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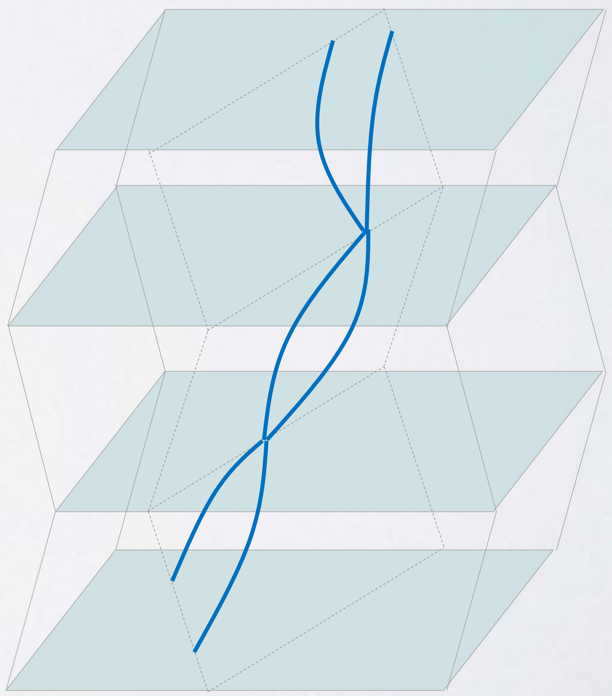
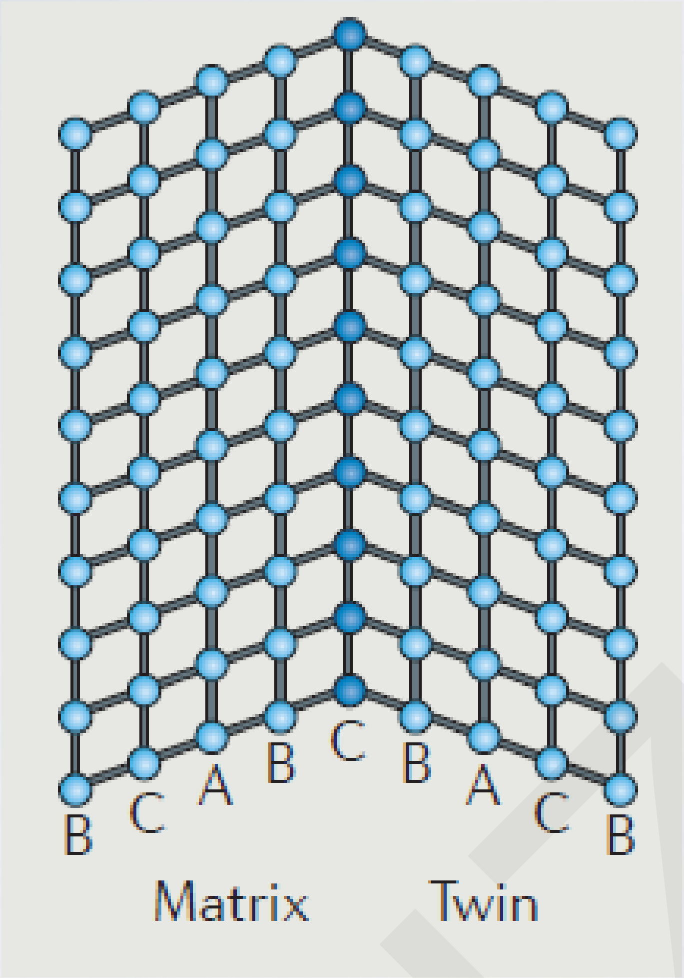
Correlated necklace dislocations in highly oriented nanotwinned metals

Key words: Nanotwinned metals, Correlated necklace dislocations, Twin boundary, Size effect, Crack, Cyclic response

