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Quantification of twinning stress of CoCrFeNiMn high entropy alloy by *in situ* micropillar compression

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Motivation and methodology

- Equiatomic CoCrFeMnNi high entropy alloy (HEA) exhibits an outstanding combination of mechanical properties, under cryogenic temperatures, attributed to deformation twinning;
- In-depth understanding of twinning as a deformation mechanism in HEAs;
- Develop protocols to measure twinning stress by applying uniaxial *in situ* micropillar compression.

Theoretical critical diameter (Dc) size for partial slip

$$D_c = \frac{2\alpha\mu\left(b\frac{m_1}{m} - b_1\right)b_1}{\gamma_{SF}}$$ [1]

[8 3 10] 152 nm
[9 6 11] 143 nm

[1] *E. Bitzek/ Journal of Solid Mechanics and Materials Engineering 6 (2012) 99-105.*

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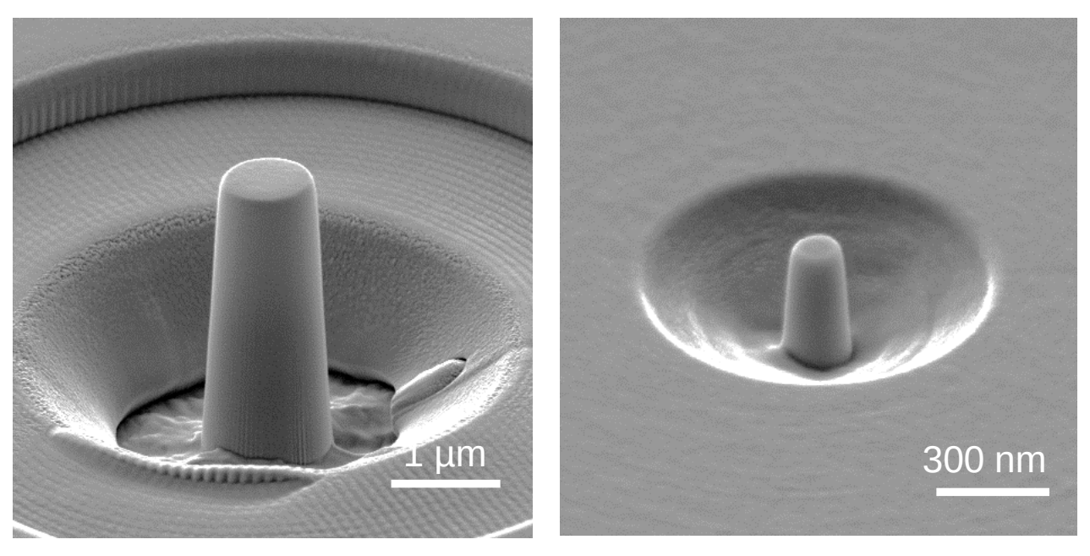

