Deformation Mechanism for Polycrystal Niobium at Cryogenic Temperature

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NSCL

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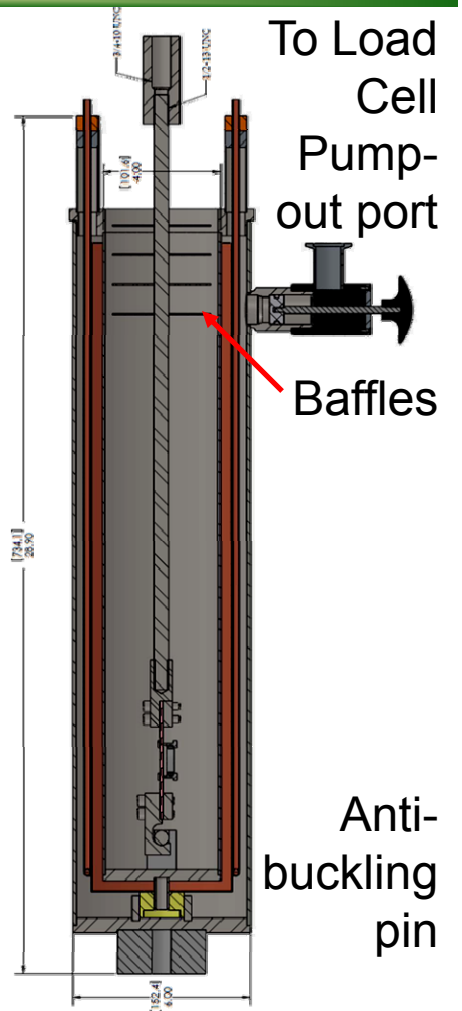
Design and Fabrication

- Use available ATS Creep-Stress Relaxation Machine
