DISSIMILAR METAL JOINING OF THIN WALLED MICROPARTS

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JOINING

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Dissimilar Metal Joining of Thin Walled Microparts

Applications:

- ✓ Micro Electro Mechanical Systems (MEMS)
- ✓ Medical devices and tools
- ✓ Packing systems
- ✓ Sensors
- ✓ Automotive (ignition, airbags) and aerospacial microparts
- ✓ Watch mechanisms
- ✓ Battery cars

Dissimilar Metal Joining of Thin Walled Microparts

Reactive Microjoining

⇓

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Using multilayer thin films as nanoheater:

☺ An “internal” and highly localized energy source;

☺ Excellent filler/base material interface (direct deposition onto base materials);

☺ High quality and controllability of the filler material;

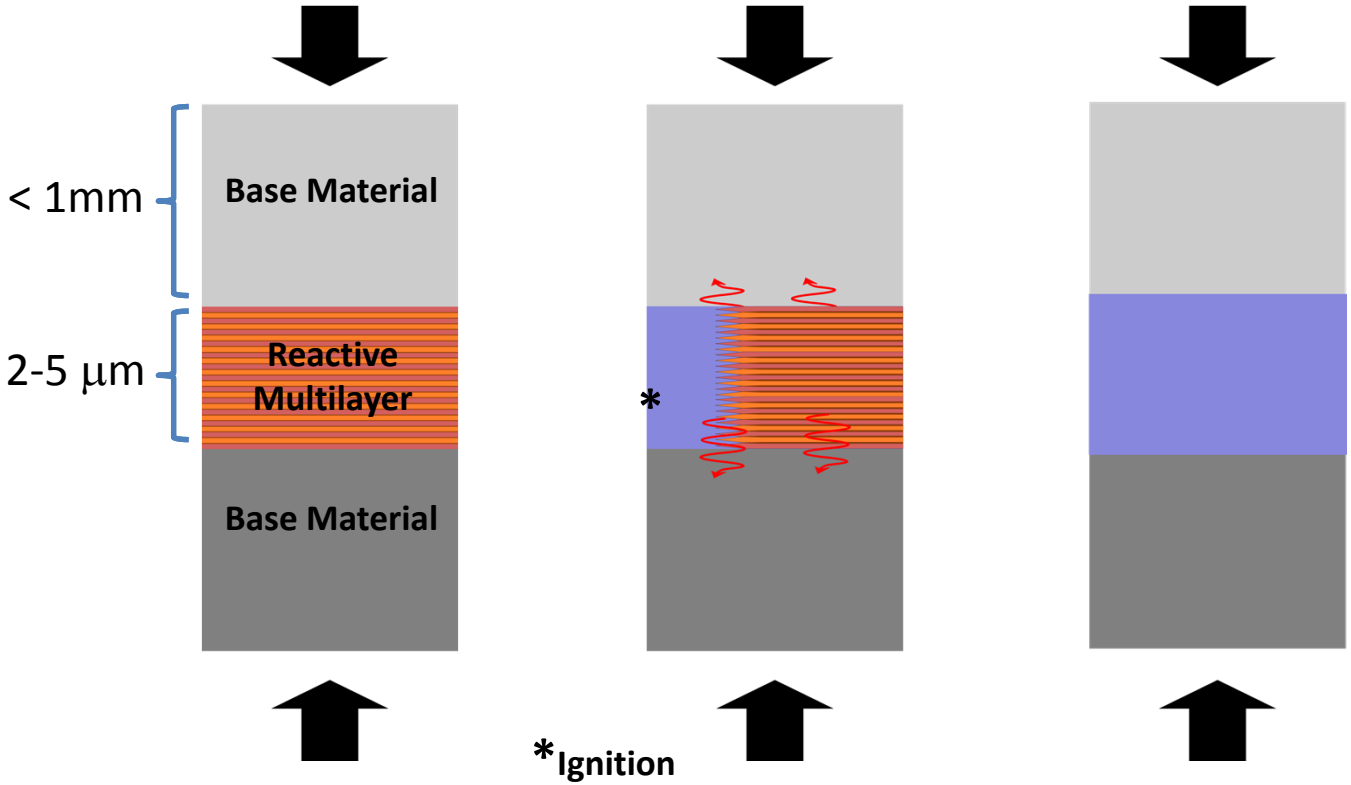
☺ The possibility of providing an interface zone with an intermediate thermal expansion coefficient, avoiding cracks and fracture during dissimilar joining.

