

Dynamic Impact Tests of Tantalum Single Crystals

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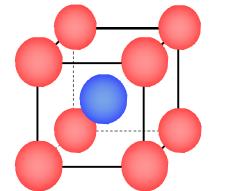
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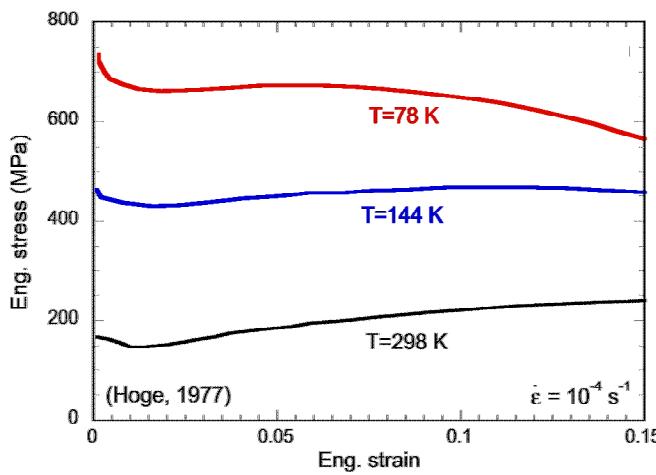
Tantalum



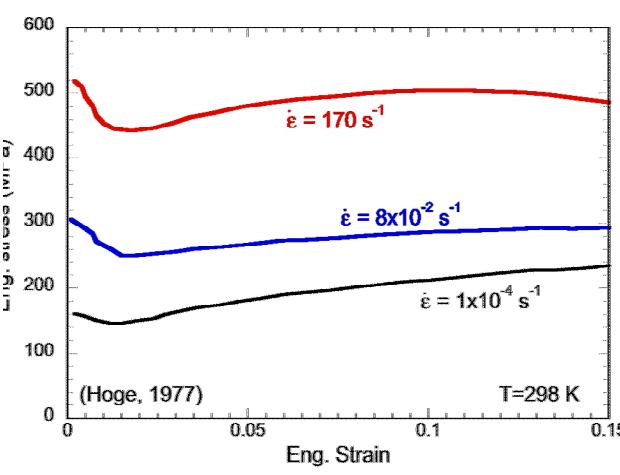
- BCC refractory metal
- High melting point (3290 K) & density (16.7 g/cm³)
- Strong, ductile, high corrosion resistance
- Nuclear / surrogate / ballistics applications.
- Electronic components (capacitors and resistors), alloying.
- Strong temperature and strain-rate dependent flow strength



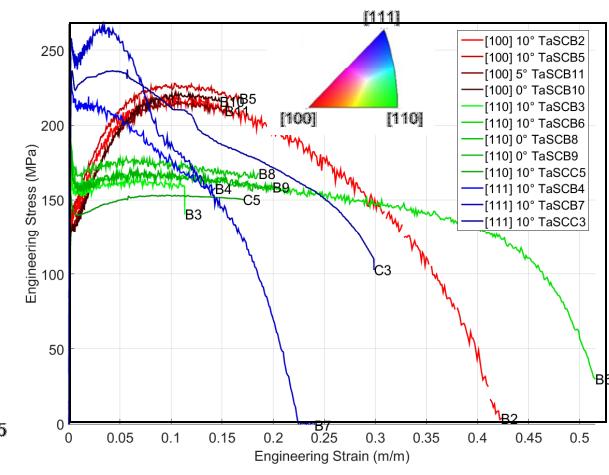
BCC structure



Polycrystalline Ta
Temperature dependence



Polycrystalline Ta
Strain rate dependence

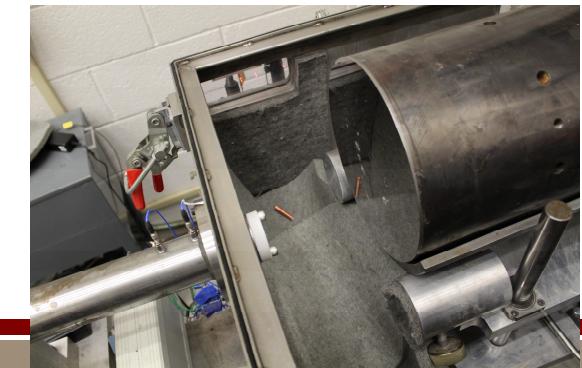
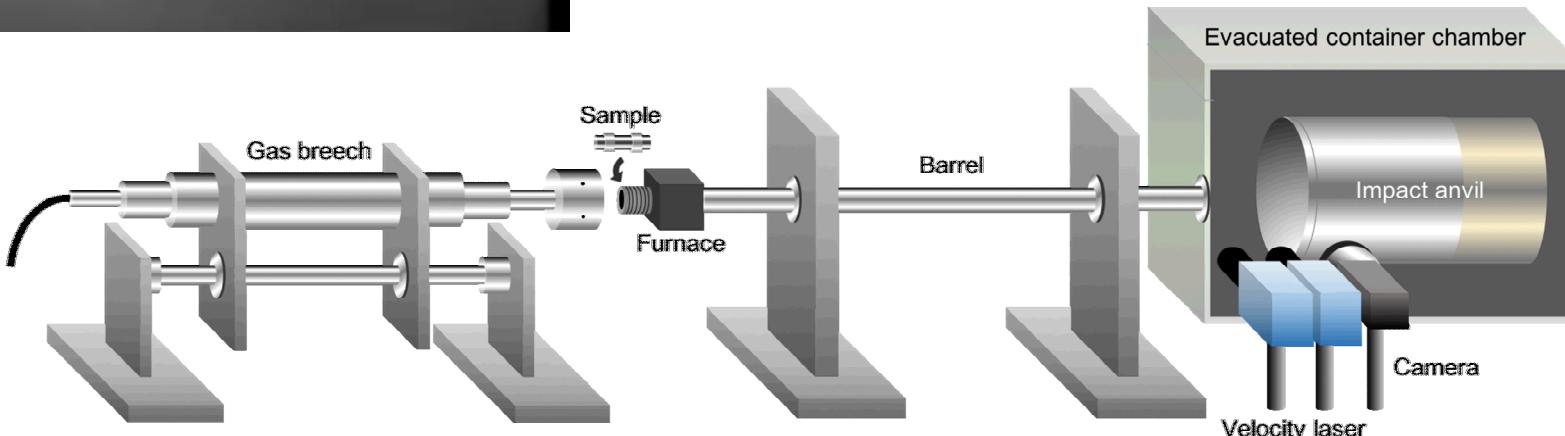