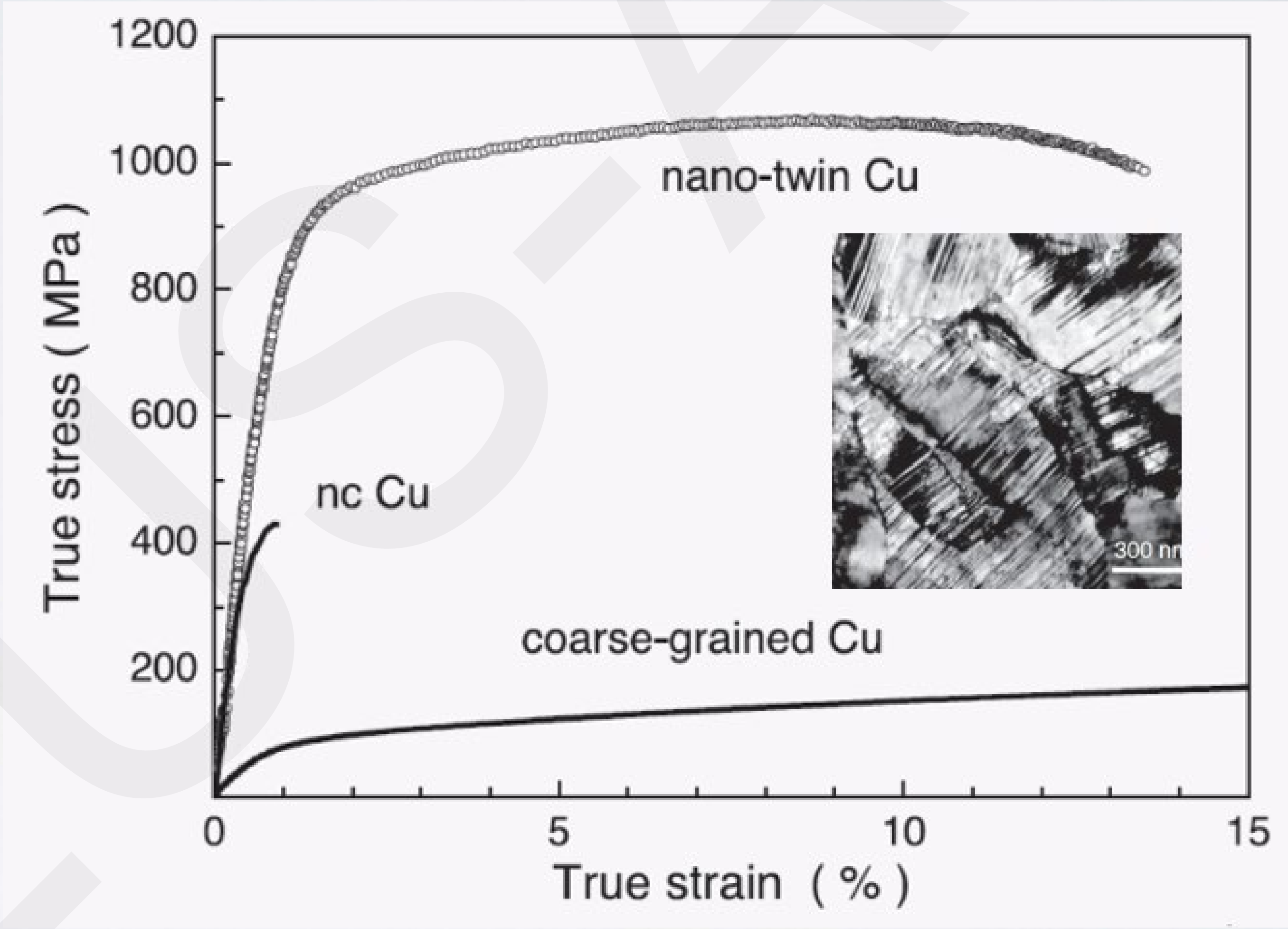


Nanotwinned (NT) metals

Twin boundary



NT Copper

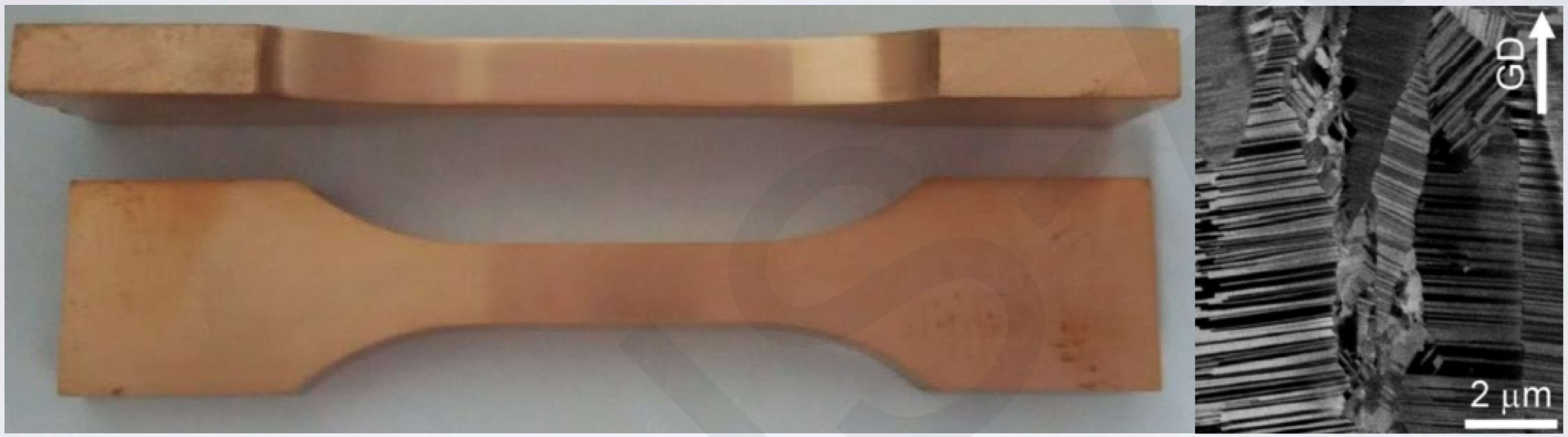


