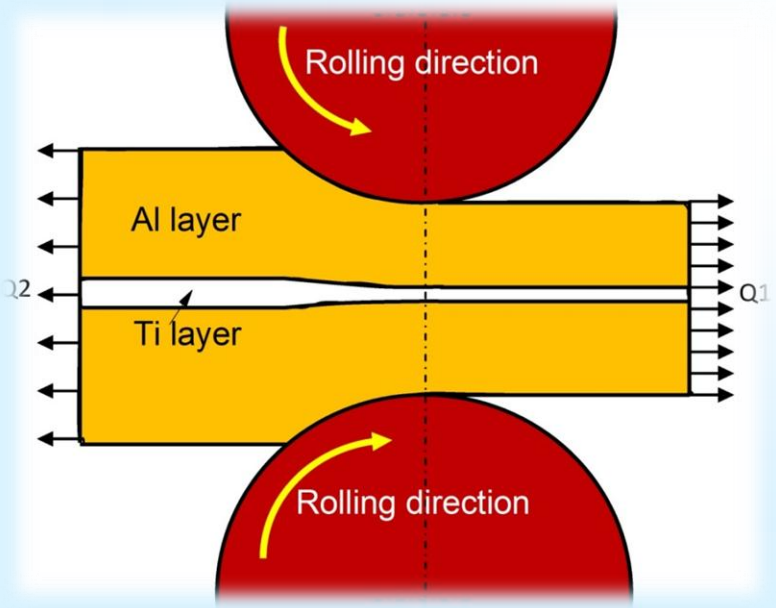
UNIVERSITY OF WOLLONGONG

ICTP2014, Nagoya

Advanced rolling technologies for producing ultrafine-grained/ nanostructured alloys



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20 October 2014

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- Background
- Asymmetric cryorolling
- Four-layer ARB
- ARB & AR

Background

- **SPD techniques: ECAP, HPT and TE**

  - Equal Channel Angular Pressing (ECAP)
  - High Pressure Torsion (HPT)
  - Twist Extrusion (TE)

Main drawbacks

- *Productivity very limited*
- *Only suitable for small samples*
- *Expensive and large load equipment*

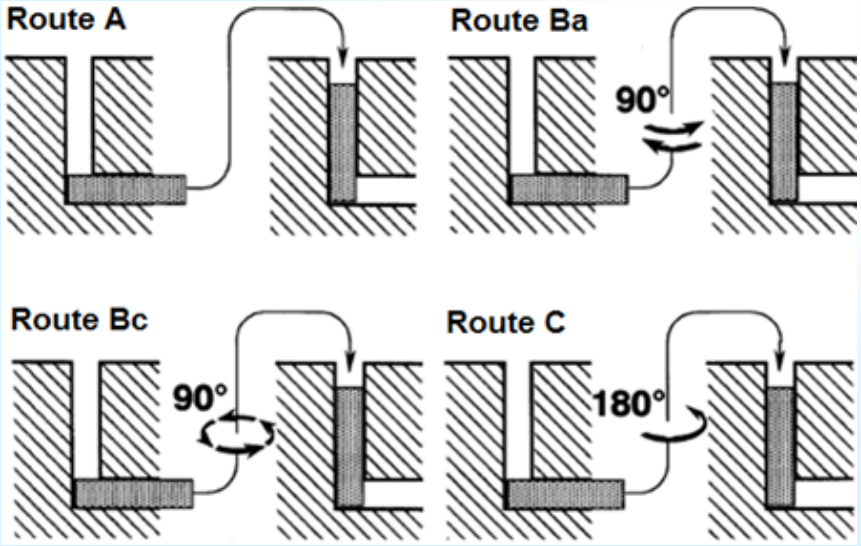


Fig. 1 ECAP

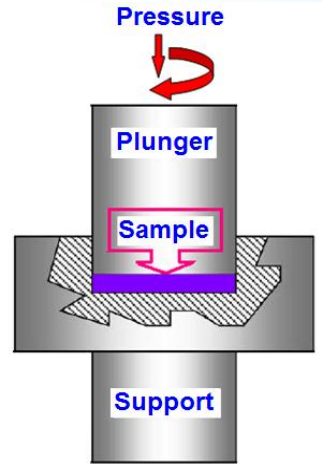


Fig.2 HPT

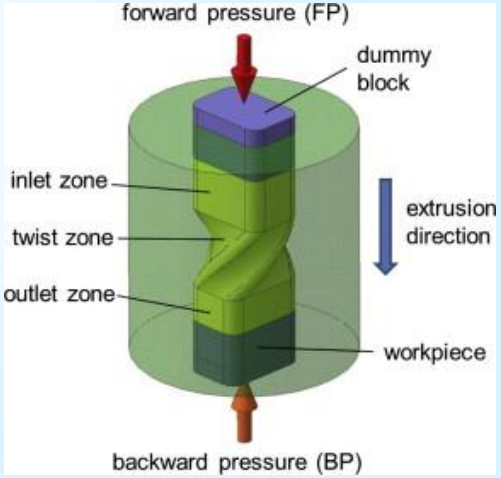


Fig.3 TE

Background

SPD technique: ARB

➢Accumulative roll bonding (ARB)

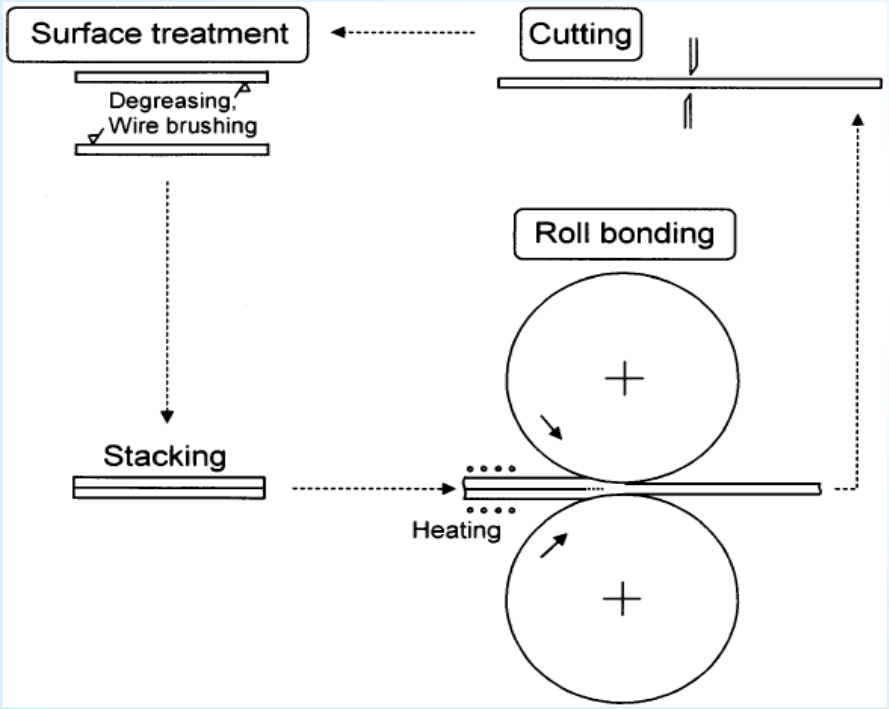


Fig.4 ARB

Main drawbacks

- Degreasing and wire brushing is needed
- For good bonding, elevated temperature
- Edge cracking is a major problem

1. Asymmetric Cryorolling

- **SPD technique: ACR**

  - Additional shear strain contributes to grain rotation and subdivision, producing grain refinement and modification of crystallographic texture. This improves the properties of the sheet.