☹ Expensive;

☹ Undesired diffusion towards the base materials;

☹ Formation of brittle intermetallic phases.

Reactive Microjoining



Use of the reactive character of Me1/Me2 nanolayered thin films for joining microparts/microdevices – **Reactive Microjoining**

If the reactive multilayer could be ignited, the coated parts can be joined at room-temperature in any atmosphere or under vacuum.

Reactive Microjoining

Base Materials (< 1 mm thick):

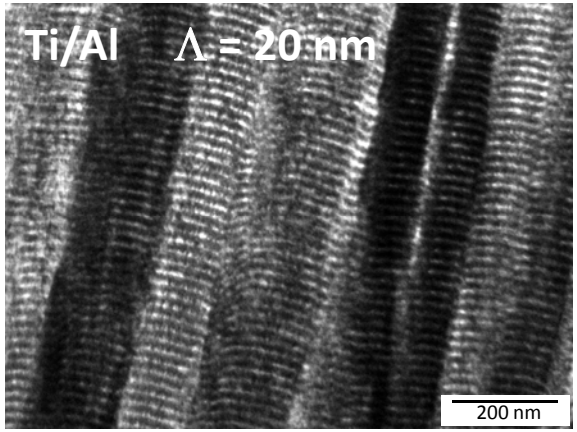
- ✓ Intermetallic Compounds – TiAl-based alloys
- ✓ Shape Memory Alloys - NiTi
- ✓ Stainless steels
- ✓ Gold, copper

Reactive Multilayers with Nanometric Period* (Λ):

- ✓ Ti/Al, Ni/Ti
- ✓ Ni/Al, Ti/Si
- ✓ Pd/Al, Pt/Al

↓ Heat of Reaction

Multilayer systems must have sufficient reaction energy.