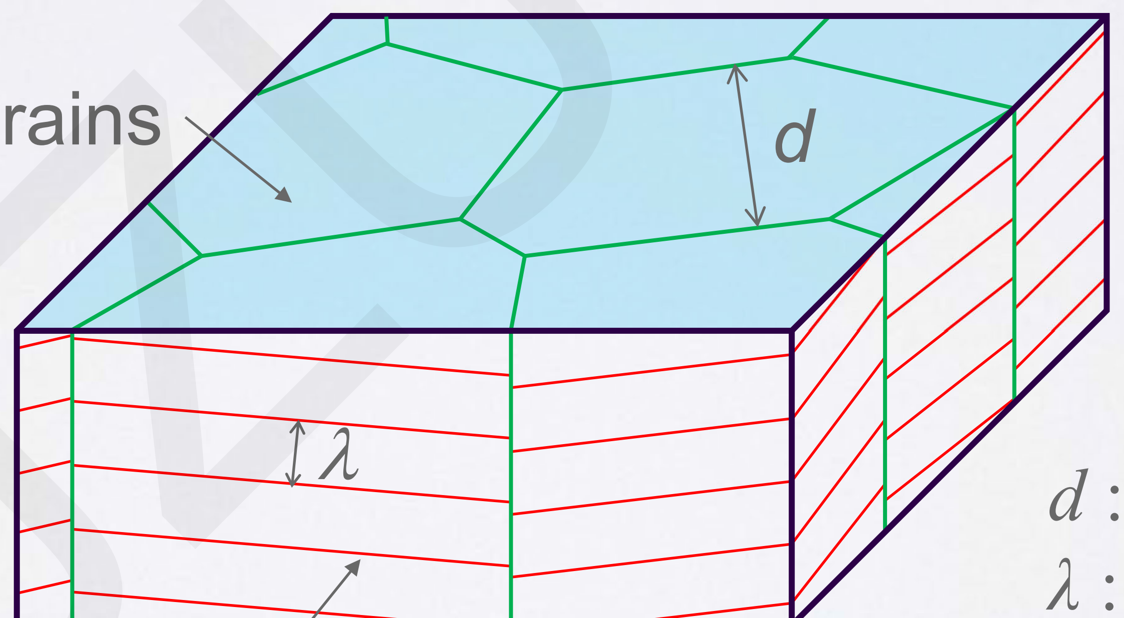
- high strength combined with large tensile ductility
- enhanced resistance to fracture and fatigue