  - The suppression of dynamic recovery during deformation at extremely low temperatures preserves a high density of dislocations generated by deformation.

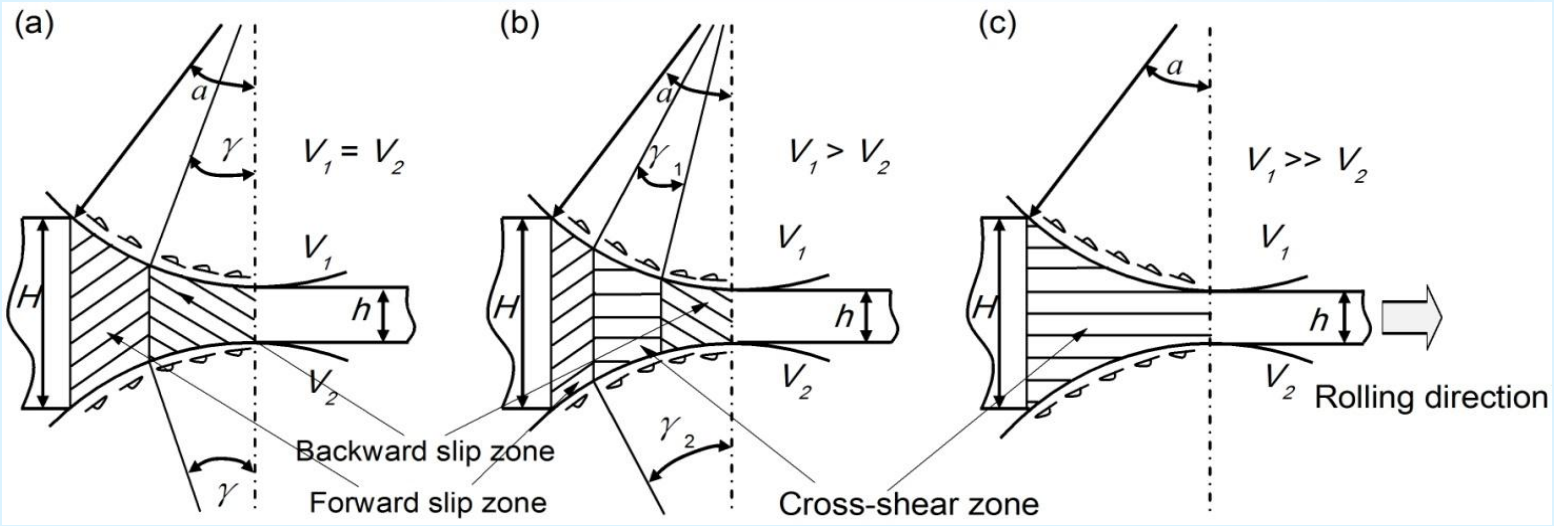


Fig. 5 Cross-shear zone in the rolling deformation zone

1. Asymmetric Cryorolling

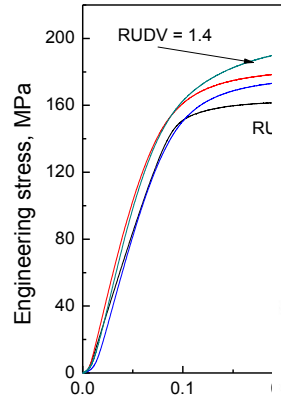
- **World's first ACR experiments**

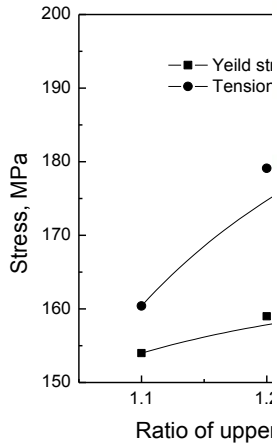
Fig.6 Asymmetric Cryorolling of aluminum sheets

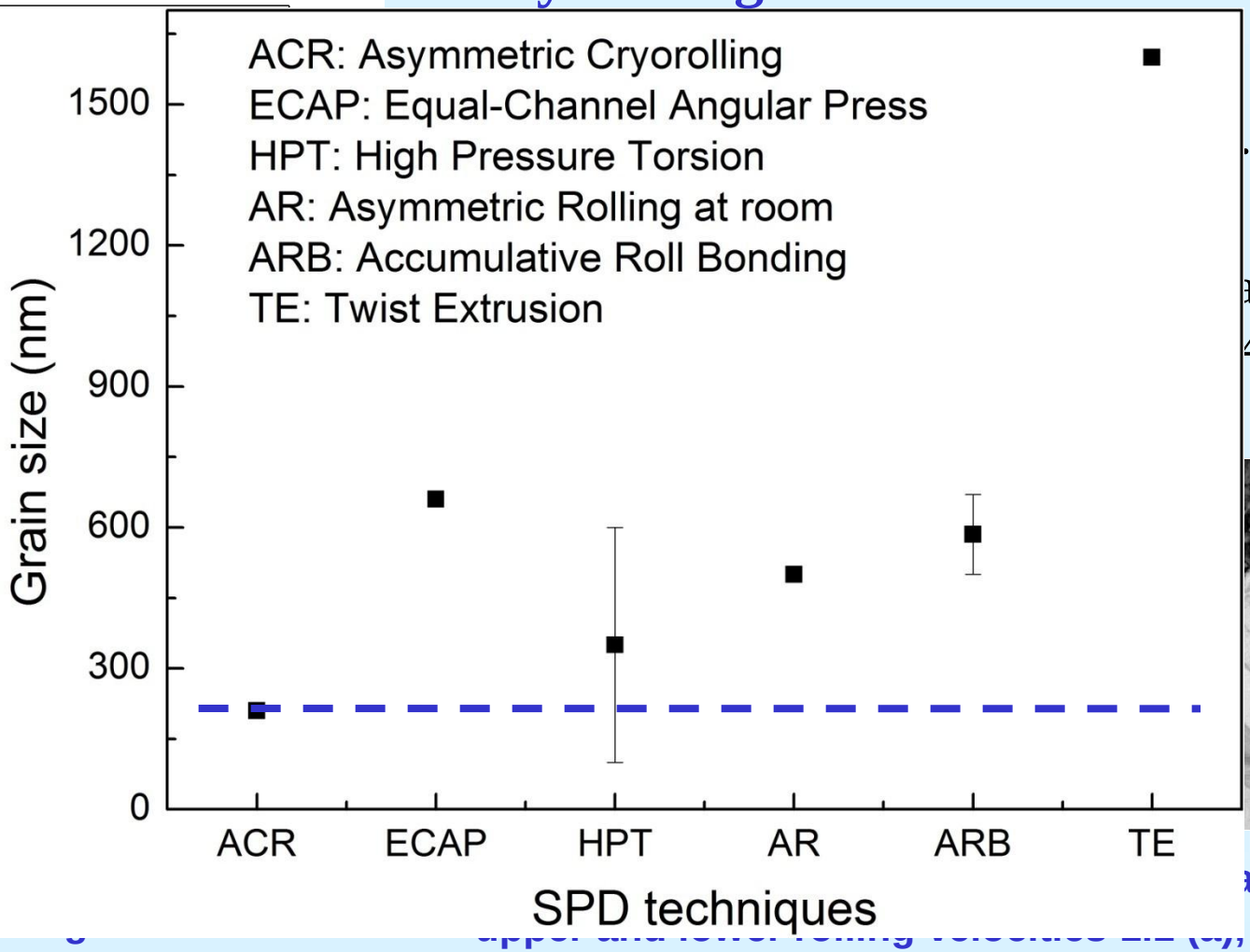
Yu H.L.*, Tieu K., Lu C., Liu X.H. et al. ***Mater. Sci. Eng. A*** 568 (2013) 212.