Single crystal Ta
Crystal orientation dependence

Taylor impact test

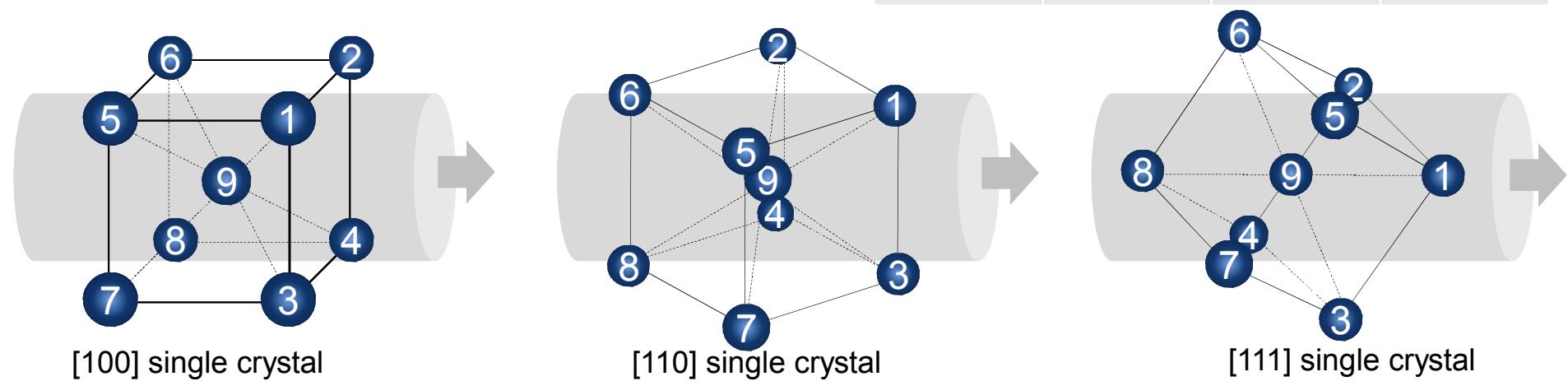
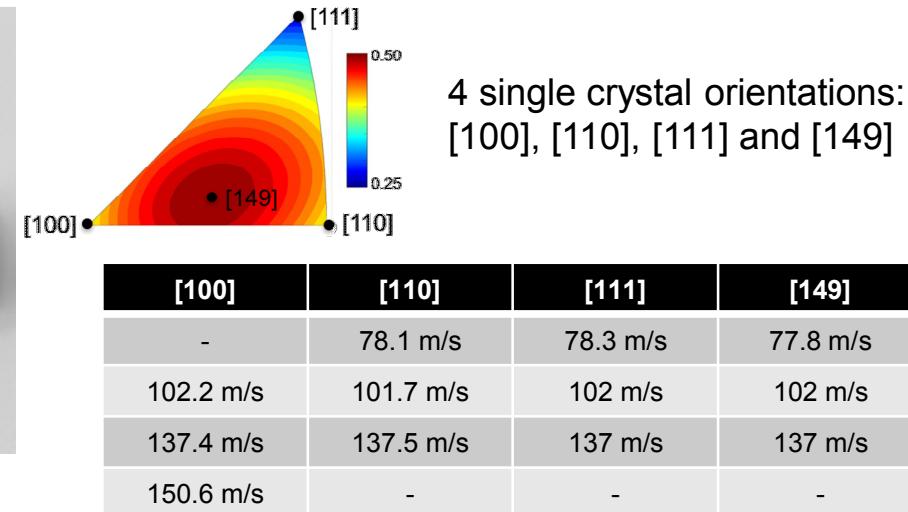
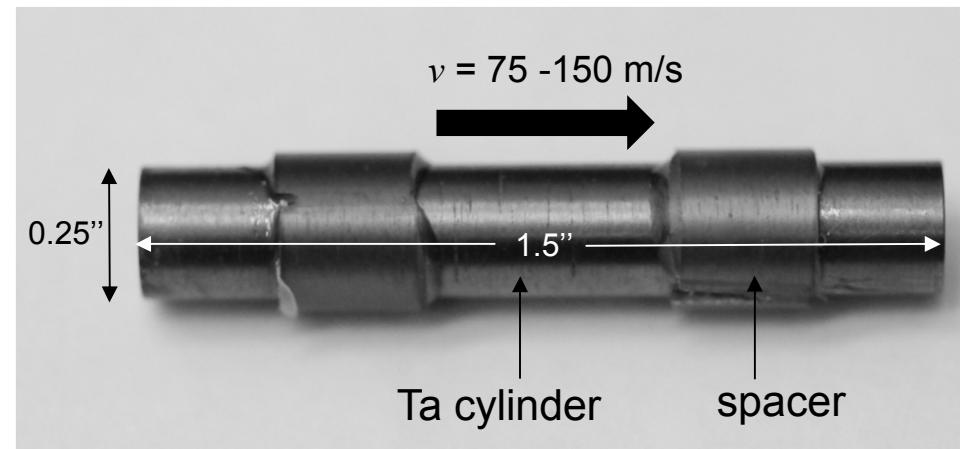


- Simple and robust technique to understand dynamic behaviors
- Large temperature & strain rate gradients
 $\dot{\varepsilon} < 5 \times 10^4 \text{ s}^{-1}$ and $T < 1000 \text{ K}$
- Provides strength & plastic anisotropy
- Non-destructive technique



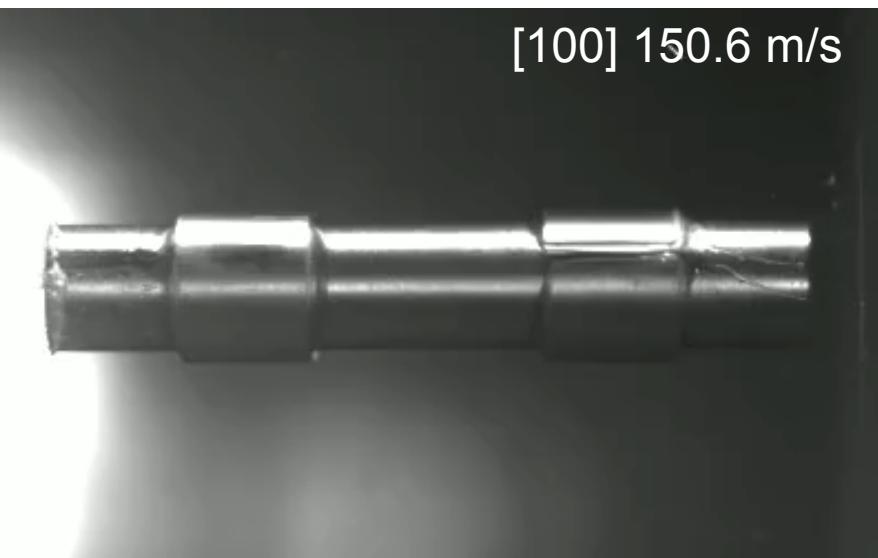
Single crystal experiments

- Extreme anisotropy
- Understand single grain scale deformation at high rate
- Dynamic behaviors (rate < shock regime) less well-known – no Taylor results