K. Lu 2016 Nature Reviews Materials 1, 16019.
L. Lu et al. 2004 Science 304, 422.

Highly oriented nanotwins

- Synthesized by electrodeposition

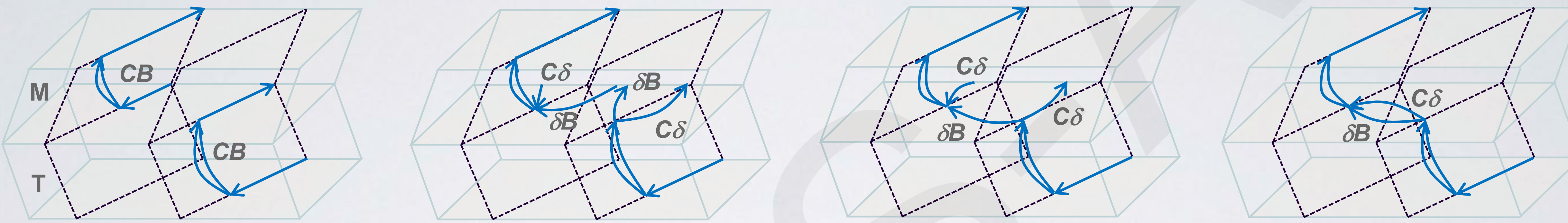




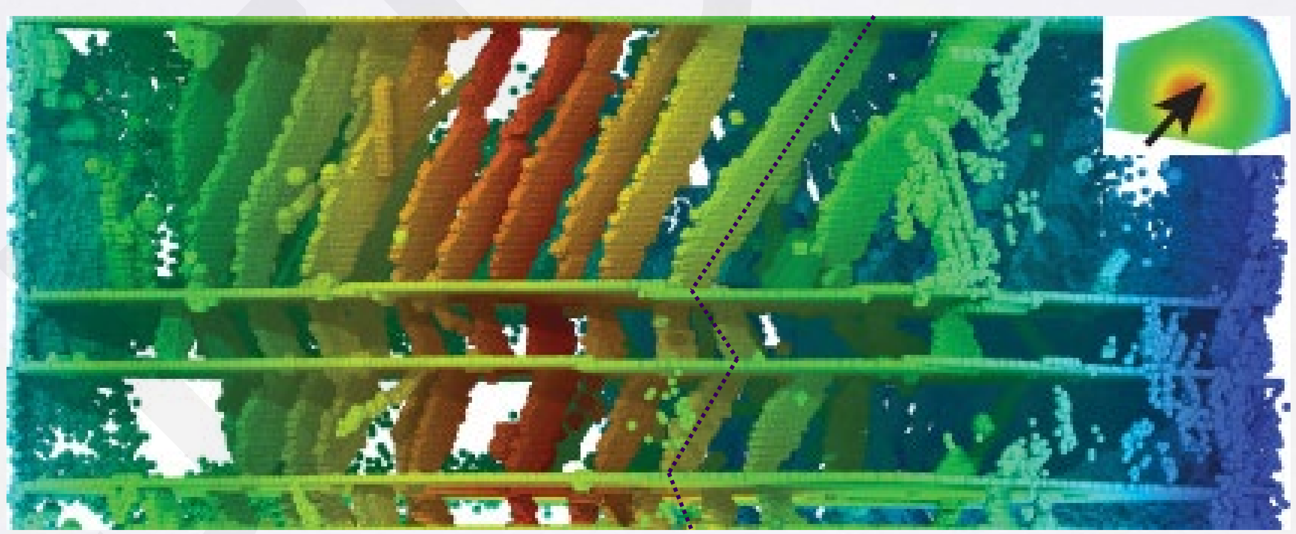
Q.S. Pan et al. 2017 Nature 551, 214.