1. Asymmetric Cryorolling

●Key findings







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4.

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1.4 (b)

Fig. 7 Engine

Yu H.L.*, Lu C., Tieu K., et al. ***Sci. Rep.*** 2 (2012) art.772.

1. Asymmetric Cryorolling

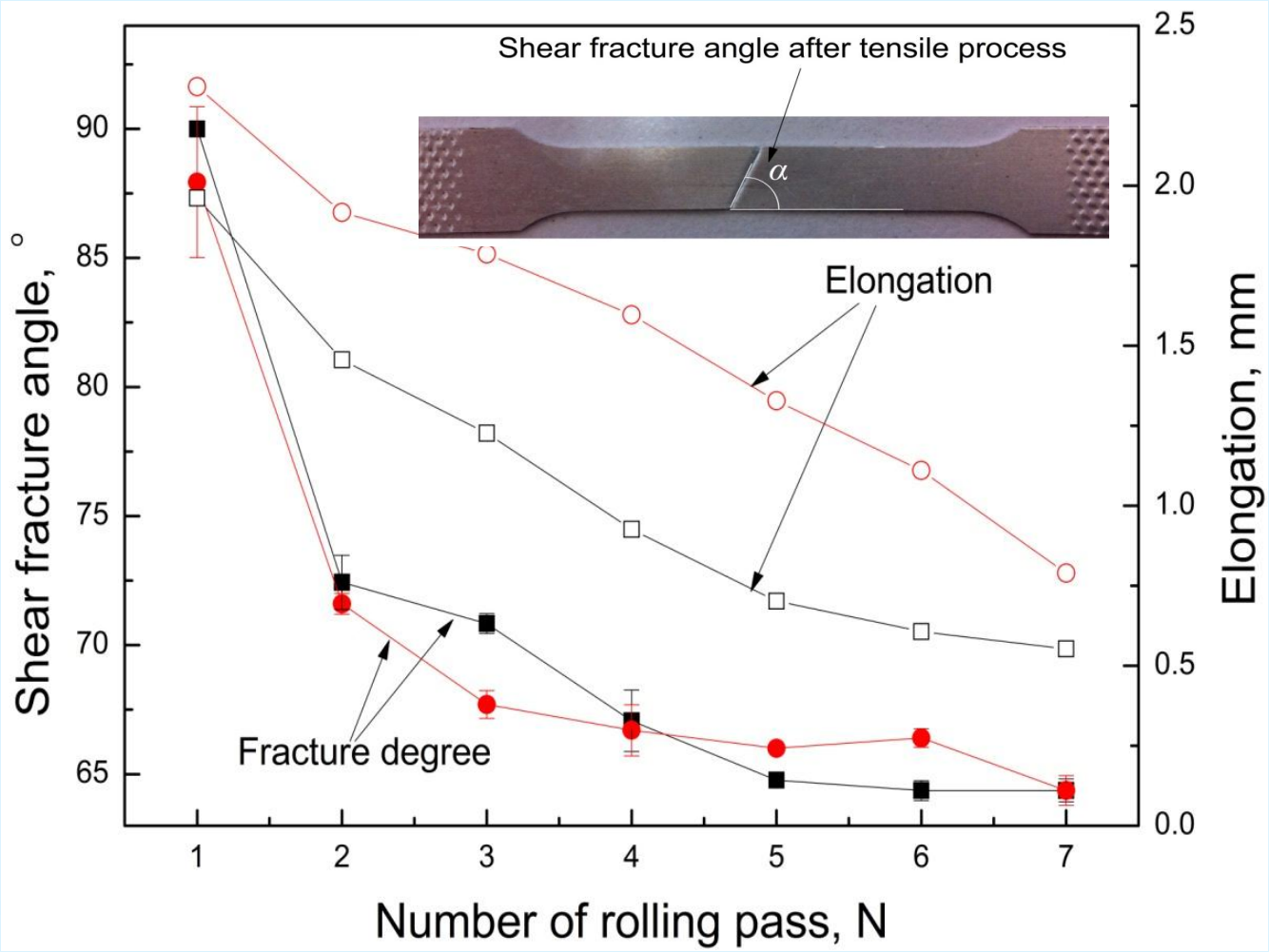


Fig. 9 Fracture degree and elongation for rolled and aged samples in tensile test.

Yu H.L.*, Tieu K., et al. ***Int. J. Damage Mech.*** 11(2014)1077.