Single crystal Taylor impact shots

[100] 150.6 m/s



[111] 78.3 m/s



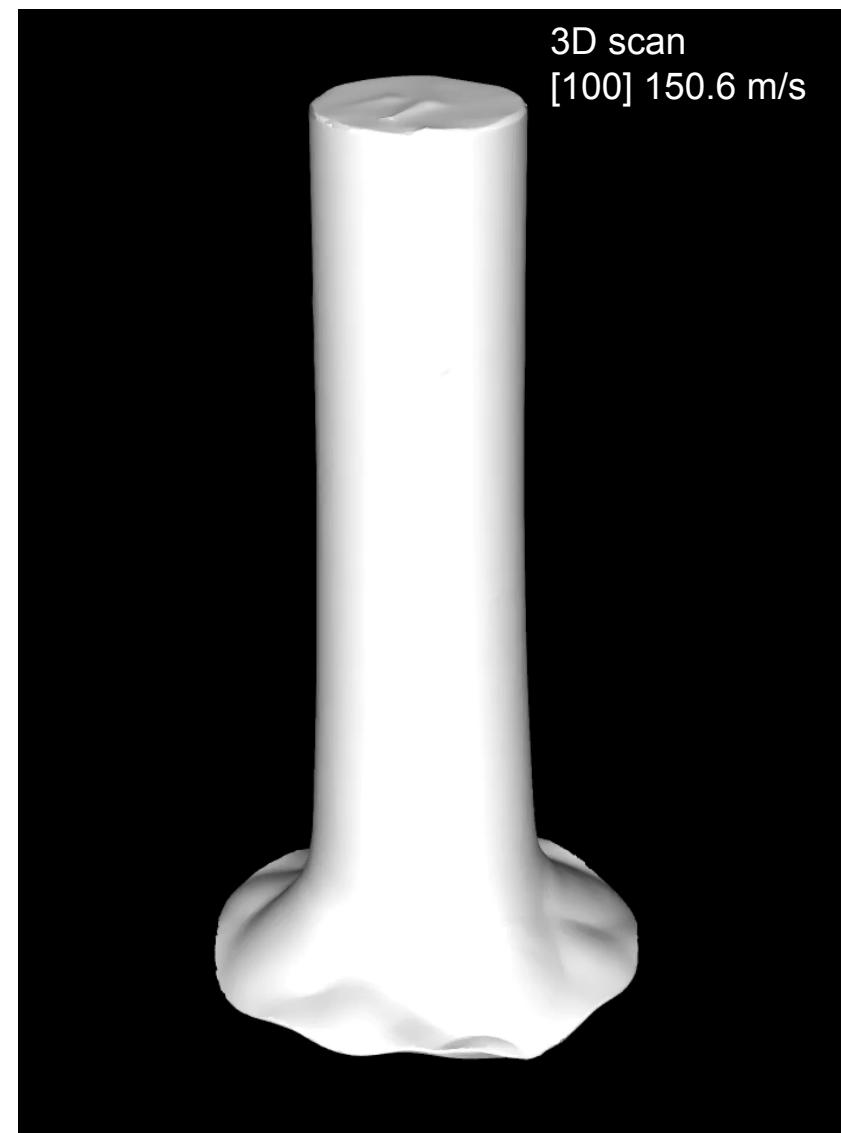
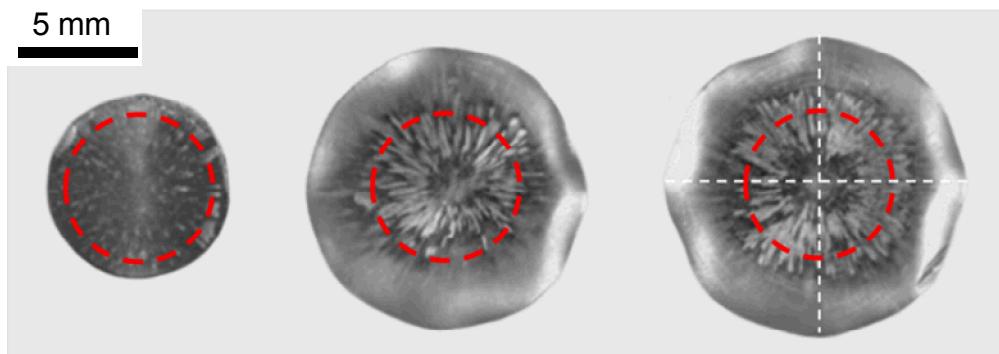
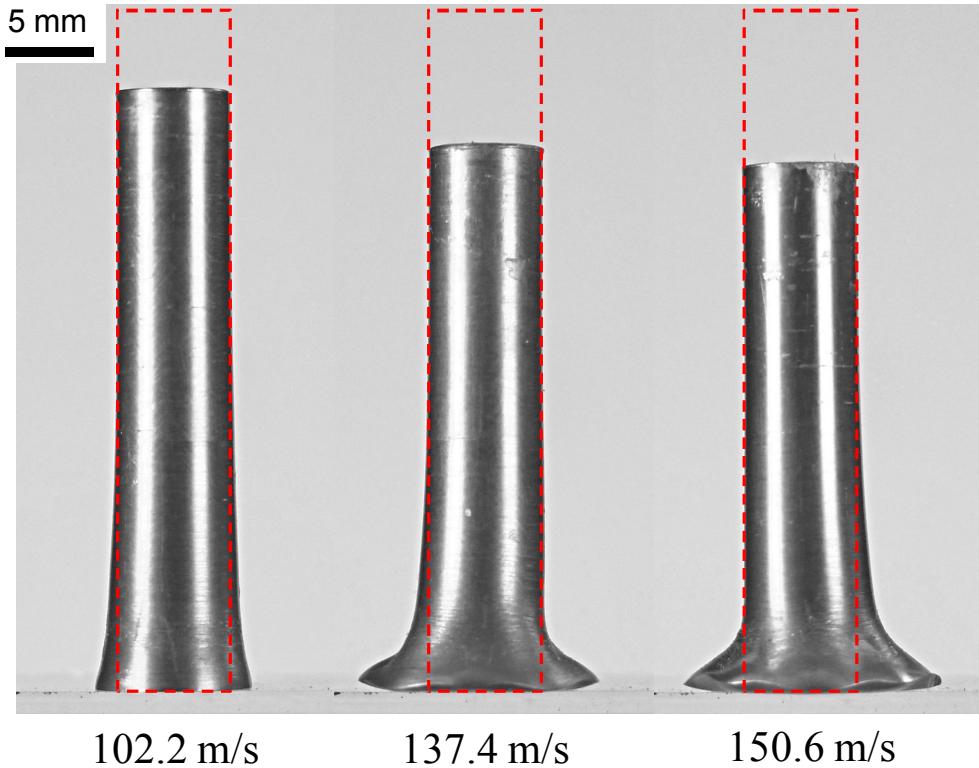
[110] 78.1 m/s