- Design adapted from cryogenic system developed at FSU/National Magnet Lab, Tallahassee, by Bob Walsh
- Dewar designed and built by ***Niowave, Inc***.



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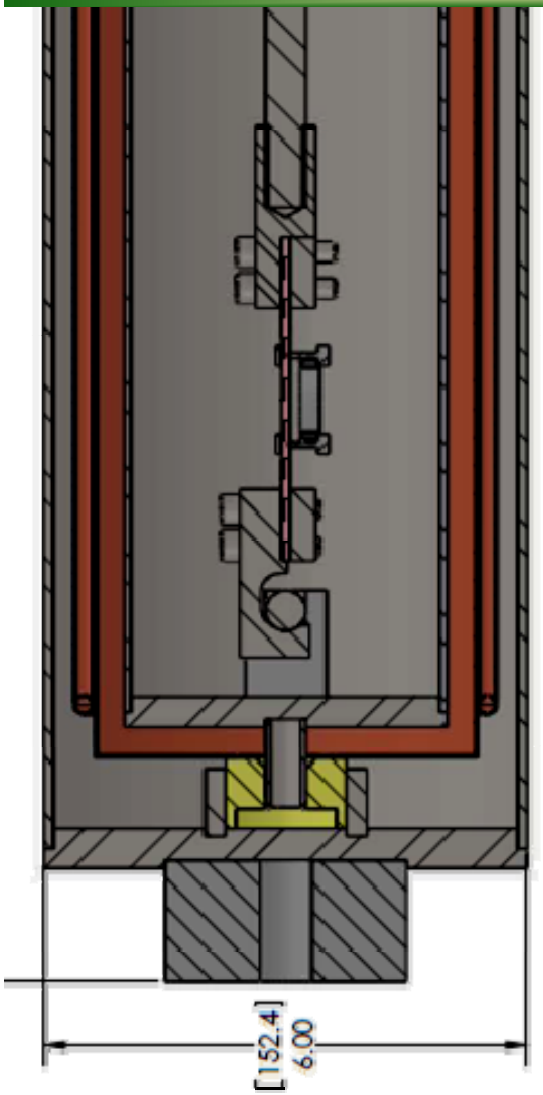
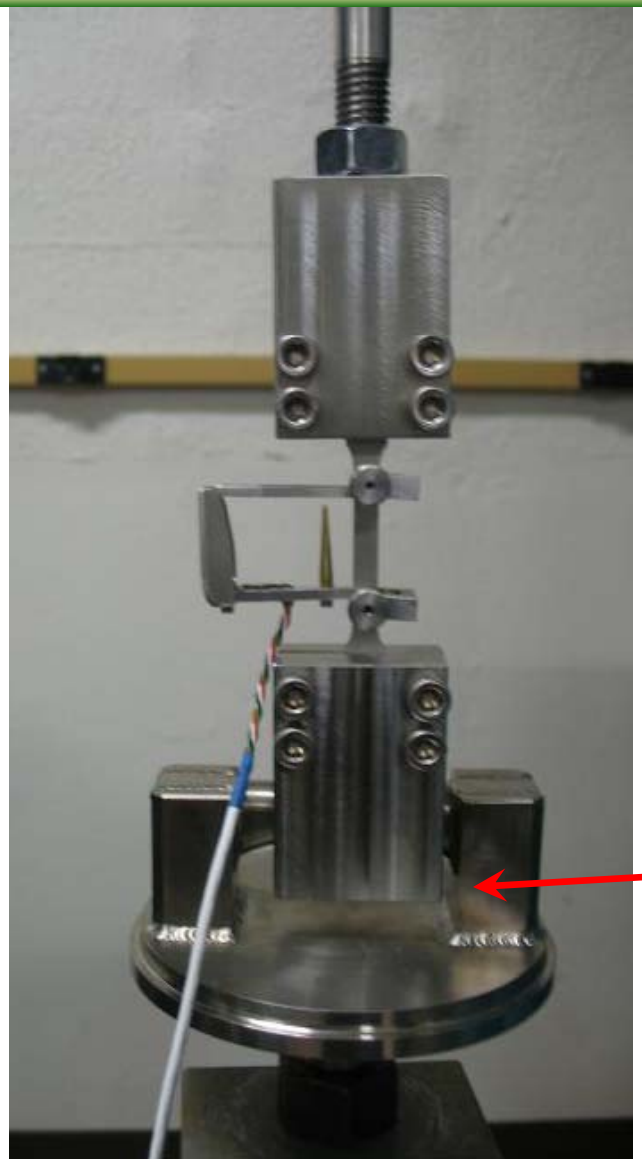
Clevis hook is on bottom of inner Dewar chamber