2. Four-layer ARB

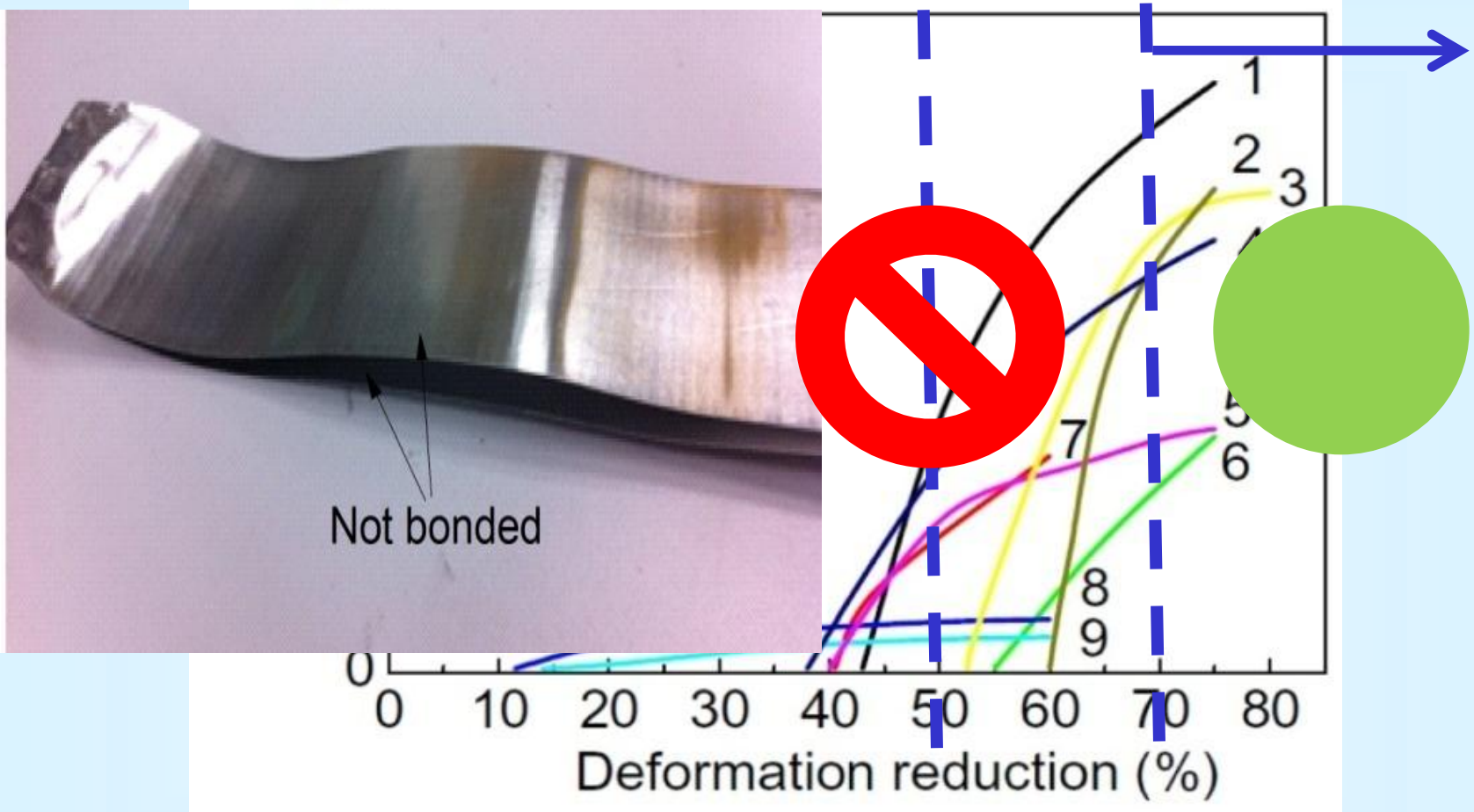
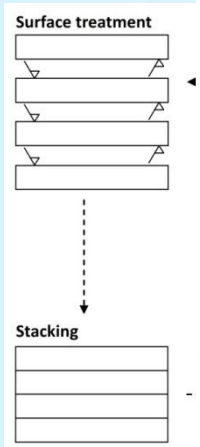
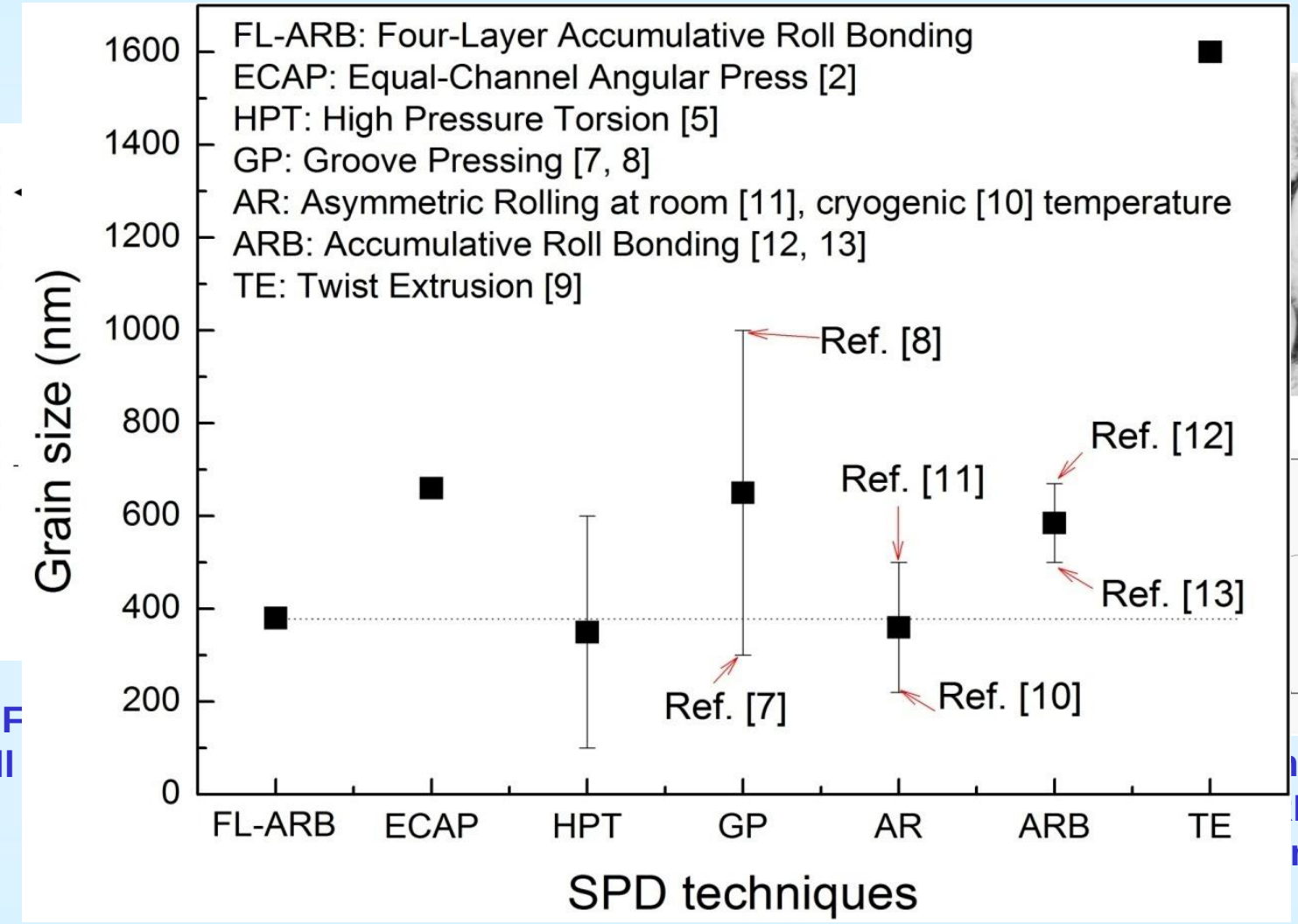