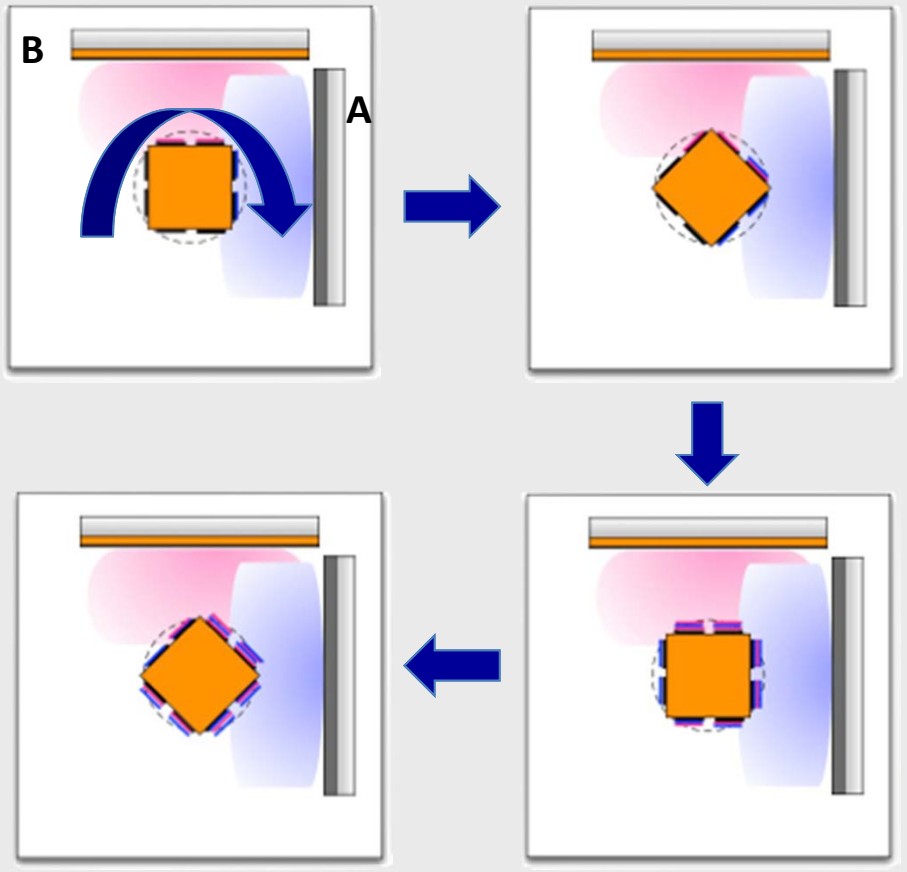


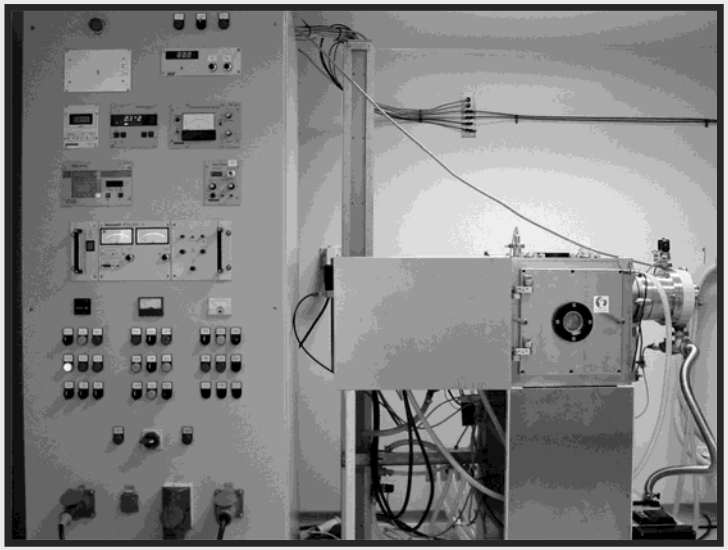
*Bilayer Thickness (Λ)