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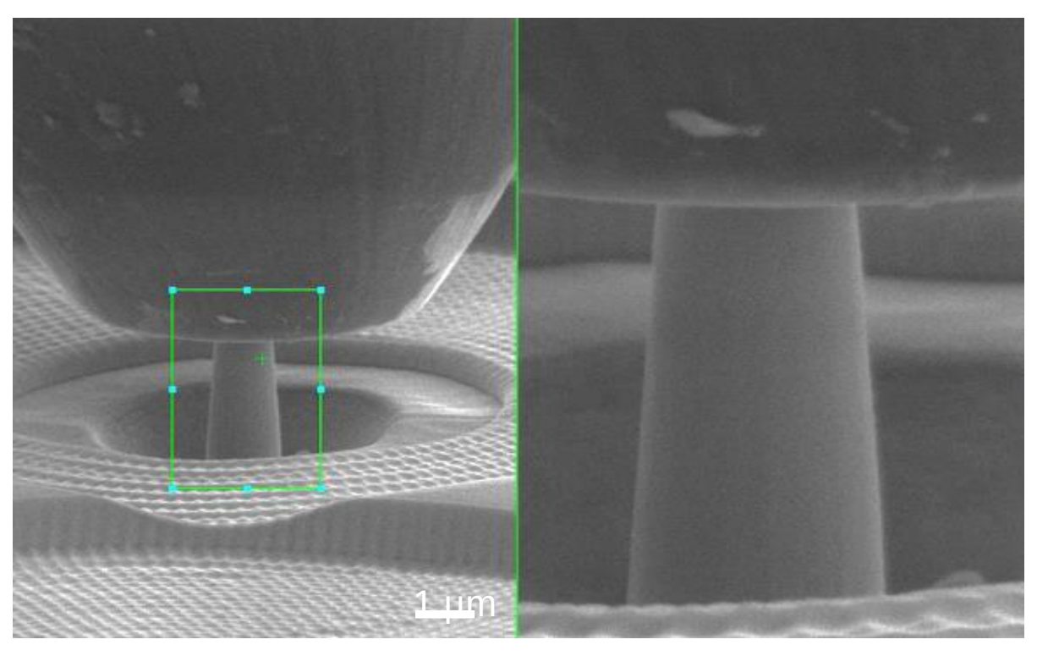
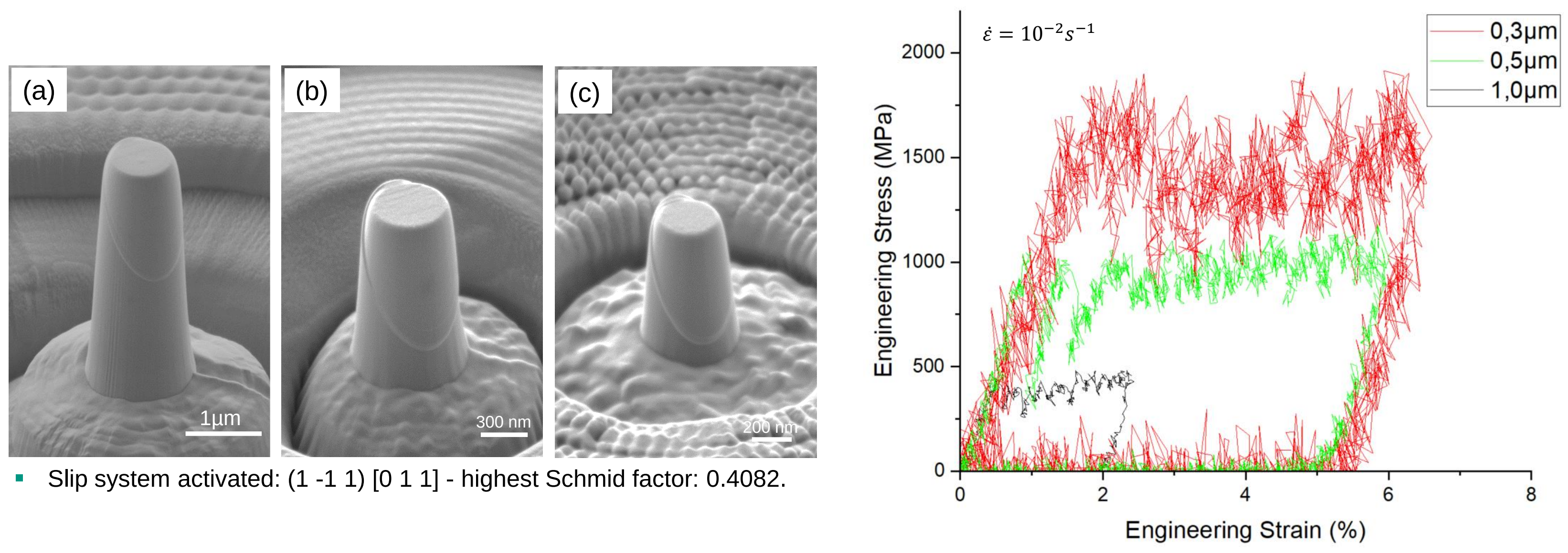