Fig. 10 Bond strength vs. reduction in deformation during cold rolling

Yu H.L.*, Liu X.H., et al. ***Metall. Mater. Trans. A*** 45 (2014) 1001.

2. Four-layer ARB





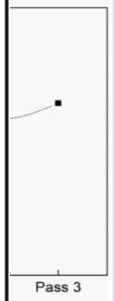


Fig. 11 F
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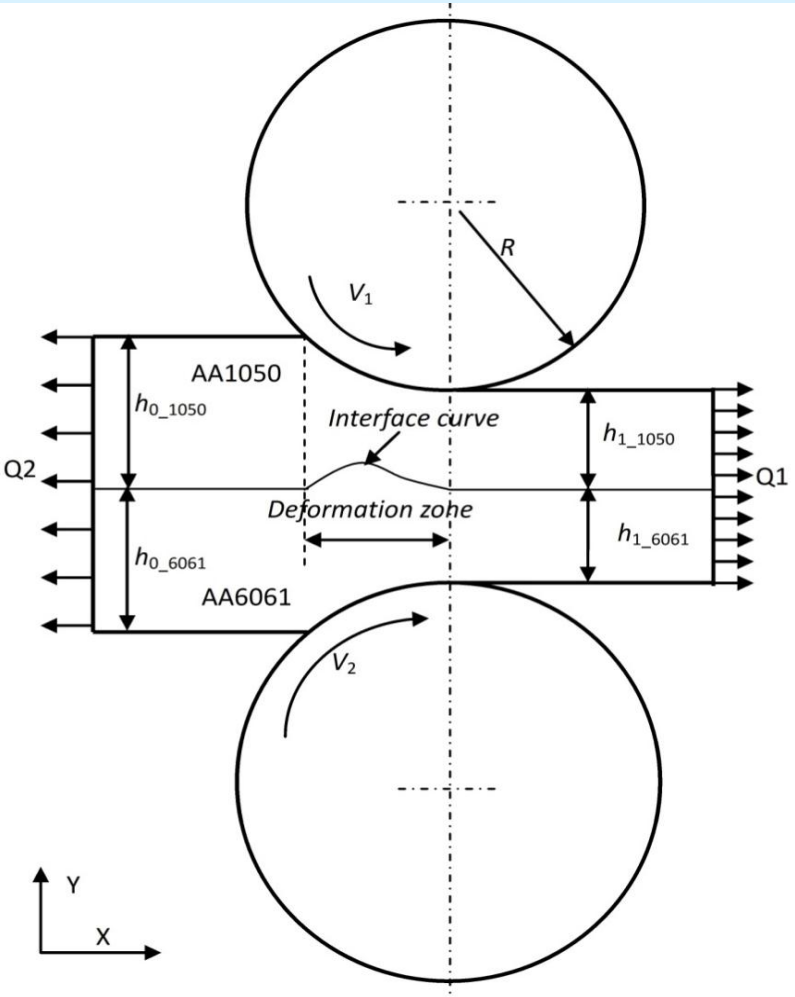
3. ARB & AR



- **Innovative combination of ARB and AR**
  - ARB technique can produce nanocomposite sheets.
  - Asymmetric rolling can produce thinner foils.

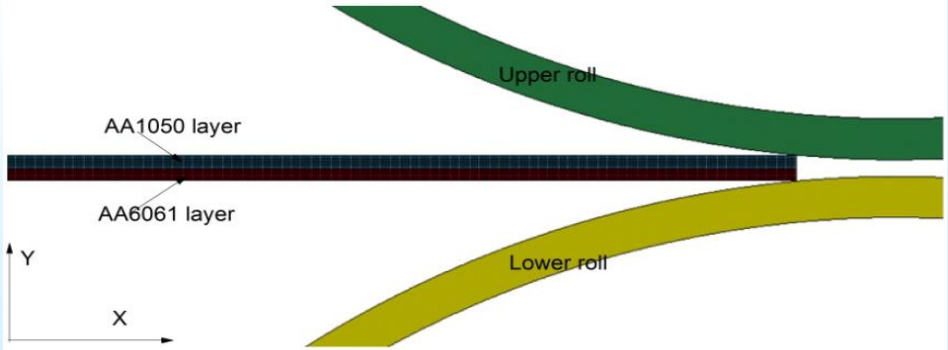
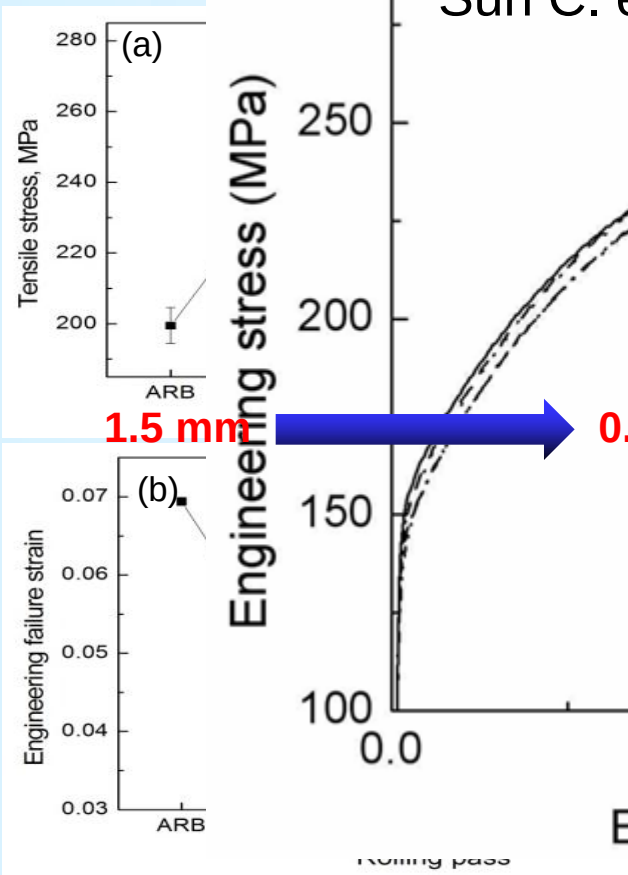


