Mechanical Engineering
Materials and Machining System
Materials Science for Engineering

Machine Material

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Materials with large grains
- Low strength and toughness
- Difficult high-temperature plastic deformation

Evaluation of various material properties by nanostructure control

Amorphous materials
Nanocrystalline materials
- High strength and toughness
- Easy high-temperature plastic deformation

Planetary Ball Mill

Attritor

Fabrication of Amorphous and/or Nanocrsytalline Powders
- Mechanical Alloying (MA)
- Mechanical Grinding (MG)

Estimation of Material Properties
- Nanostructure
- Mechanical Property

Diamond Wire Saw

Instron Testing Machine

Electric Current Assisted /Activated Sintering System

Rapid Densification
- Electric Current Activated/Assisted Sintering System
- Millimeter Wave Sintering System

Millimeter Wave Sintering System

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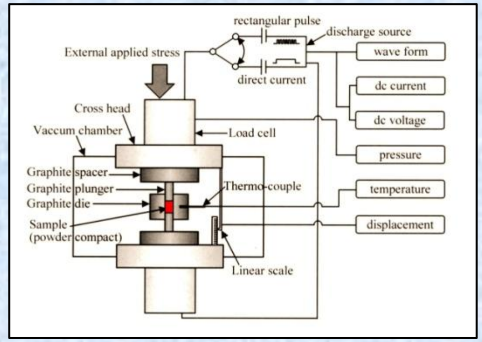
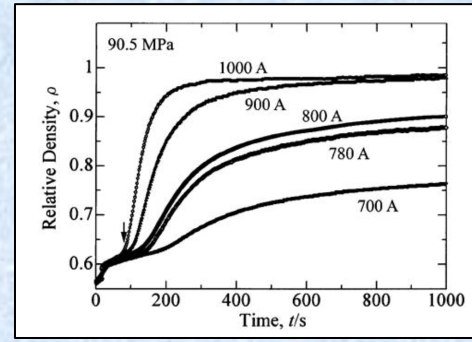
Theme 1 Rapid Densification and Deformation of Yttria-Stabilized Zirconia Powder

1) Fabrication of fully densified nano-crystalline yttria-stabilized zirconia (Y-ZrO_2) powder compacts by electric current activated/assisted sintering (ECAS) technique

An amorphous Y-ZrO_2 powder filled in a graphite die and plungers was densified by applying a constant compression stress (90.5MPa) and dc (900-1000 A) for 999s in a vacuum chamber. The obtained powder compacts showed high relative densities above 98%.



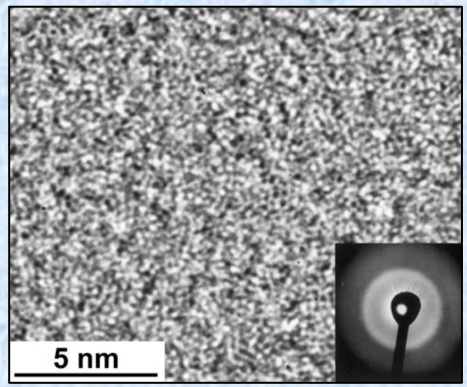
Schematic of ECAS Apparatus



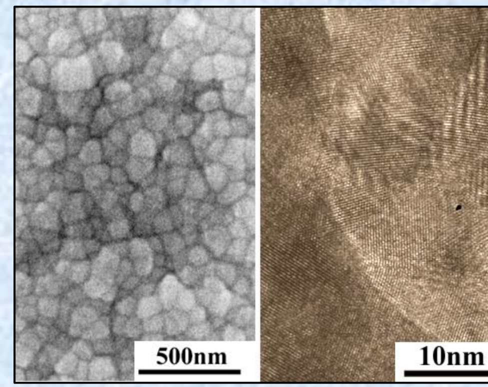
Densification Curve

2) Microstructures of amorphous Y-ZrO_2 powder and nanocrystalline Y-ZrO_2 powder compacts

During densification, crystallization occurs in the amorphous Y-ZrO_2 powder. Densifiction proceeds by superplasticity of the nanocrystalline Y-ZrO_2 polycrystals.