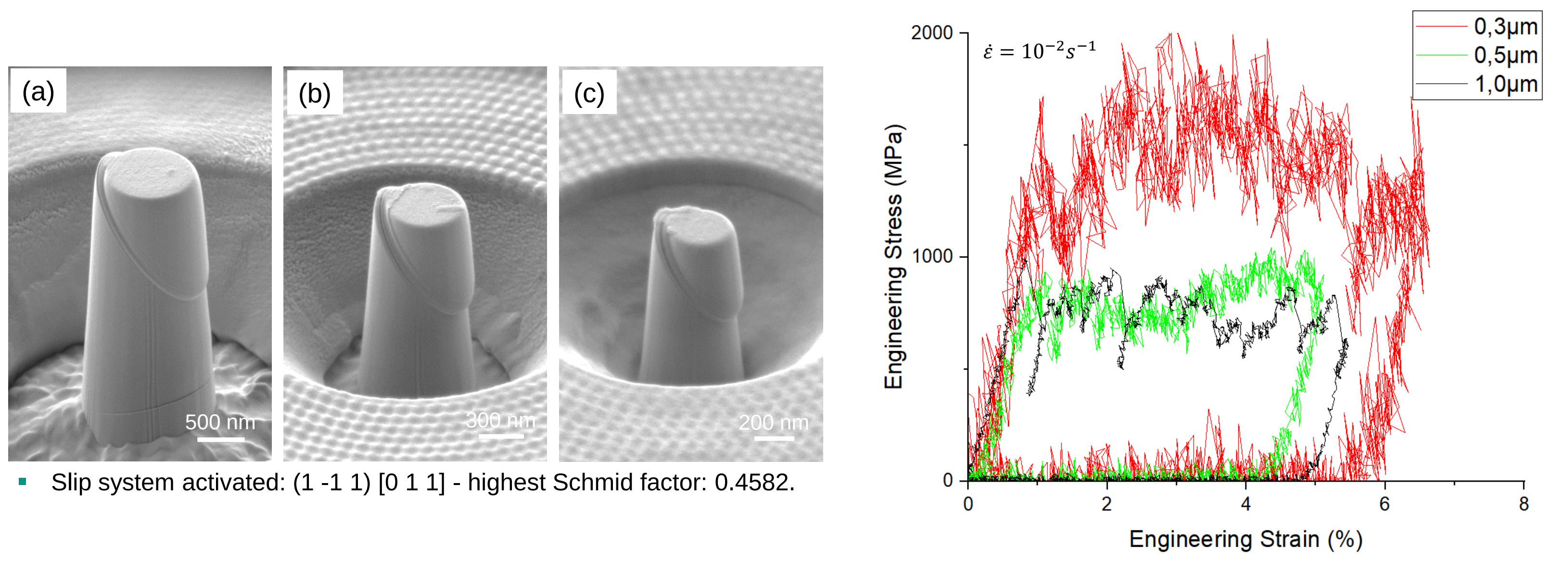
Results

In situ micropillar compression



- Slip system activated: (1 -1 1) [0 1 1] - highest Schmid factor: 0.4082.

Fig. 1 – *Post mortem* SEM images of [9 6 11] orientation pillars of diameter: 1.0 (a), 0.5 (b) and 0.3 µm (c). Representative engineering stress and strain curves (d).



- Slip system activated: (1 -1 1) [0 1 1] - highest Schmid factor: 0.4582.

Fig. 2– *Post mortem* SEM images of [8 3 10] orientation pillars of diameter: 1.0 (a), 0.5 (b) and 0.3 µm (c). Representative engineering stress and strain curves (d).

