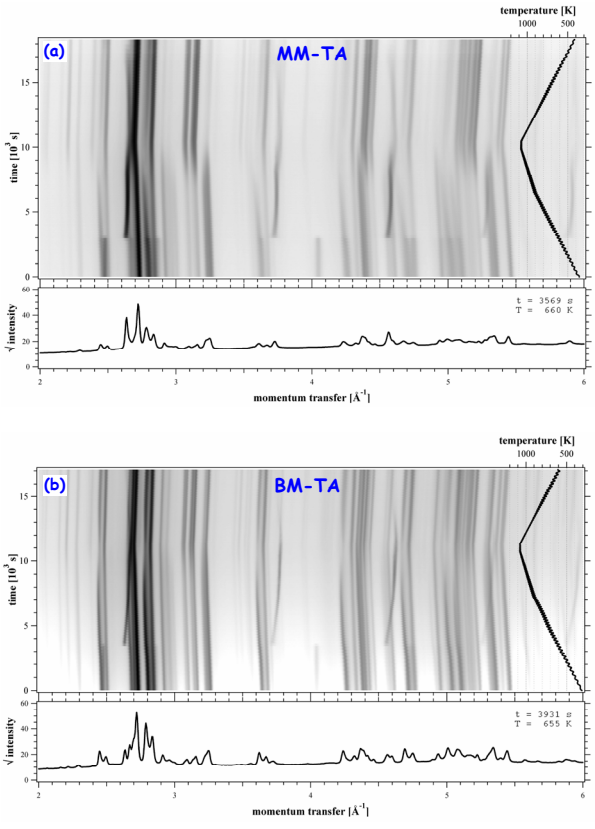
In-situ synchrotron X-ray experimental setup



a and b: evolution of phase fractions obtained by Rietveld refinement as a function of temperature for MM-TA and BM-TA, respectively.

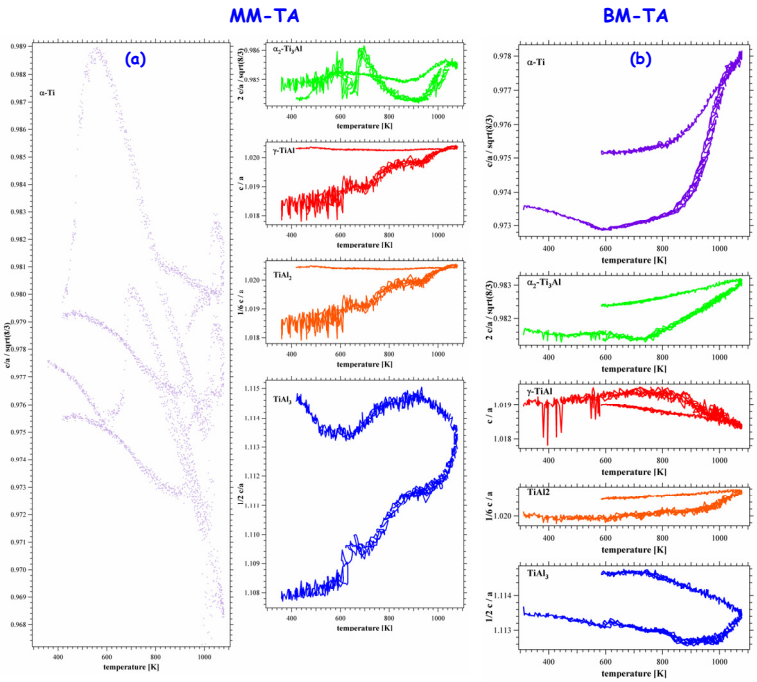


a and b: Phase fraction histograms before (blue) and after (red) the heating cycle as a function of Al concentration for MM-TA and BM-TA, respectively.



a and b (top): gray-coded intensity levels as a function of temperature for MM-TA and BM-TA, respectively.

a and b (bottom): typical powder diffraction patterns for MM-TA and BM-TA, respectively.



a and b: Lattice parameter ratios c/a normalized to closed packed ratios as a function of temperature for MM-TA and BM-TA, respectively.

The starting temperatures for phase transformations were found to be higher for the fine grained BM-TA than for the coarser grained MM-TA.

Upon heating, the coarser grained MM-TA was initially further away from thermodynamic equilibrium and evolved more strongly towards it afterwards, such that it ended up closer to it.

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