Cyclic deformation

Threading dislocation CND

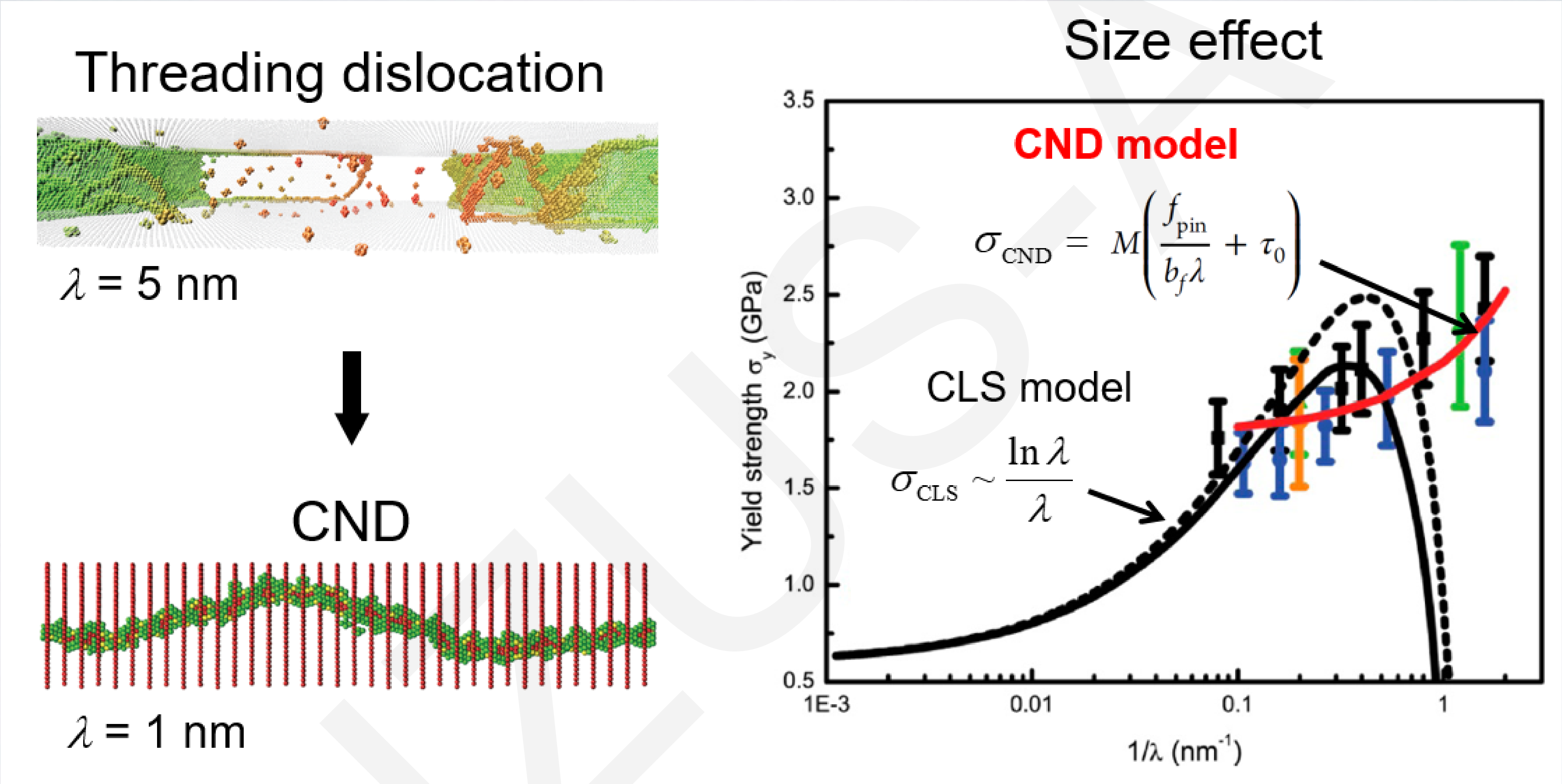


- Under cyclic loading, the threading dislocations emerge to form a CND



Q.S. Pan et al. 2017 Nature 551, 214.