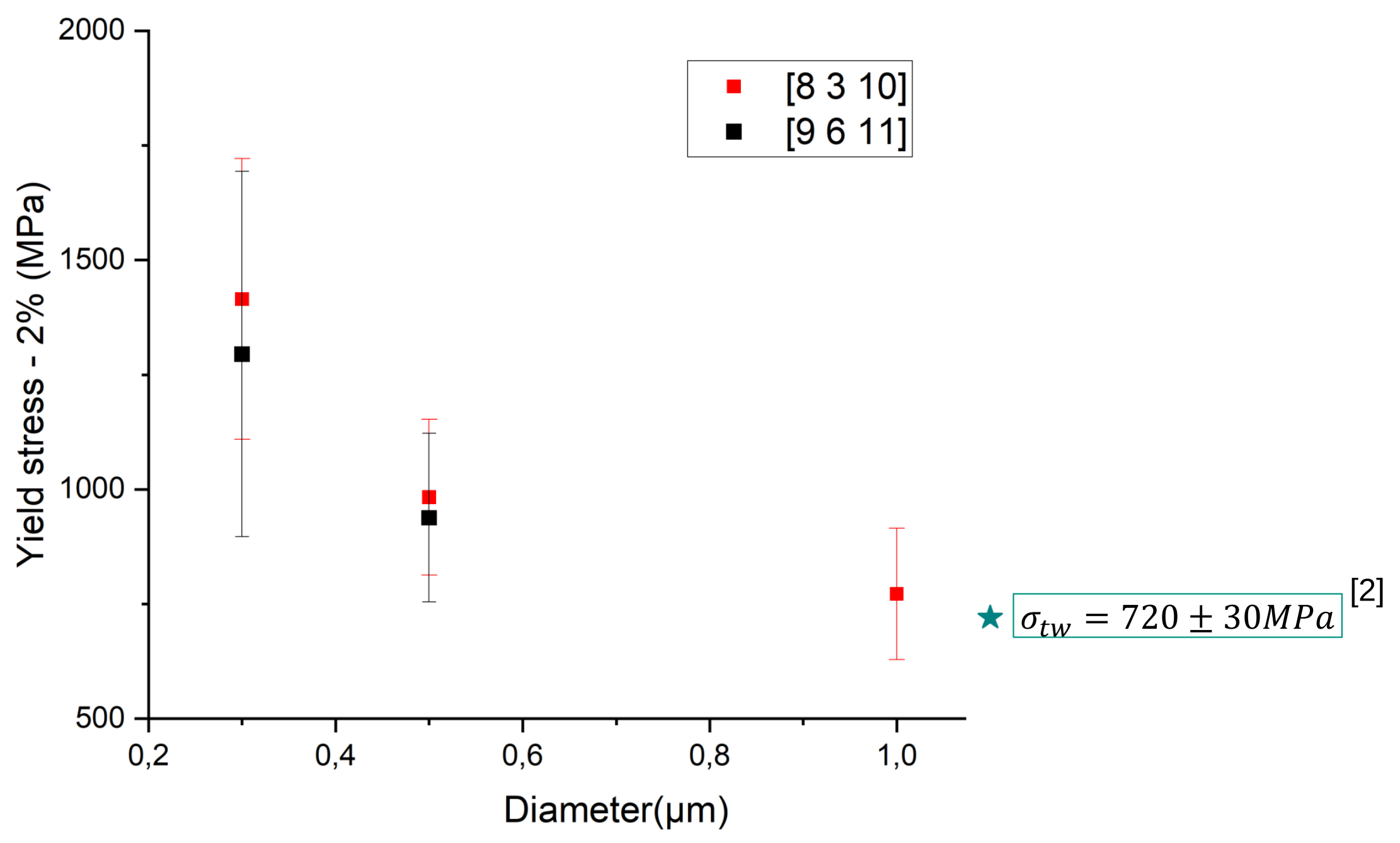


Fig. 3 – Average yield stress at 2% strain of [8 3 10] and [9 6 11] orientation pillars, with respective diameter, and critical twinning stress estimated for a bulk sample [2].