Fig. 13 Illustration of asymmetric rolling process of bimetallic foils

3. ARB & AR

●Key fi



1.5 mm → 0.04 mm

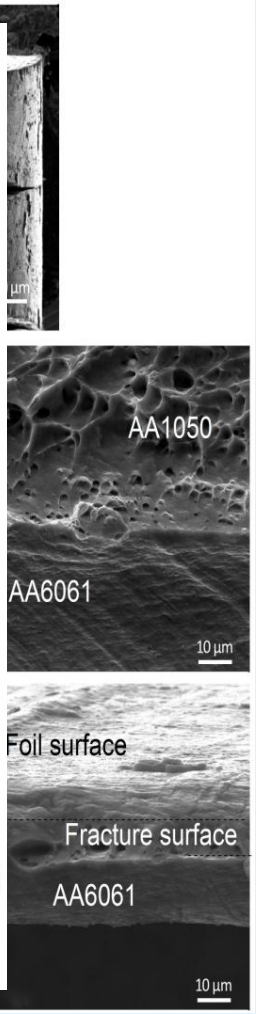
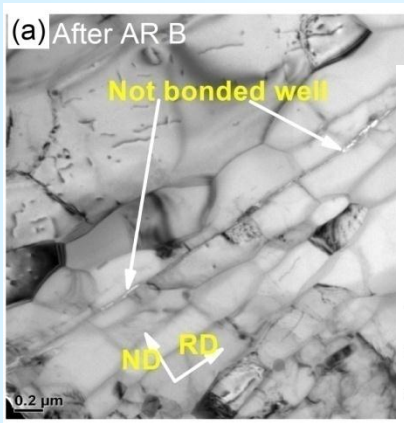


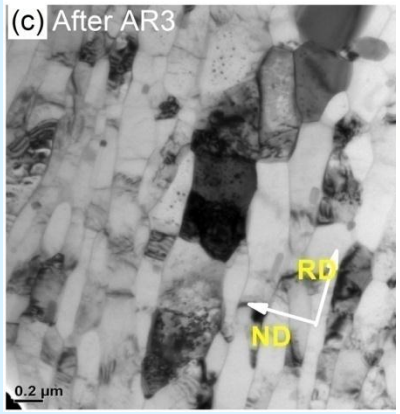
Fig. 14 Tensile test for rolled bimetallic foils Fig. 15 Fracture graphs of tensile test samples

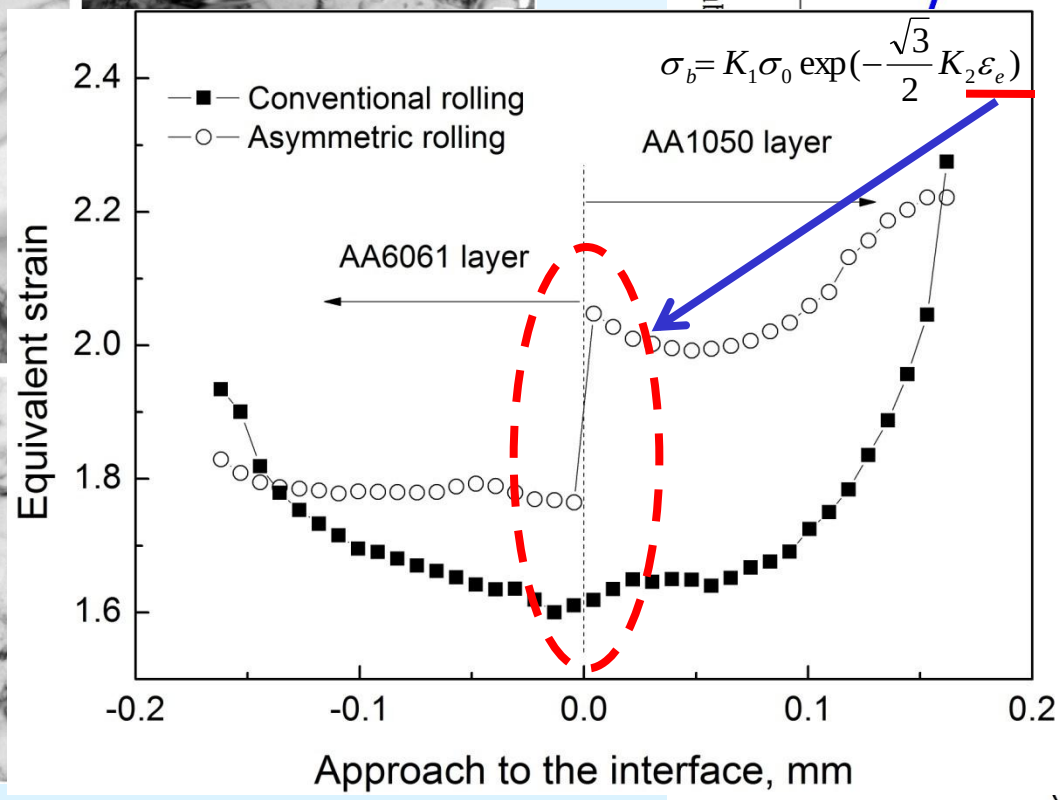
Yu H.L.*, Lu C., Tieu K., et al. ***Sci. Rep.*** 3(2013) art. 2373.