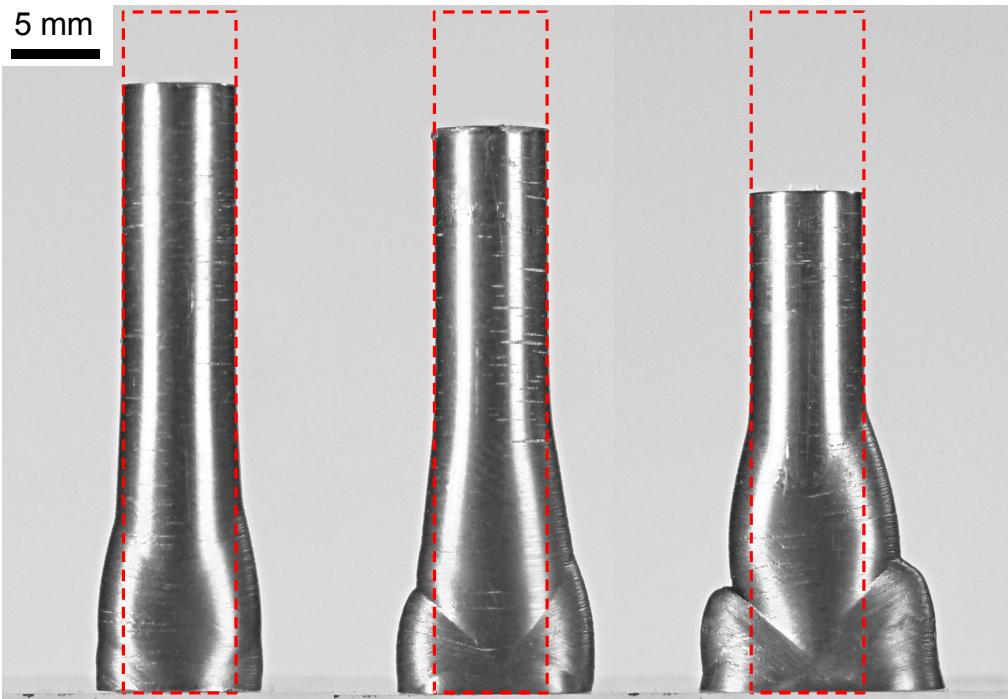
[149] 77.8 m/s



[100] single crystal specimens



[110] single crystal specimens



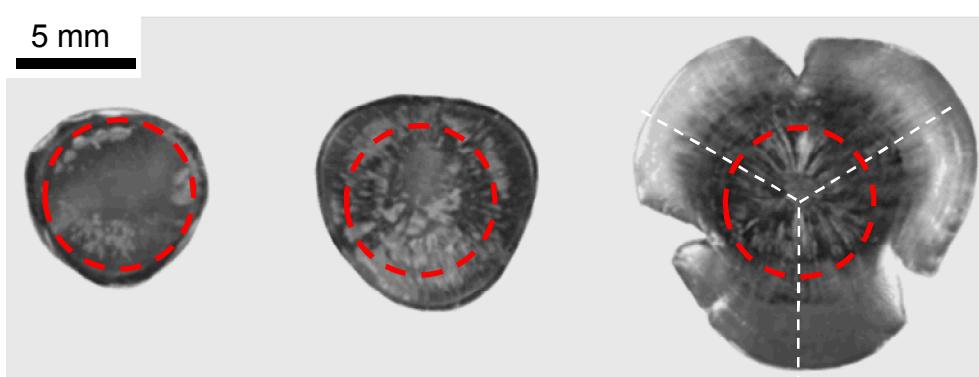