[2] *G. Laplanche et al./ Acta Materialia 118 (2016) 152-163.*

STEM and TKD analyses

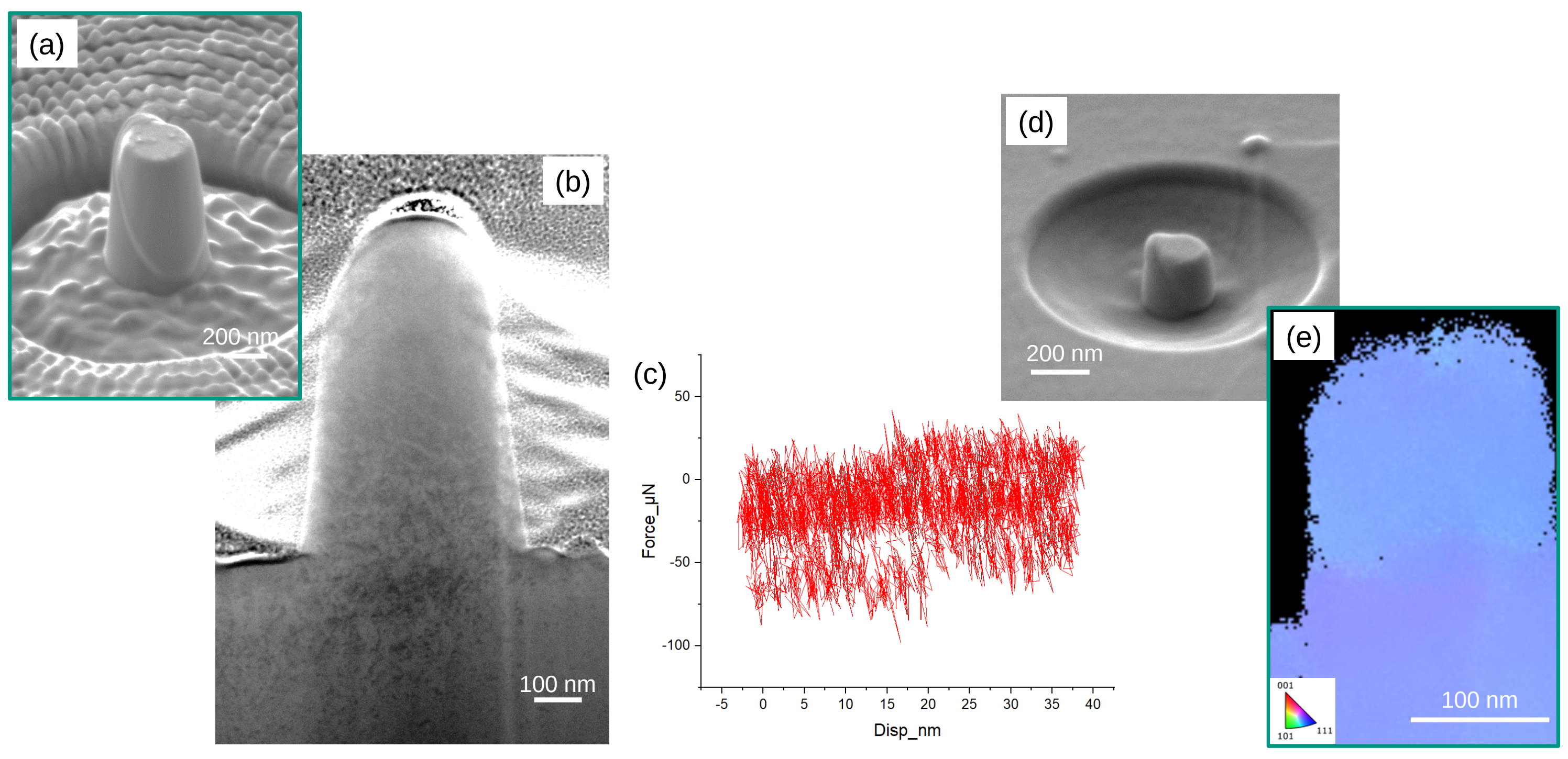


Fig. 4 – STEM images (b) for [9 6 11] orientation pillar of diameter 0.3 µm (a). Setbacks testing 130 nm diameter samples (c). TKD analyses IPF Z (e) for a [8 3 10] orientation pillar of diameter 130 nm (d).

Take home message

- *Post mortem* STEM and TKD analyses were performed to verify if twin microstructure could be observed;
- Pillars smaller than the Dc for twinning were tested and literature critical twinning stress achieved, however no twinning could be observed.

Next steps

- Apply the same protocol to the CoCrNi MEA, it has a lower stacking fault energy compared to the Cantor alloy and Dc of 188 nm;
- Tests with a different micromechanical geometry (cantilever) will also be conducted to verify if twinning would occur in these conditions.

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