Yes, it is not very well aligned here

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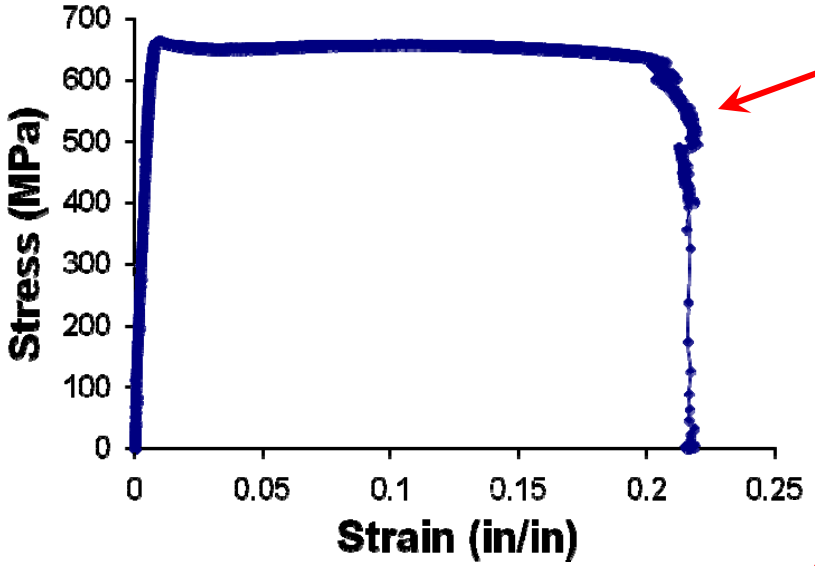
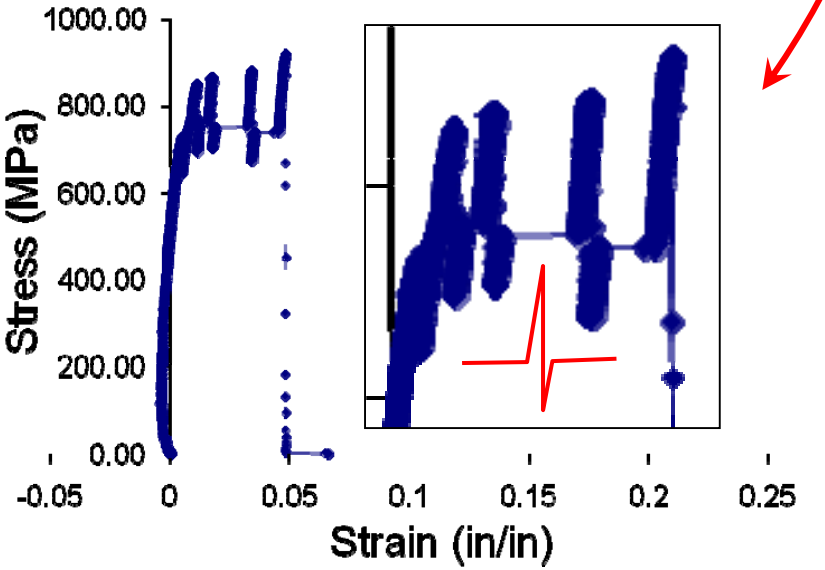
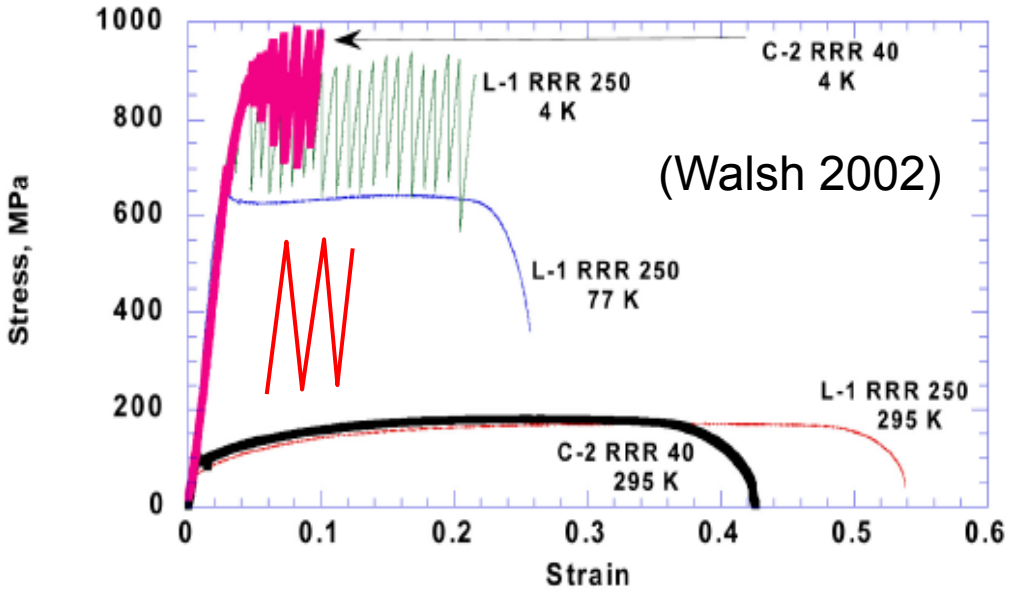
Polycrystalline samples deformed at 77 and 4K agree with data from literature