3. ARB & AR

●Key findings







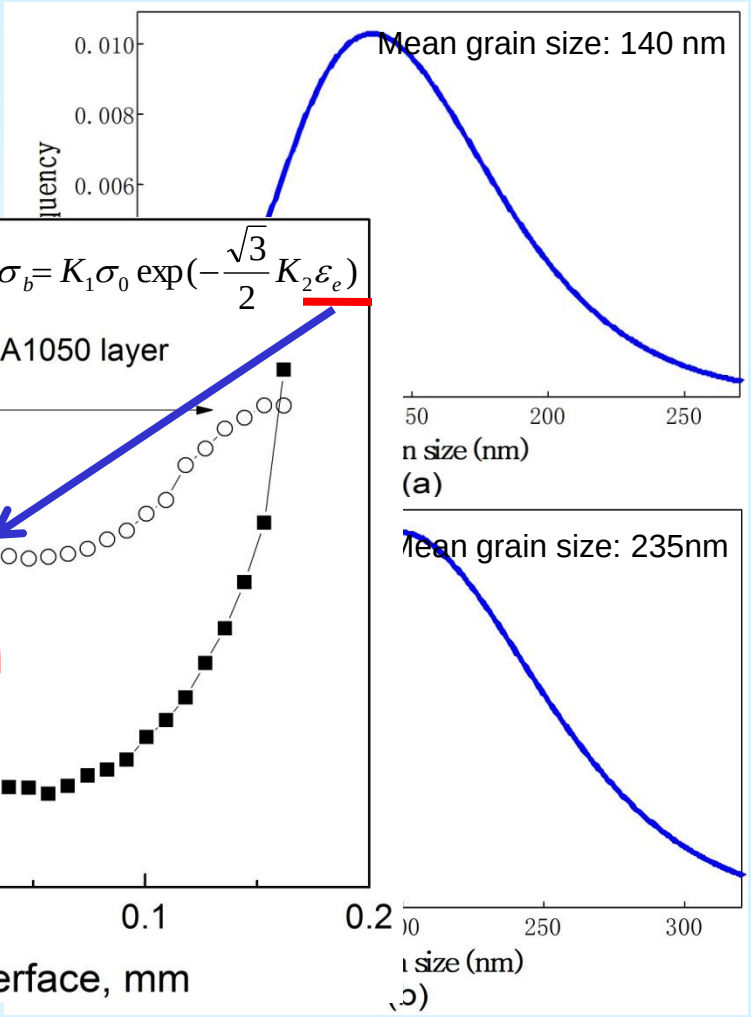


Fig. 16 TEM graph of the bonding zone

Fig. 17 Log-normal distribution of grain size

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3. ARB & AR

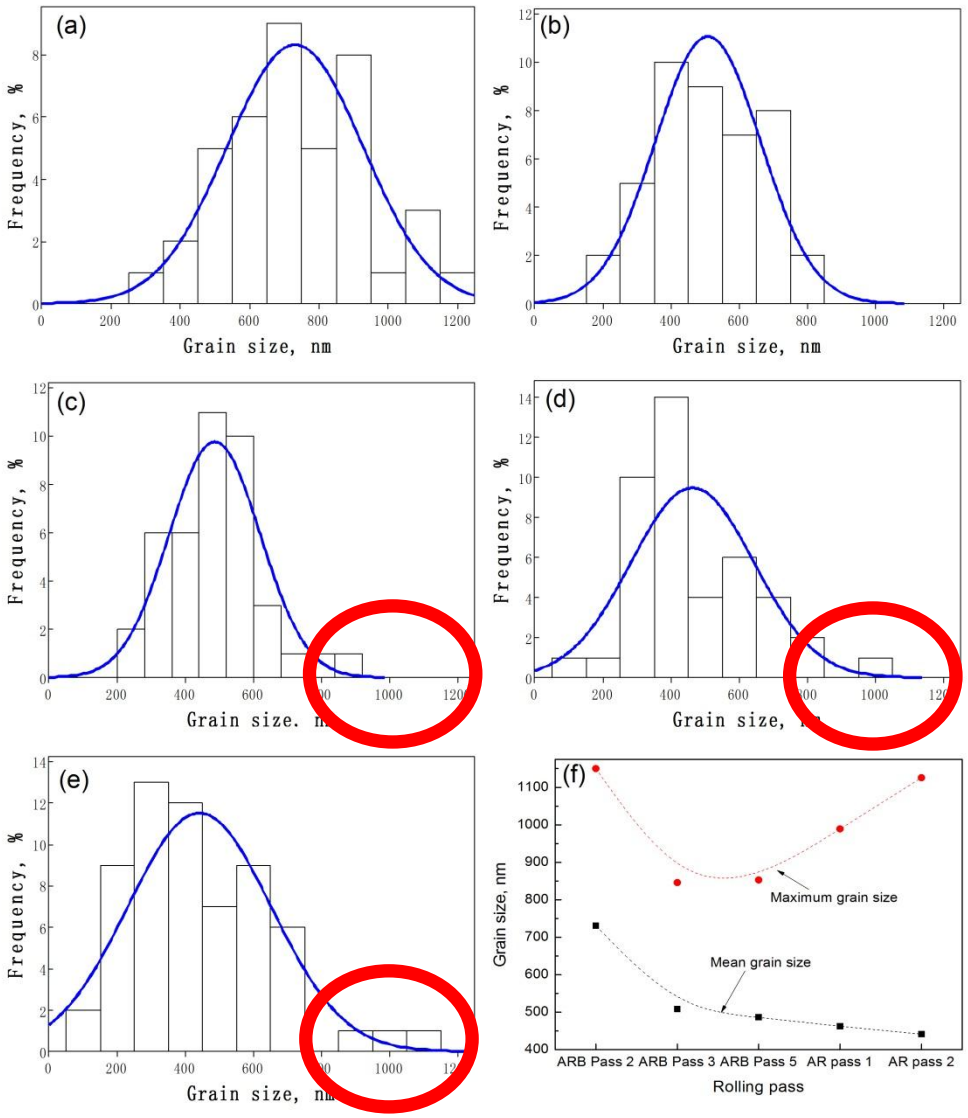

Fig. 18 Micro- foils of thickne g.

