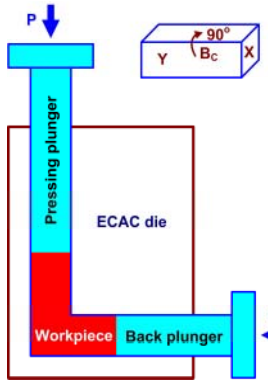


### Equal channel angular pressing



### Objectives

- Uniformly dispersing reinforcing particles in the matrix
- Breaking reinforcing particles to ultrafine or nano-scale
- Generating good bonding between matrix and reinforcing phases
- Consolidating the mixture into fully dense bulk nanostructured composite

### Strategy

- Employing ball milling to realize the first three objectives
- Using back pressure equal channel angular (ECA) consolidation to attain full density

### Synthesis processing

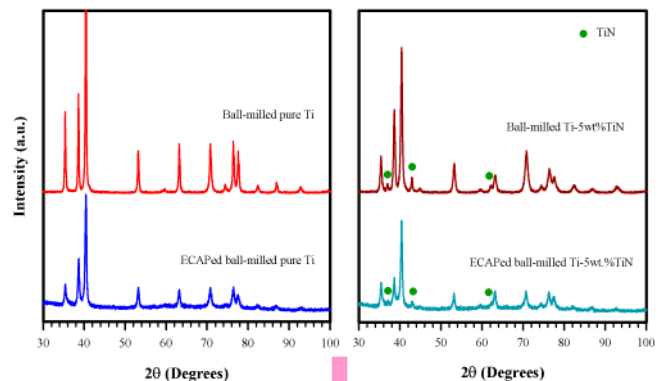
Ball milling for the mixture of pure Ti (~ 80 μm) and TiN (< 2 μm, up to 10 wt.%) particles for 20 h

BP-ECA consolidation of the ball-milled mixture at 500 °C for 4 passes

Measured and calculated densities of consolidated Ti-TiN nanostructured composites (without considering the presence of oxides for calculation)

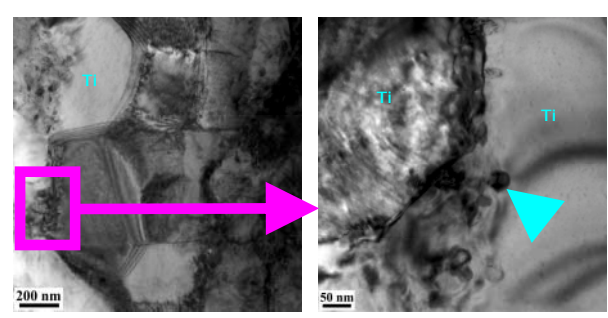
Sample	Measured density (g/cm <sup>3</sup> )	Calculated density (Ti and TiN only) (g/cm <sup>3</sup> )	Percentage (measured/calculated)
Pure Ti	4.46±0.02	4.507	98.96%
Ti-2wt%TiN	4.43±0.01	4.522	97.97%
Ti-5wt%TiN	4.46±0.02	4.546	98.11%
Ti-10wt%TiN	4.43±0.02	4.585	96.62%

### XRD of ball-milled and ECAPed Ti and Ti-5wt.%TiN (at the same intensity scale)



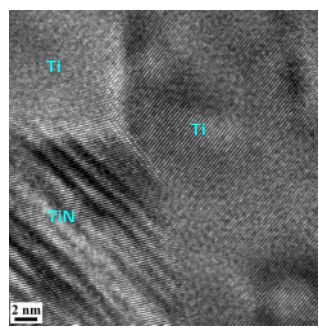
The introduction of TiN into Ti greatly facilitated the refinement of Ti grains

ECAPed Ti-5wt.%TiN, 4 passes at 500 °C



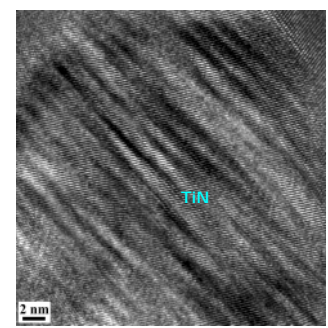
Nanoscale TiN phases of 20-50 nm distributed at grain boundaries of the ultrafine-grained Ti of 500-1000 nm

### Interface between Ti and TiN in ECAPed Ti-5wt.%TiN



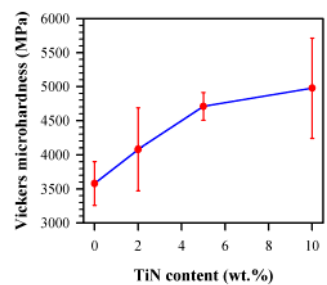
Good bonding between Ti and TiN

### Interior of TiN in ECAPed Ti-5wt.%TiN

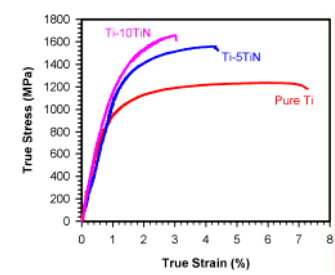


Formation of stacking faults

### Vickers microhardness

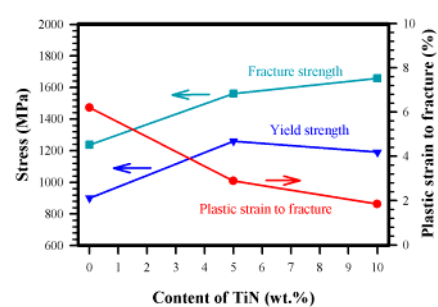


### Compressive stress-strain curve



### Mechanical properties of ECAPed Ti-TiN composites

Sample	Yielding strength (MPa)	Strength to fracture (MPa)	Plastic strain to fracture (%)
Pure Ti	900	1237	6.2
Ti-5wt%TiN	1260	1561	2.9
Ti-10wt%TiN	1190	1659	1.85



With increasing TiN content, strength increased but with a decrease in ductility. An improvement is expected if more ECAP passes are imposed.

- Nanostructured Ti/TiN composites have been synthesized by consolidating ball-milled mixtures of pure Ti and TiN particles using back pressure equal channel angular pressing for 4 passes at a temperature of 500 °C.
- The strategy of employing both ball milling and BP-ECAP is feasible to produce nanostructured composites with high strength and appreciable ductility.

W. Xu\*, X. Wu, K. Xia\*  
Department of Mechanical Engineering, University of Melbourne, Australia

\*Dr. Wei XU (weixu@unimelb.edu.au) and Assoc. Prof. Kenong XIA (k.xia@unimelb.edu.au)