Amorphous Y-ZrO_2 Powder

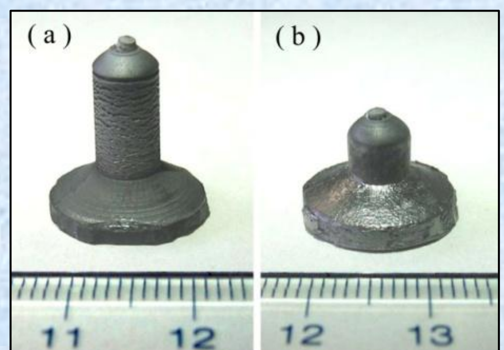


Nanocrystalline Y-ZrO_2 Compact

3) Hot-extrusion of nanocrystalline Y-ZrO_2 powder compacts

The nanocrystalline Y-ZrO_2 compacts could be hot-extruded using a graphite extrusion die by ECAS. Apparent grain growth was suppressed for rapid extrusion (999s).

We can be fabricated nanocrystalline Y-ZrO_2 materials of various shapes with higher density.



Hot-extruded Y-ZrO_2 Billet

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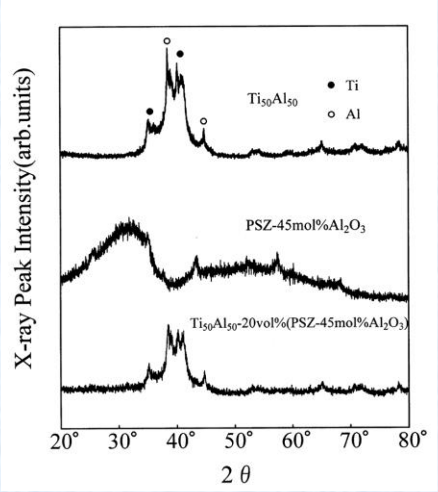
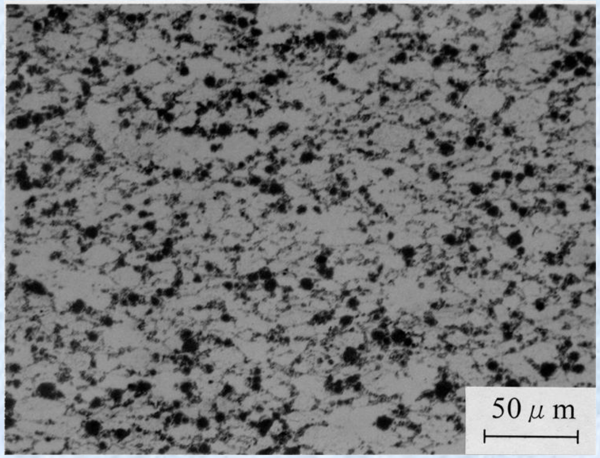
Theme 2　Preparation of nanocrystalline metal matrix composite by pulse current pressure sintering

Preparation of nanocrystalline $Ti_{50}Al_{50}$-20vol%(PSZ-45mol%Al_2O_3) composite by Pulse Current Pressure Sintering.

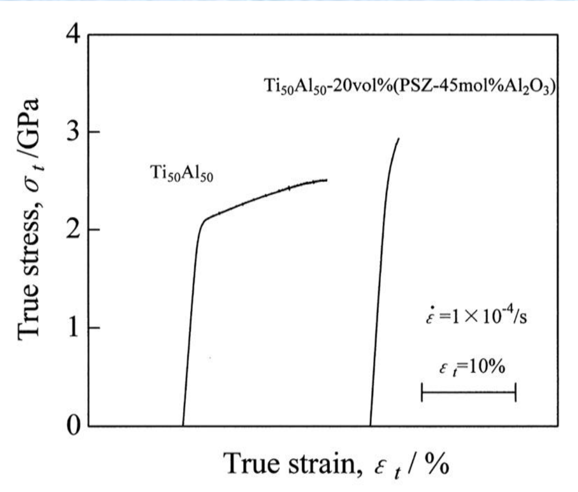
A nanocrystalline $Ti_{50}Al_{50}$-20vol%(PSZ-45mol%Al_2O_3) composite is fabricated by pulse current pressure sintering of the mixed powder of mechanically milled Ti-50mol%Al powder and amorphous PSZ-45mol% Al_2O_3 powder.



X-ray diffraction patterns of the mechanically milled $Ti_{50}Al_{50}$ powder, amorphous PSZ-45mol%Al_2O_3 powder and $Ti_{50}Al_{50}$-20vol%(PSZ-45mol%Al_2O_3) powder.



The microstructure of the $Ti_{50}Al_{50}$-20vol%(PSZ-45mol%Al_2O_3) composite.