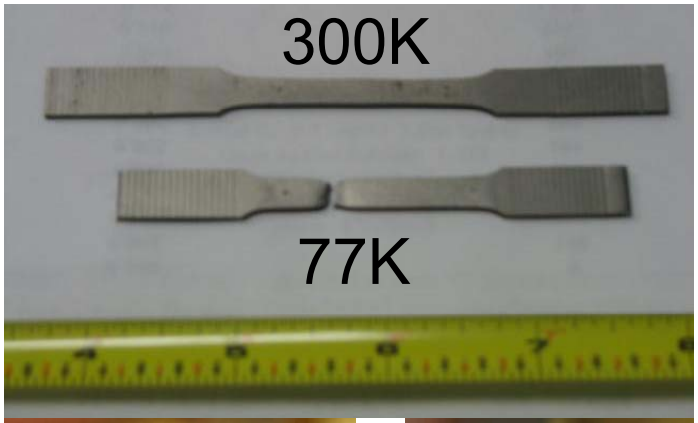


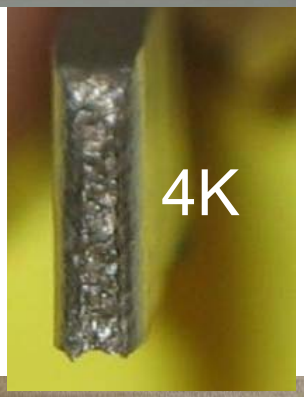


- High RRR Nb has same yield and flow behavior at 77 K
- At 4K, Sample showed 5 instances of jerky flow before fracture, at lower strain than samples from literature



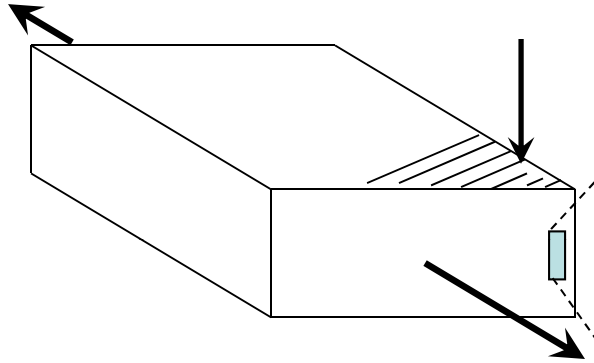
Tensile fracture features



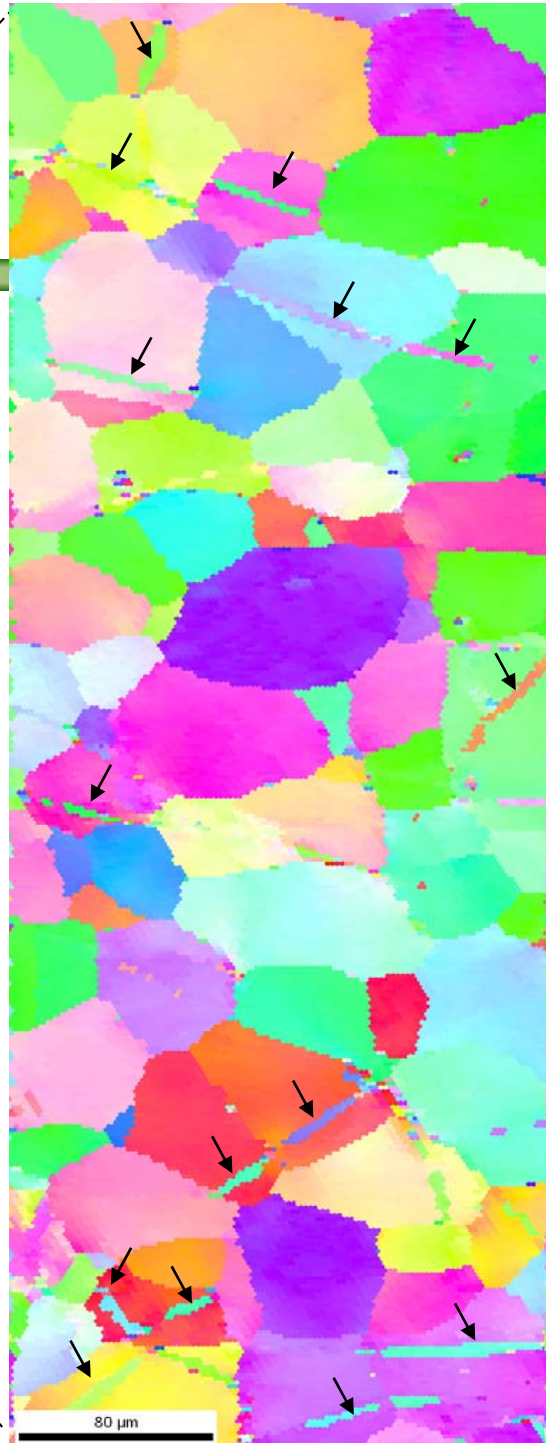


- At 300 K, no fracture
- At 77K, fracture involved considerable necking, typical ductile failure features with perpendicular fracture
- At 4K, multiple shear bands observed; one caused shear fracture.