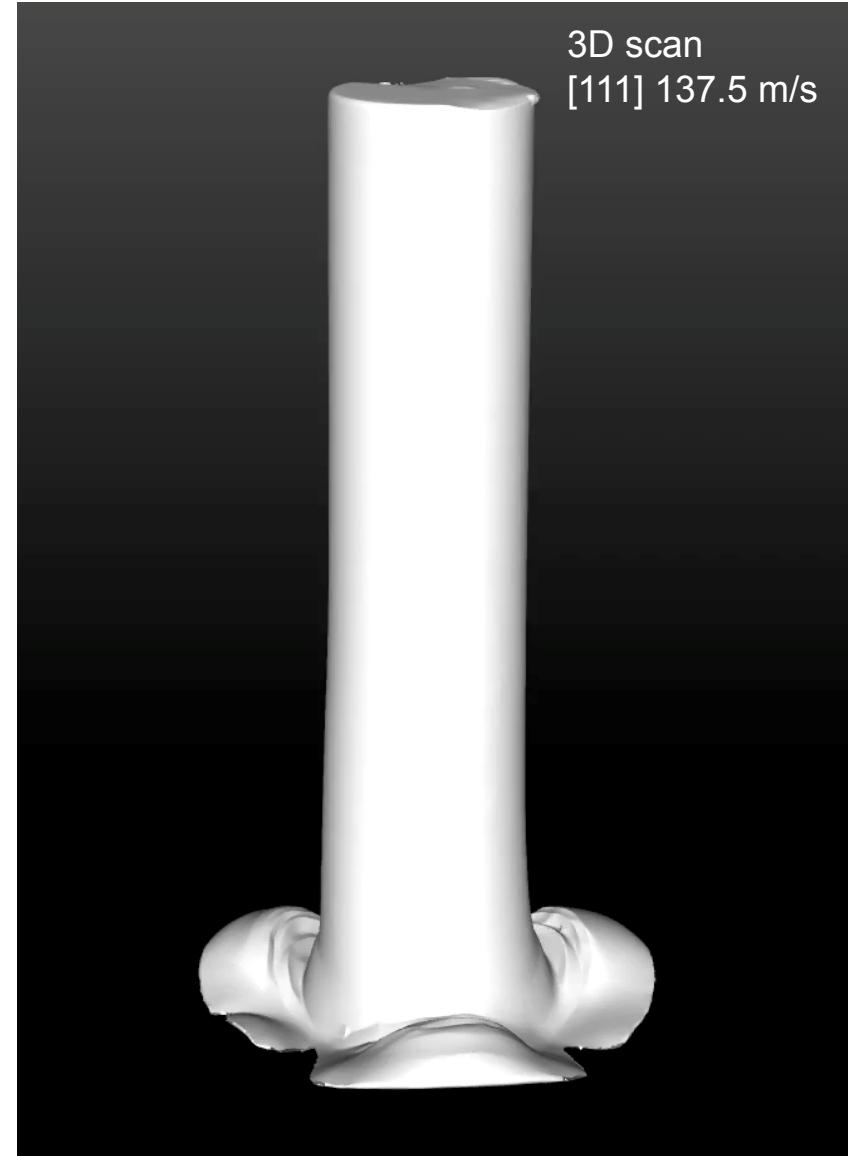
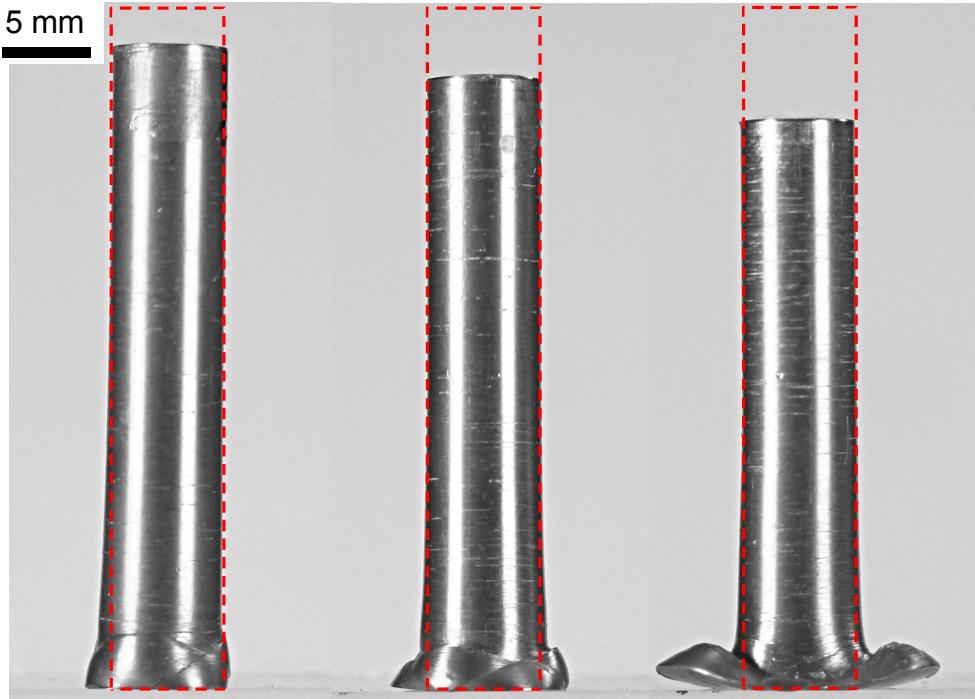
78.1 m/s

101.7 m/s

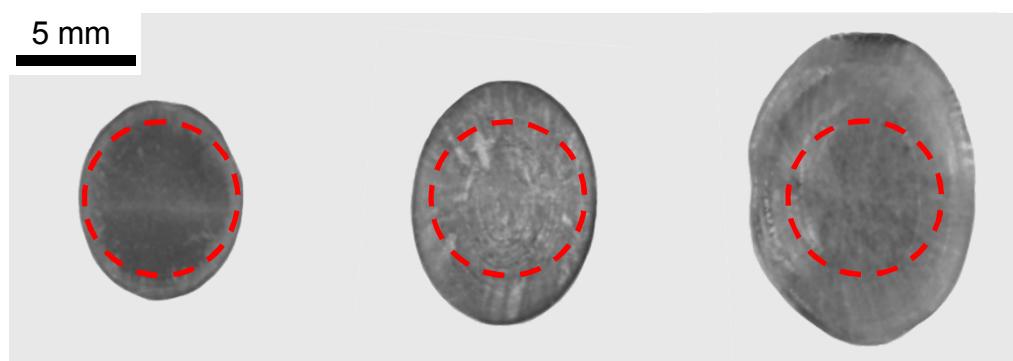
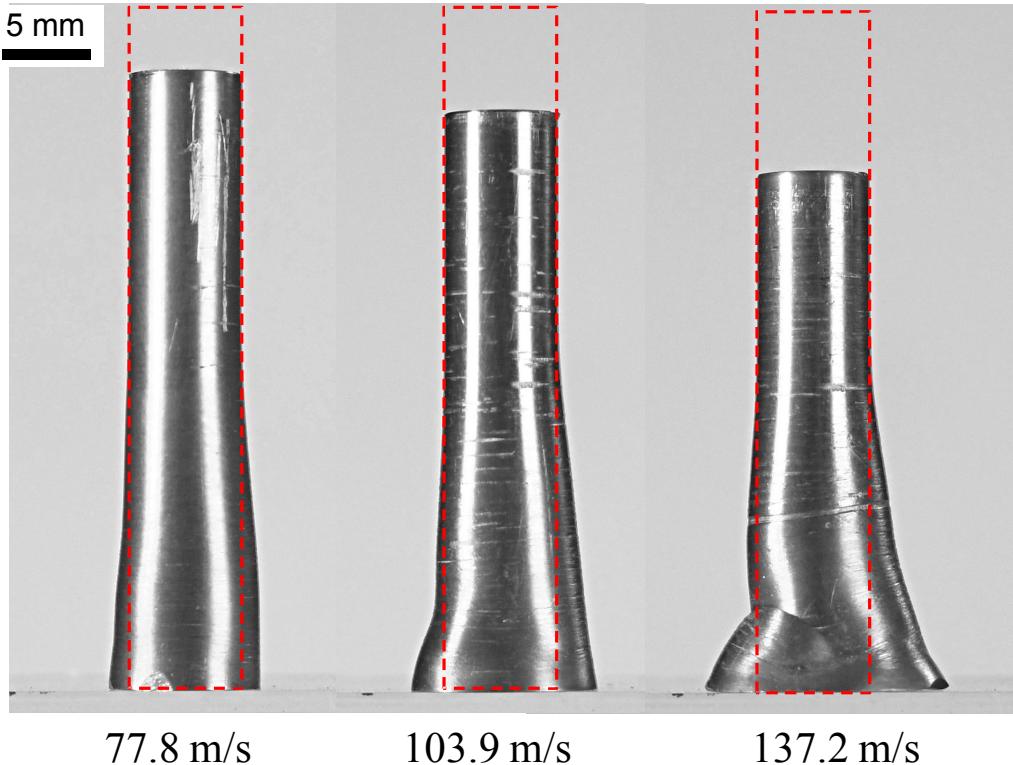
137.5 m/s