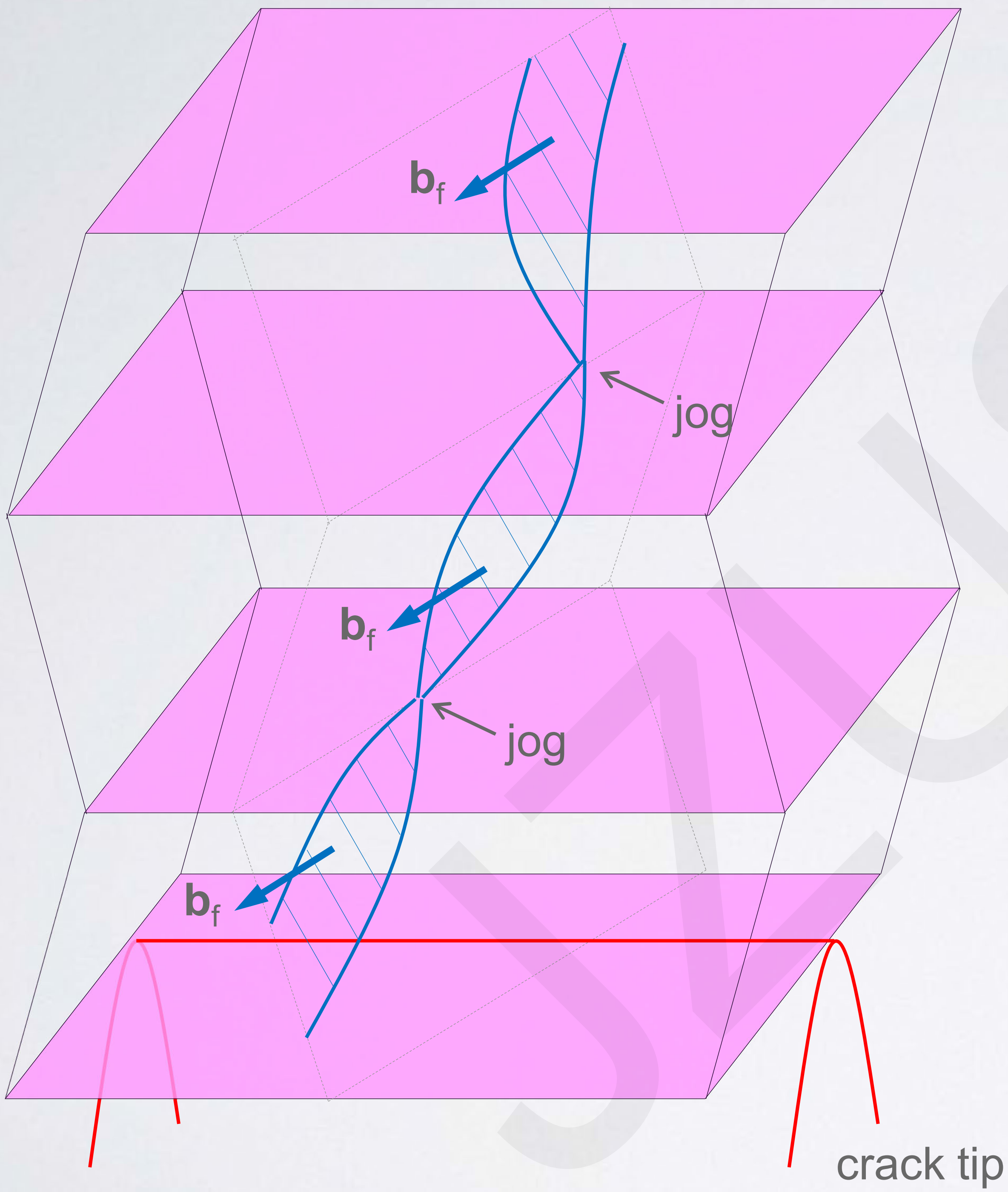
Strengthening behavior



- ➢ Continuous strengthening due to transition from threading to CND

H. F. Zhou et al. 2014 Nano Letters 14, 5075.

Crack tip plasticity



- Formation of CNDs from crack-like sharp sources

H. F. Zhou and H. J. Gao, 2015 Journal of Applied Mechanics 82, 071015.

Conclusions and perspectives

- Cyclic deformation, large stress at extremely small twin spacing and stress concentration at crack tip can facilitate the linking of threading dislocations in neighboring twin layers to form CNDs.
- Direct experimental characterization of the three-dimensional configuration of CNDs is challenging.
- Further studies are needed to explore whether CNDs exist for more general loading conditions, whether CNDs exist in nanolayered materials with coherent or semi-coherent interfaces.
- A physically based constitutive model which captures the cyclic response of highly oriented nanotwins is currently lacking.