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3. ARB & AR

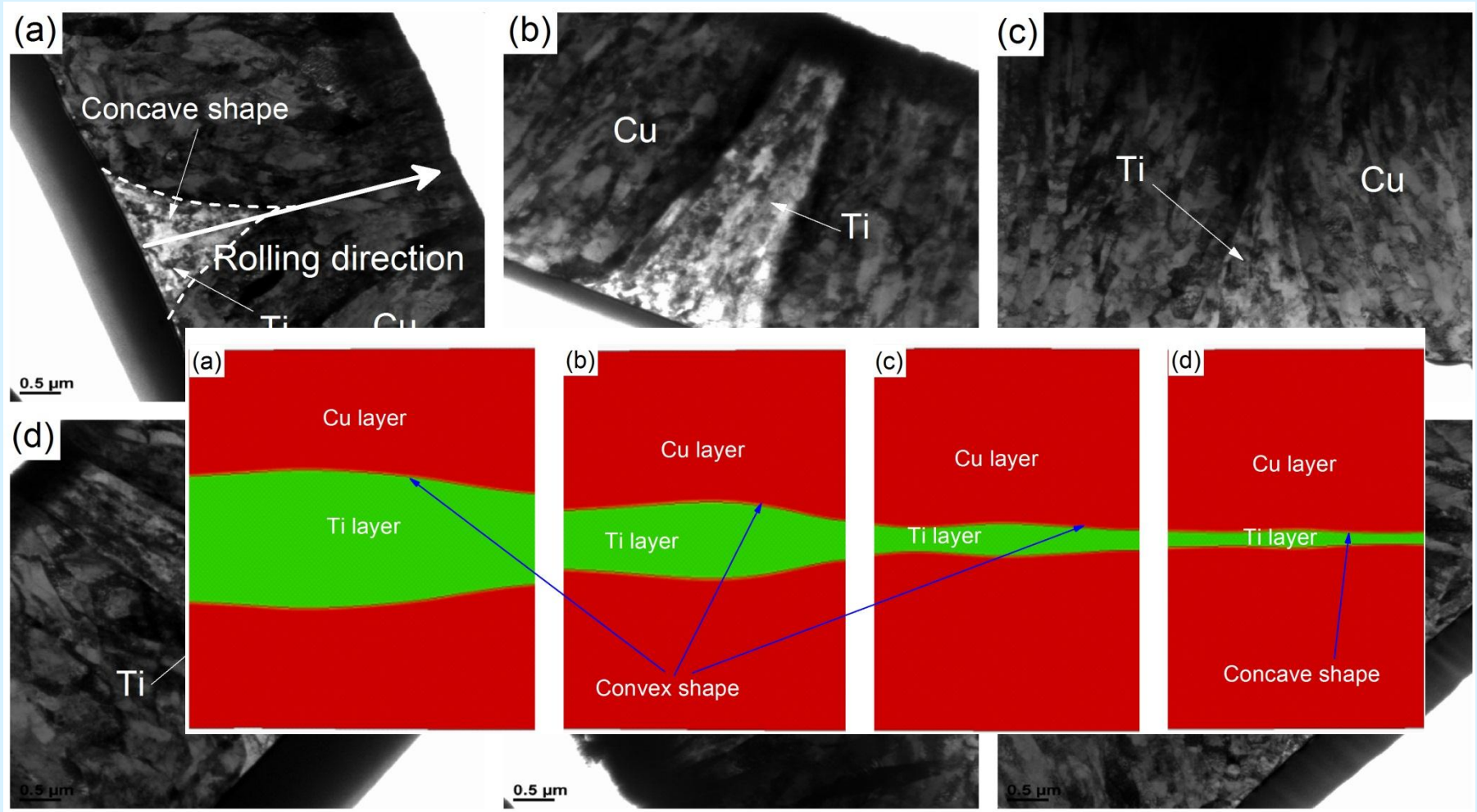

Fig. 19 TEM graph of Ti layer shape along the rolling direction.

3. ARB & AR

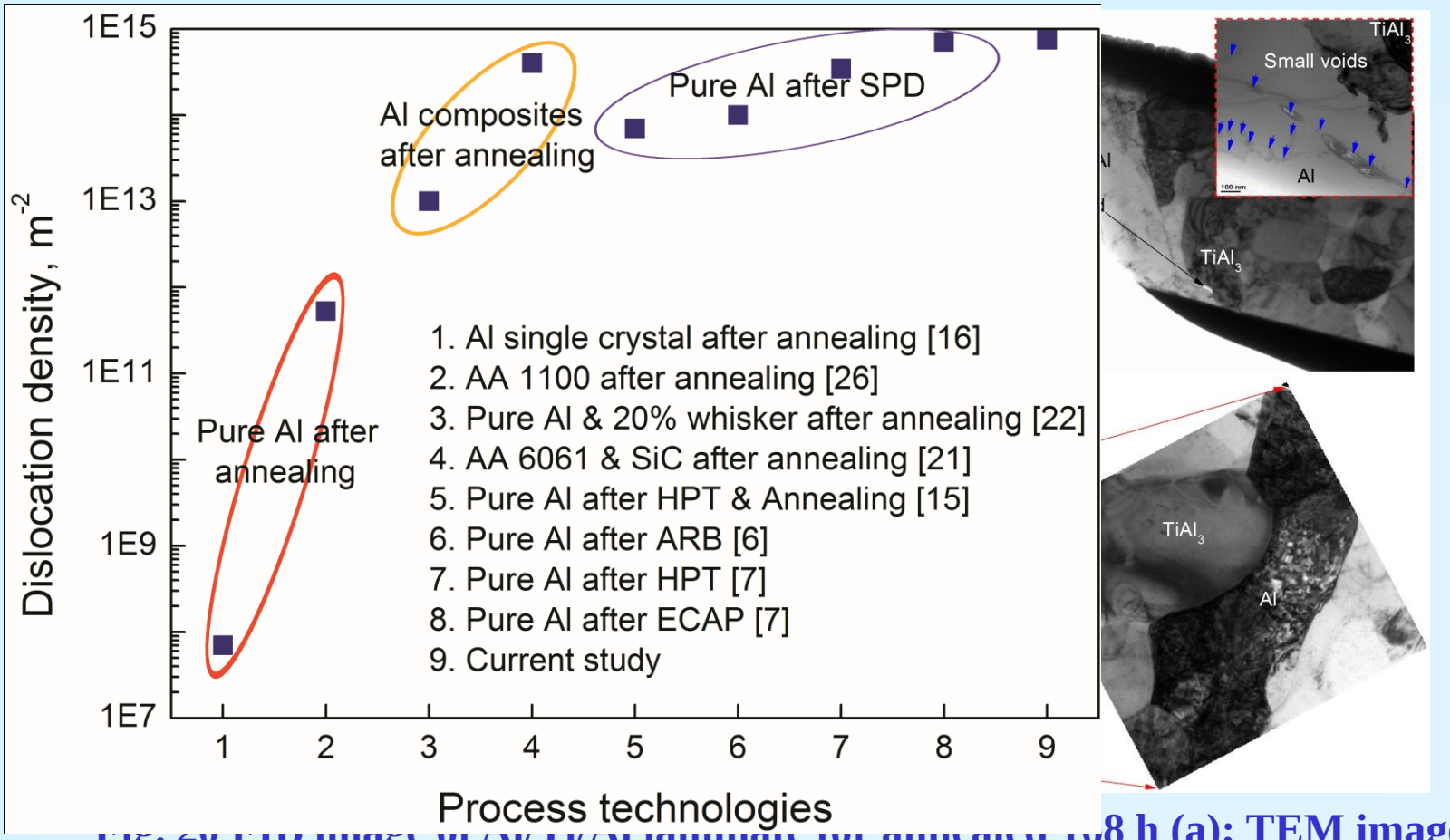

Fig. 20 FIB image of Al/Ti/Al laminate for annealed 168 h (a); TEM images of annealed Al/Ti/Al laminates in $TiAl_3$ nanoparticle frontier for 6 h (b), 12 (c) 48 h (d) and 168 h (e); (f) is a detail of (e).

ICTP2014, Nagoya

Co-authors: Prof. Kiet Tieu, UOW

A/Prof. Cheng Lu, UOW

Acknowledgements:

- **Vice-Chancellor's Fellowship Grant, UOW**
- **2013 URC small grant, UOW**
- **2014 URC small grant, UOW**
- **National Natural Science Foundation of China (51105071)**

Thanks for your attention