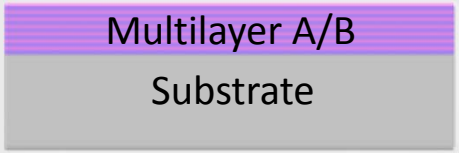
KNOW HOW

Production and Characterization of Nanolayered Thin Films

Dual cathode magnetron sputtering system with a rotating substrate



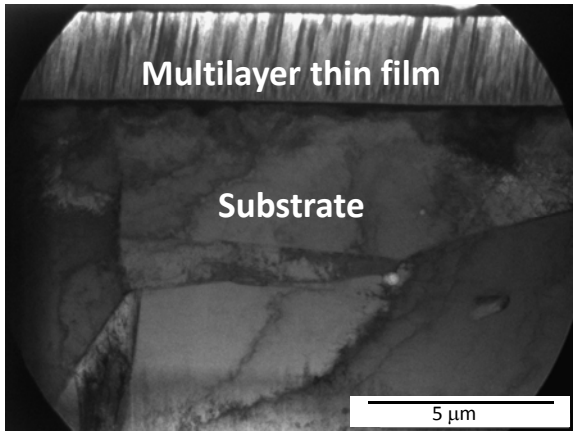




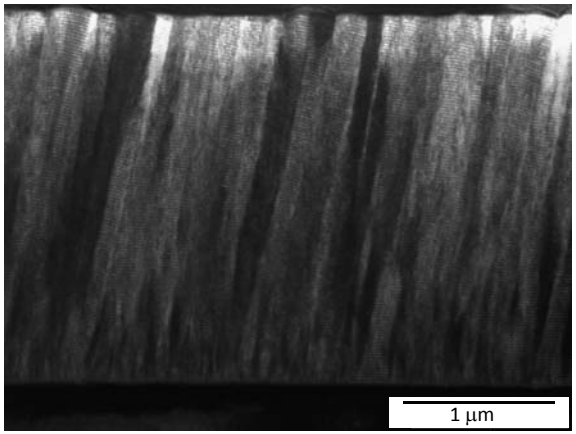
Nanolayered Thin Films

FIB / TEM

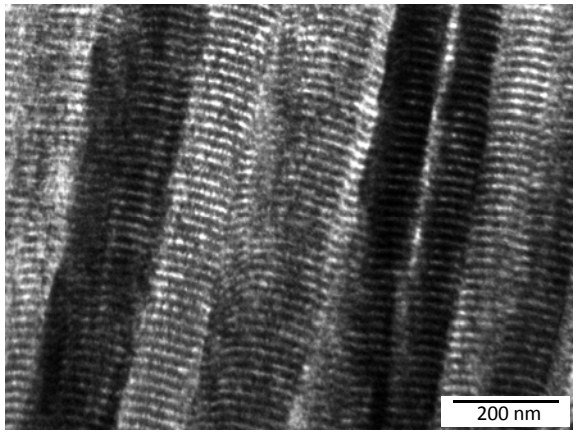
Ti/Al Λ = 20 nm



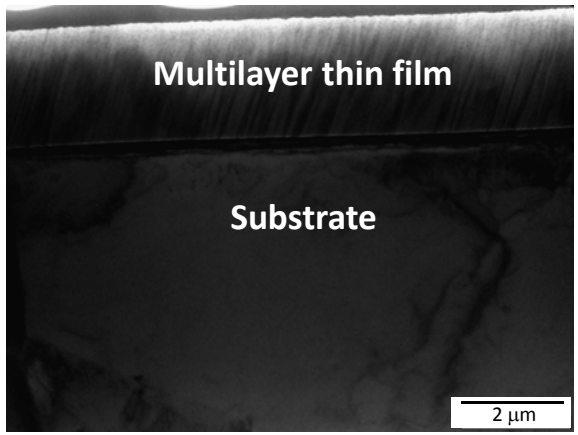
Ti/Al Λ = 20 nm



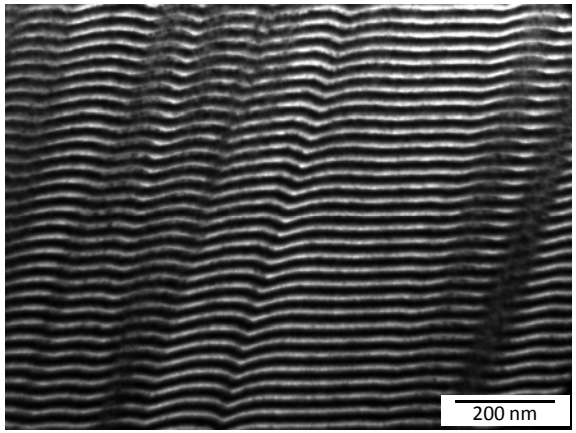
Ti/Al Λ = 20 nm



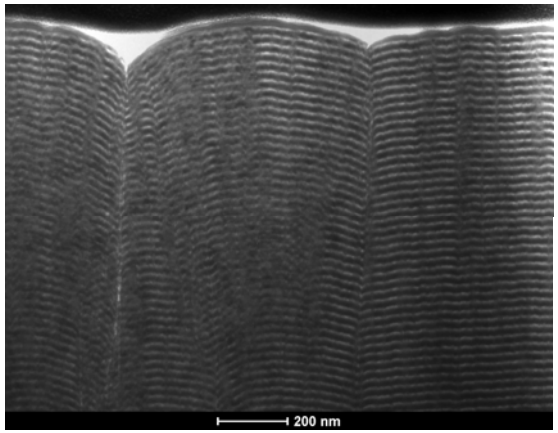
Ni/Al Λ = 30 nm