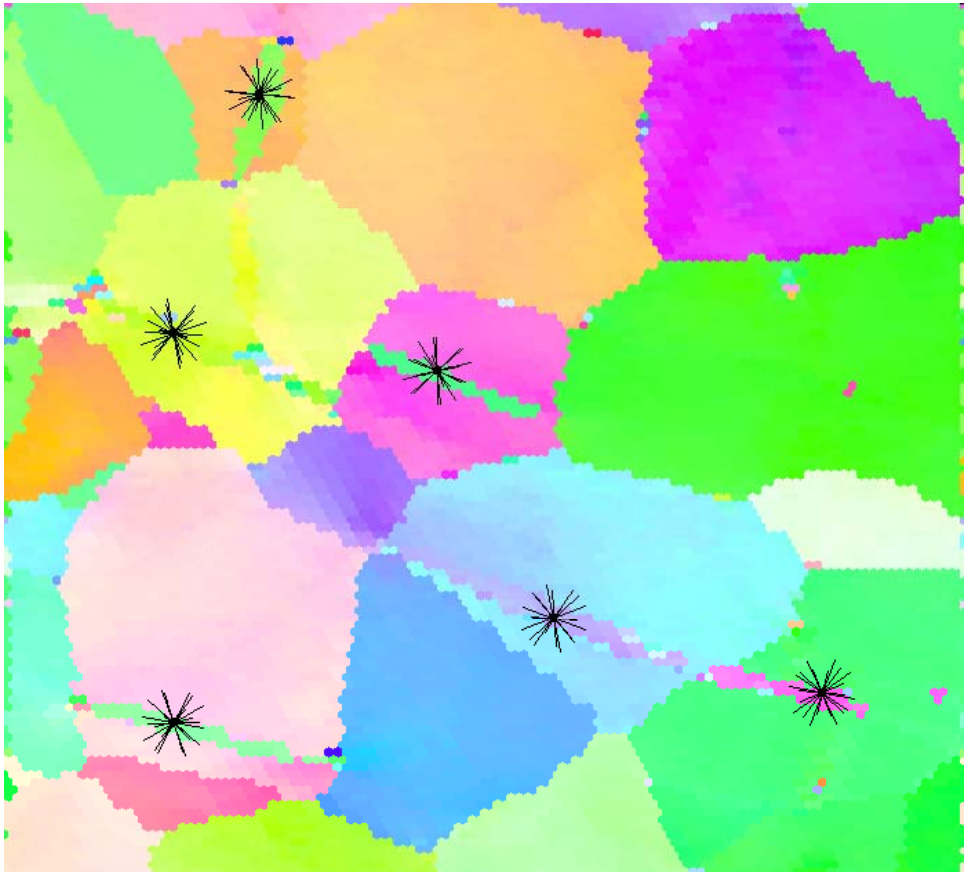
Polycrystalline Nb, tensile test @ 4K



Many mechanical twins observed, (arrows) as well as deformation gradients in grains, visible as color gradients