The true stress against true strain curves(compression test at room temperature).

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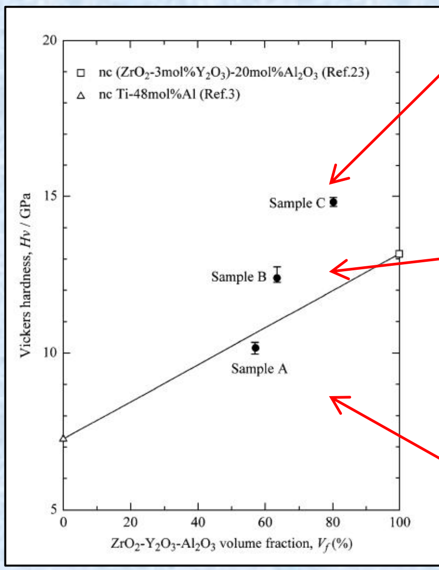
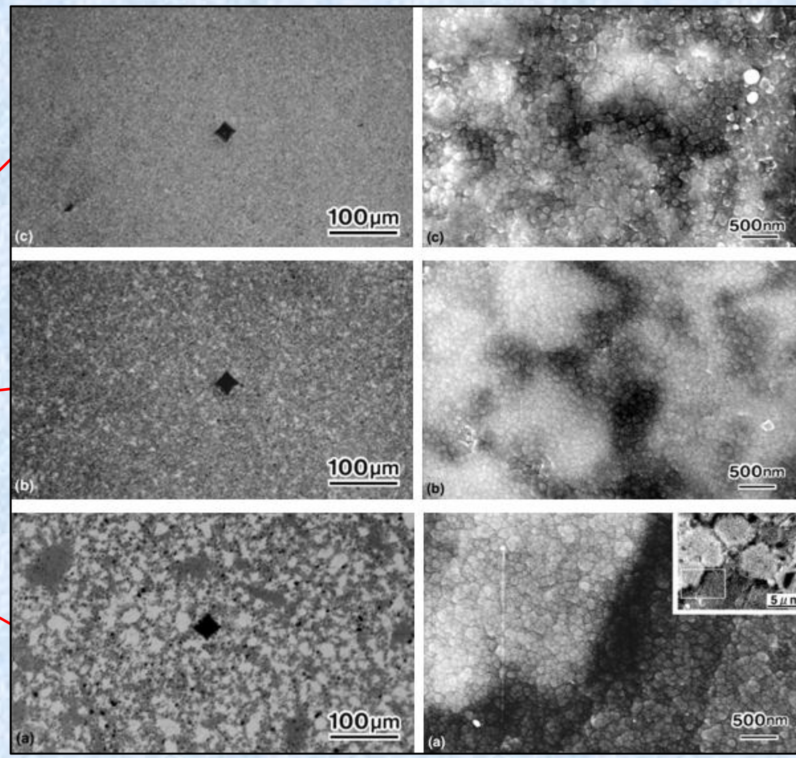
Theme 3 Development of Nanocrystalline Ceramic-Metal Composite Materials

Nanocrystalline ceramic-metal composite materials can be fabricated by rapid consolidation of mixture of ceramic and metal amorphous powders. Improvement of mechanical property can be achieved by fine and homogeneous distribution of the ceramic and metal colonies. Currently under development of nanocrystalline composite materials having various dispersion morphologies.

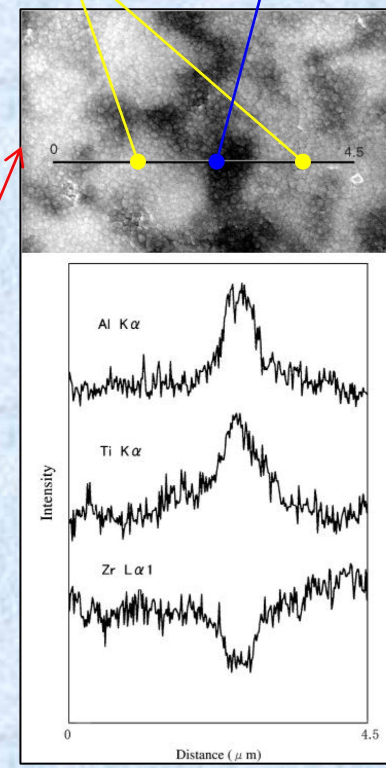


Vickers Hardness



Optical Microstructure

Transmission Electron Microscopy



Line Analysis

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