Ni/Al Λ = 30 nm



Ni/Ti Λ = 25 nm

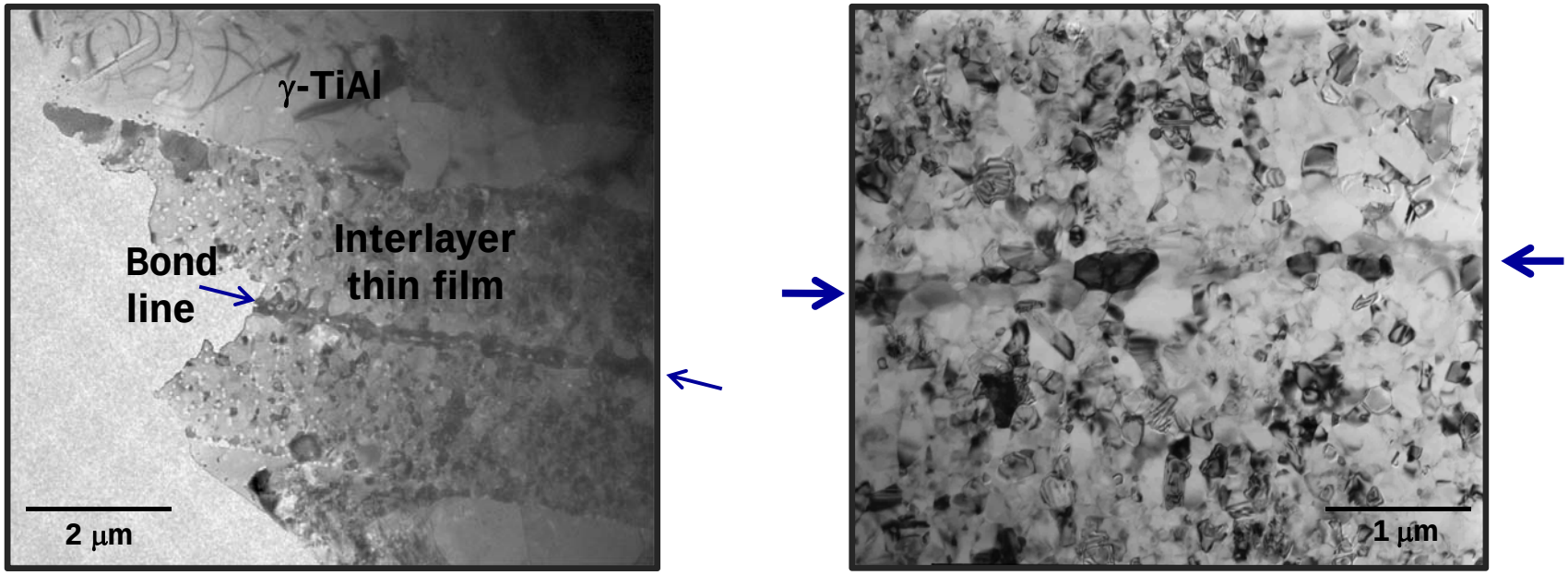


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Reaction Assisted Diffusion Bonding

TiAl/TiAl Similar Joints

900ºC / 50 MPa / 1h Ti/Al Λ = 4 nm



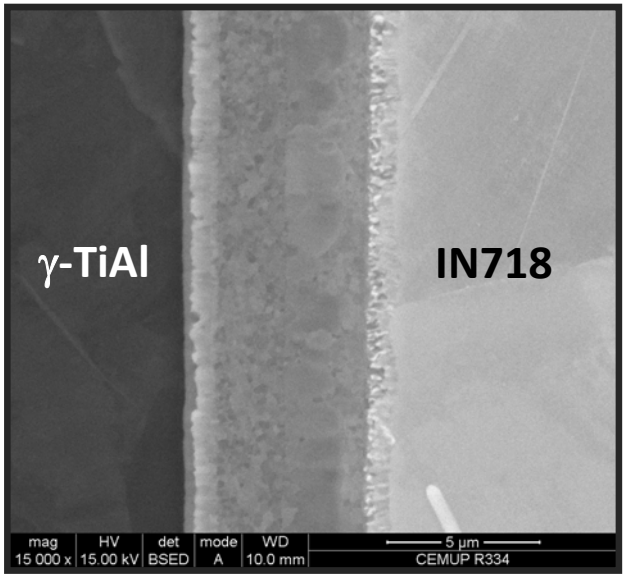
Interlayer – Ti/Al multilayer thin film with 4 nm period and a 50 nm Ti top layer

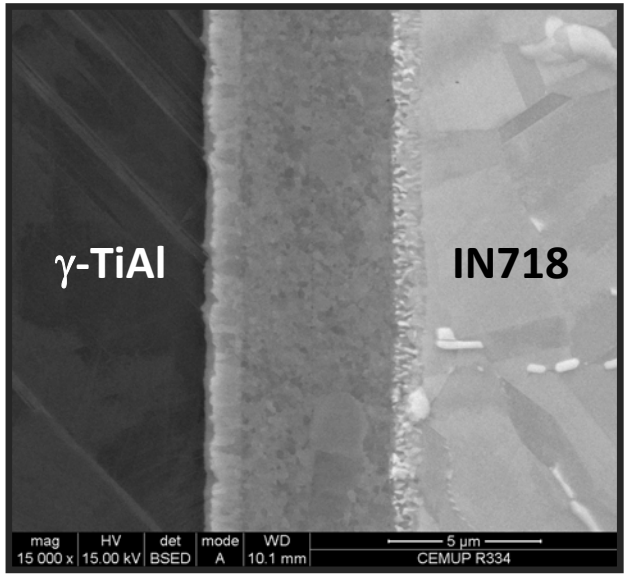
Bright-Field TEM images. The initial alternated layers of Ti and Al were replaced by nanocrystalline grains with sizes ranging from 50 to 300 nm.