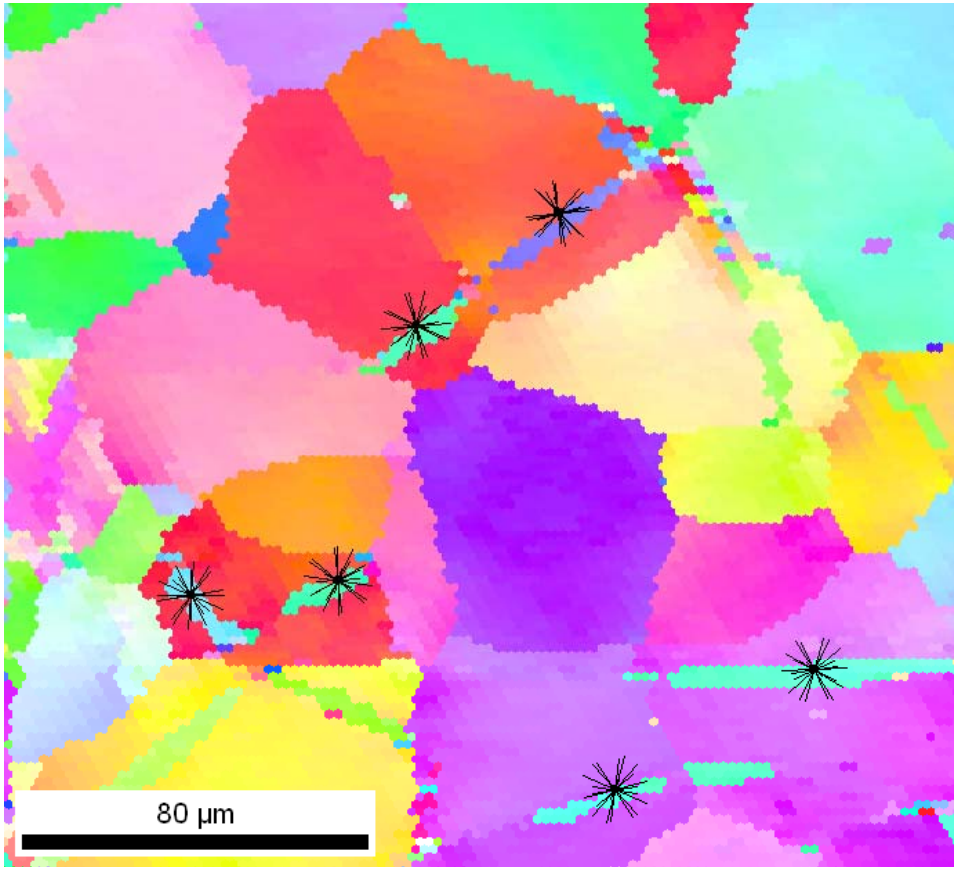
1 µm step size between data points

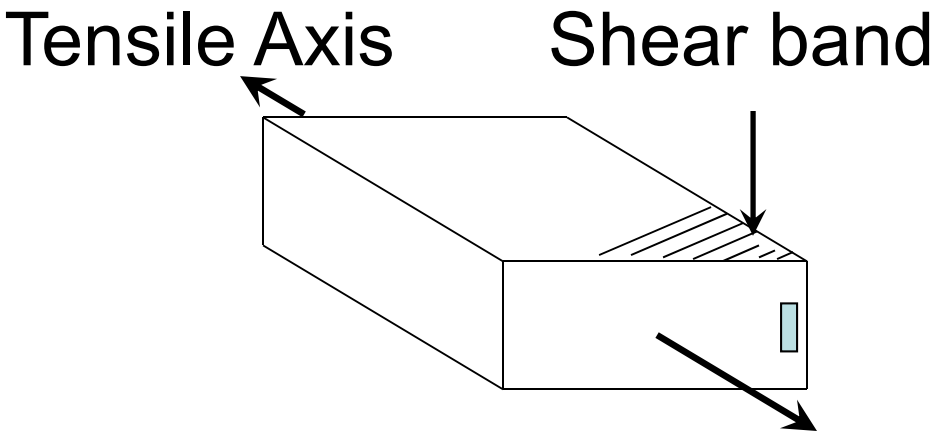


One of the family of 112 plane traces align with twins,

supports assertion of twins

(112 are twin planes for Nb)





Future plans

- ***System modifications***
  - ***Initial results are positive compared to literature***
  - ***Improve He transfer, bayonet location***
  - ***Bottom grip alignment, and retrieval***
  - ***Calibration***

- ***SRF materials test program***
  - **Test materials**
  - **Parallel testing by collaborators**
  - **Data collection and engineering documentation**
  - **Analysis of slip systems, shear banding**

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Future plans

- ***Initial materials and joints to be evaluated***

- **High purity niobium (poly-crystal)**
- **Large grain niobium**
- **Single crystal niobium**
- **Titanium**
- **Nb-Ti Alloy**
- **Niobium to Nb-Ti joint**
- **Nb-Ti to Titanium joint**
- **Niobium to stainless steel joint**

In addition, MSU's SRF materials science program will use cryogenic testing system for synergistic experiments, studying dislocation behavior at cryogenic temperature **and the effects on cavity performance (e.g. tuning)**.

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