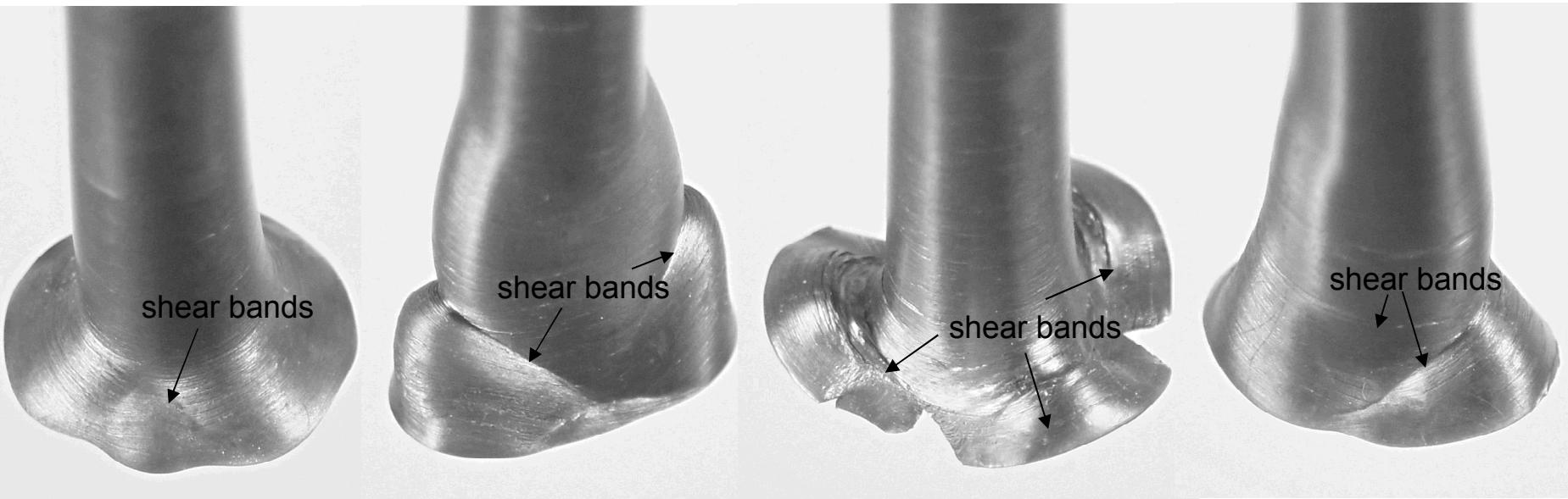
[111] single crystal specimens



$\overline{[149]}$ single crystal specimens



Strain localizations



[100] single crystal

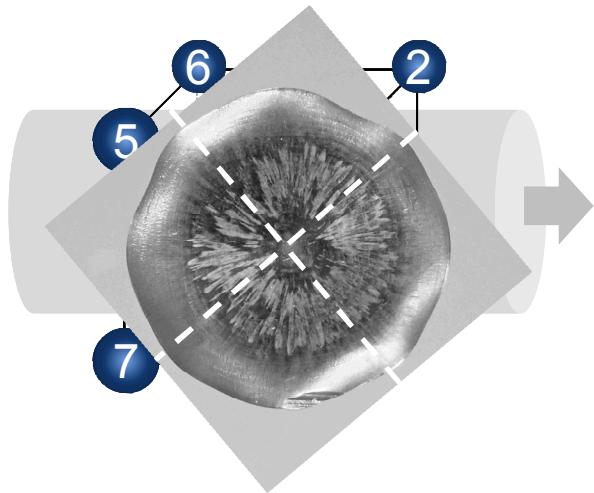
[110] single crystal

[111] single crystal

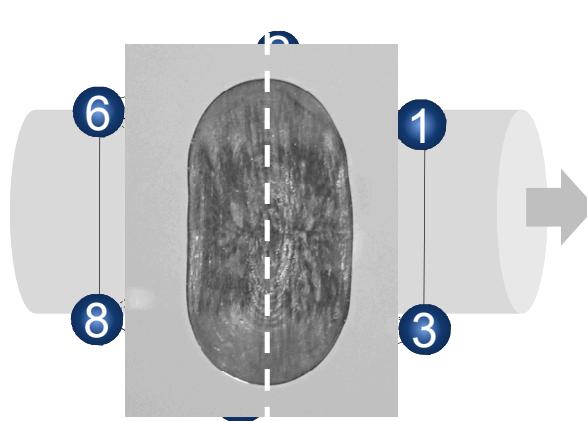
[149] single crystal

Crystallographic analysis

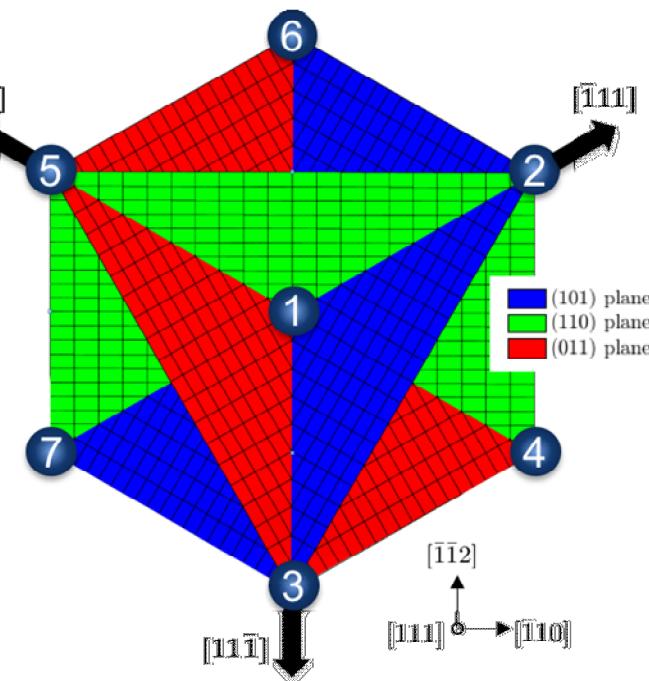
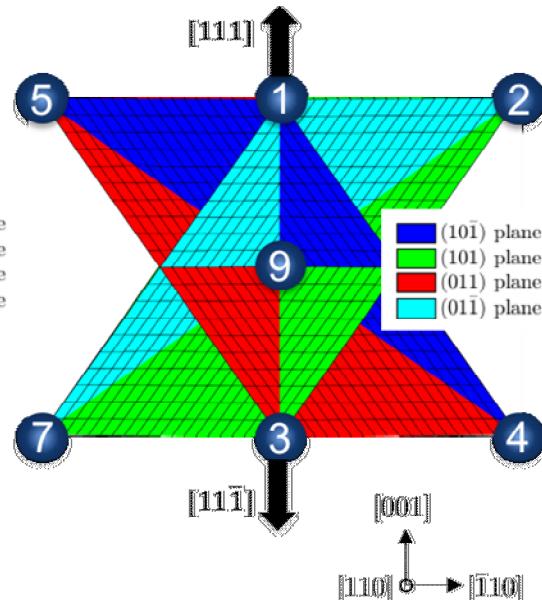
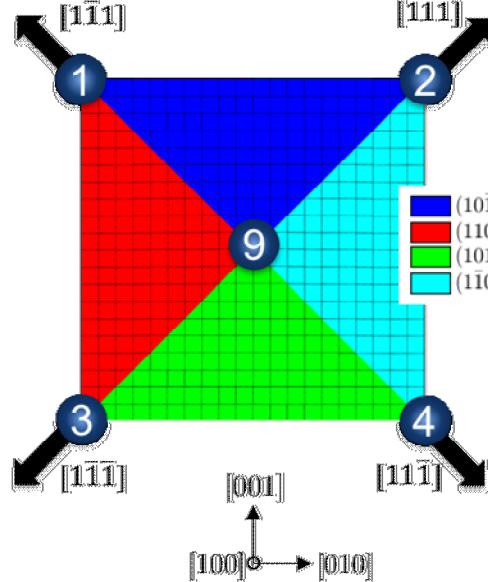
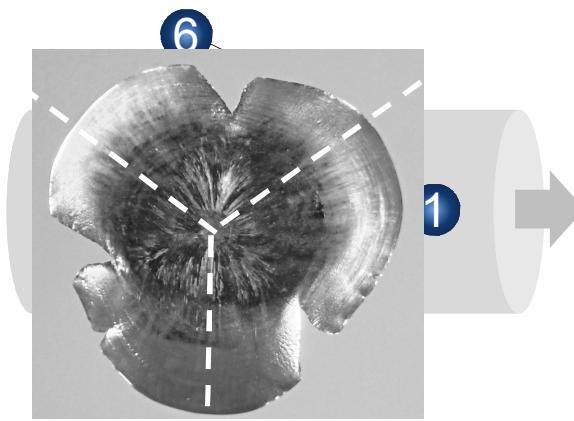
[100] single crystal