Reaction Assisted Diffusion Bonding

TiAl/Inconel Dissimilar Joints

800ºC / 5 MPa / 1h Ni/Al Λ = 14 nm

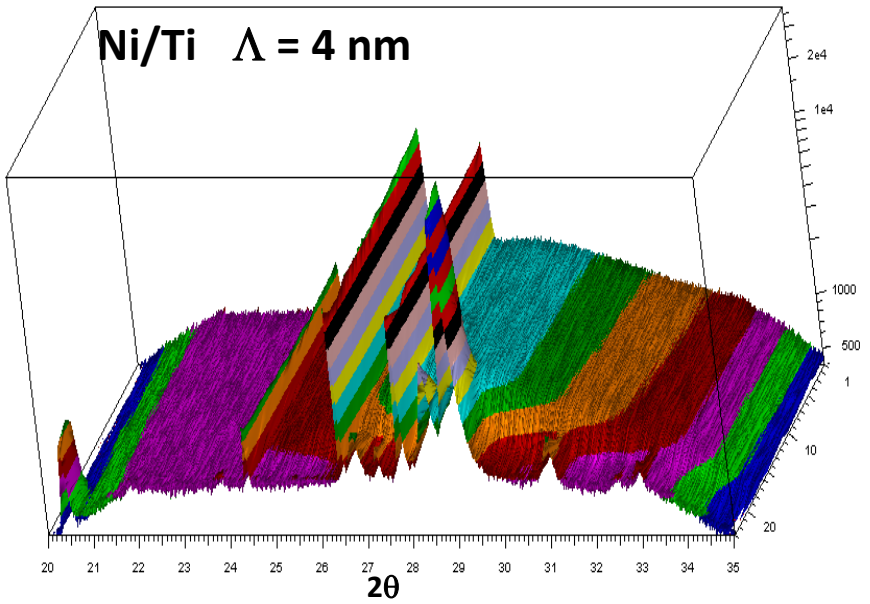


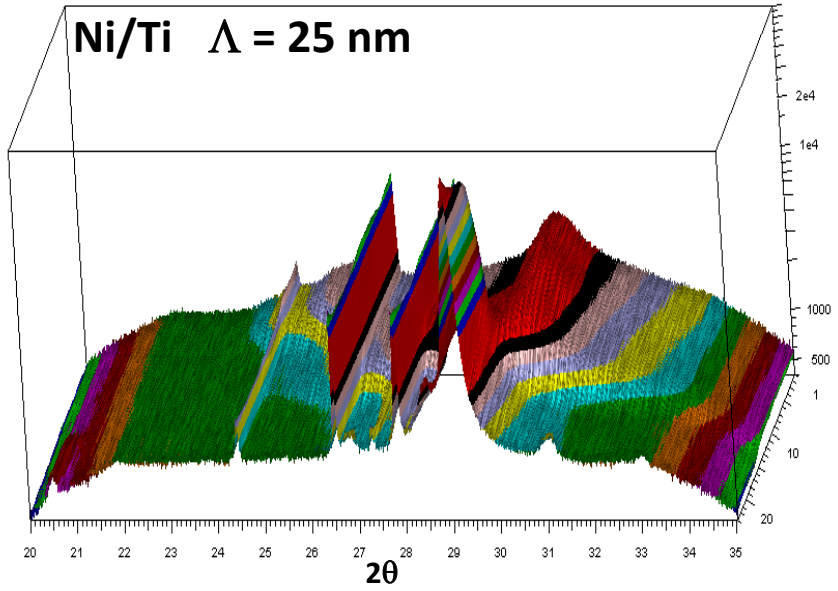


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In Situ Synchrotron Studies

Structural evolution of Multilayer thin films studied by *in situ High Temperature Synchrotron Radiation XRD*





Temperature progressing from back to front of the graphs

Dissimilar Metal Joining of Thin Walled Microparts

Looking for Partners

Alternative Low Cost Joining Techniques

Suitable for microparts/microdevices:

- Friction Stir Welding
- Laser beam microjoining/welding
- Others...

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