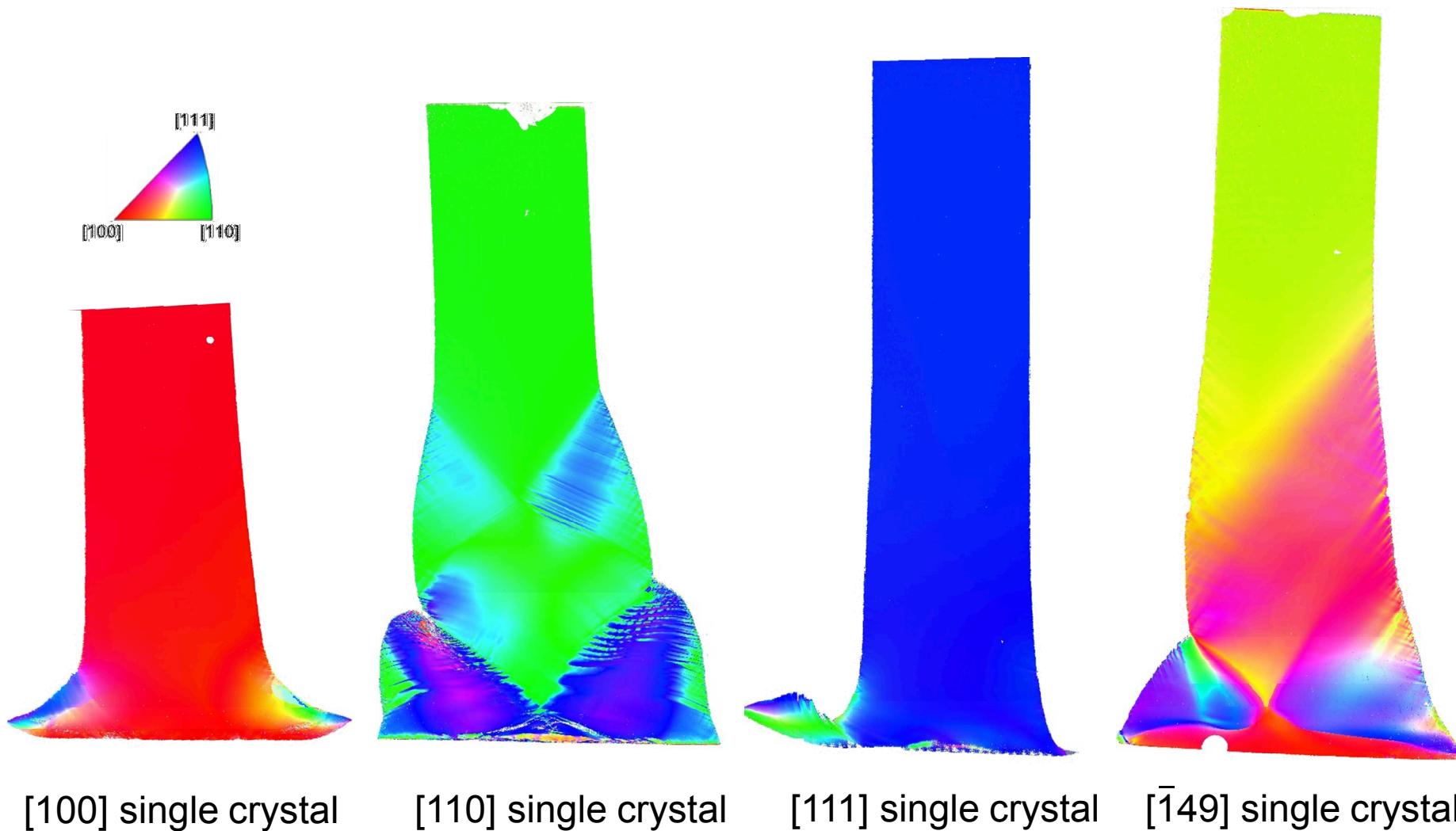
[110] single crystal



[111] single crystal

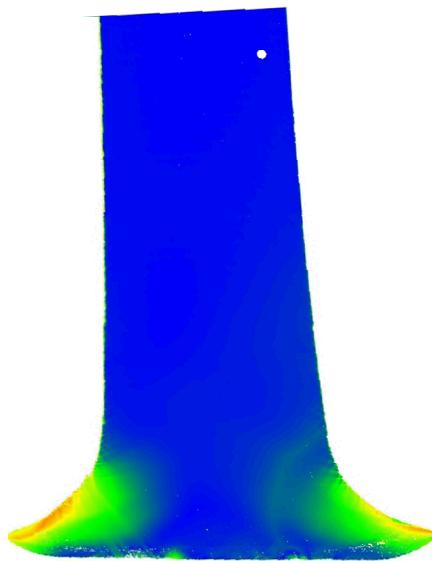
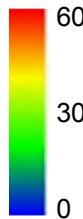


EBSD images

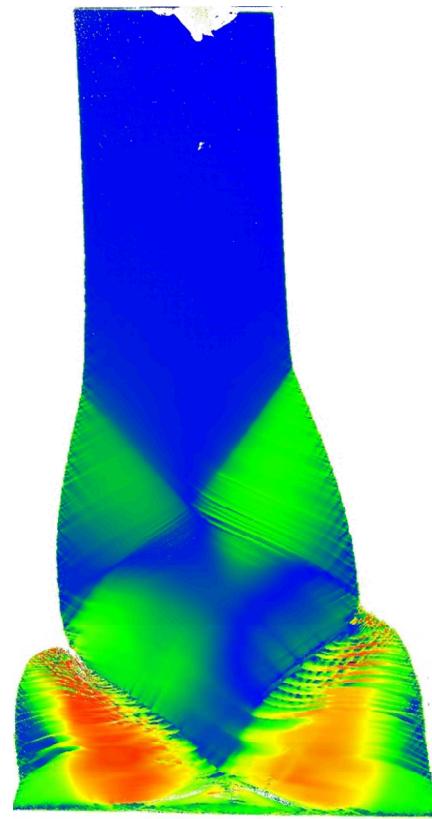


Misorientation angles

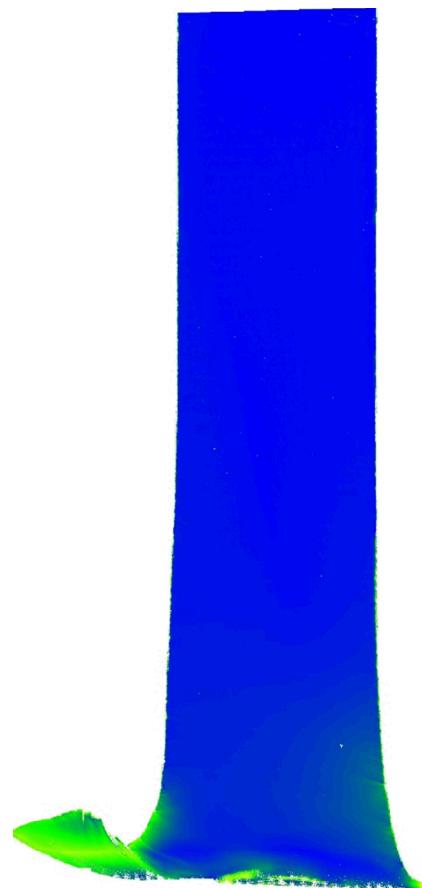
Misorientation angle
(degrees)



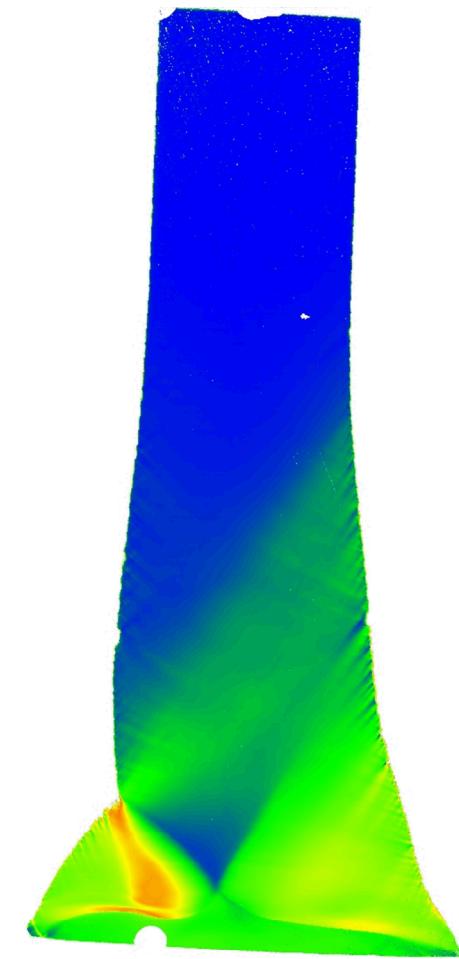
[100] single crystal



[110] single crystal



[111] single crystal



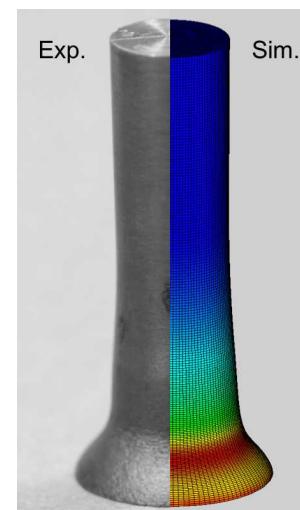
[149] single crystal

- **“Microstructure matters”**

- ✓ Conducted impact tests using single crystals
- ✓ Strong plastic anisotropy and strain localizations in single crystals
- ✓ 4, 2, 3 fold symmetries in foot shapes of [100], [110] and [111] single crystals
- ✓ Strong localization in [111] single crystals

- **Modeling challenges**

- ✓ Temperature/rate dependent strength model
- ✓ Dynamics/ explicit
- ✓ Crystal plasticity framework
- ✓ Thermo-mechanical coupling
- ✓ Contact/ friction



Polycrystalline Ta

Thank you!

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