American Mineralogist: November-December 2015 Deposit AM-15-115481
MIYAJIMA AND KAWAZOE: WBDF-TEM OF PARTIAL DISLOCATIONS IN DEFORMED WADSLEYITE

1

Supplementary Material:

The following is a flow chart to determine the partial 1/2<101> dislocations on the (010) plane;

i.e. b = 1/2[101] and b = 1/2[-101].

1. The dislocation lines parallel to [101] and [-101] directions are long enough on the TEM foil (~200 nm thickness) along the [010] zone axis, which are observed in WBDF images with g = 404 and -404 (Figs. 2d, 2e and S1).

2. Determine 2 thickness contour fringes at the extremity of the dislocation with g= 400 and 004 in the WBDF images (e.g., Fig. 3a).

3. [001] dislocations can be dissociated to two pair of screw character 1/2<101> dislocations on the (010) plane; b = 1/2[101] and b = 1/2[-101] (Fig. 4a).

4. The partial dislocations with Shockley-type stacking fault on the (010) plane are a glide configuration, which can contribute bulk strain in the simple-shear deformation and result in the development of the (010)[001] fabric in wadsleyite.

5. In addition, the 1/2<101> dislocations are terminated on the edge of the (010) staking faults. The partial dislocations was gliding in the (010) plane (Figs. 4b, S2 and S3).

American Mineralogist: November-December 2015 Deposit AM-15-115481
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2

Theoretical discussions on the glide of 1/2<101> dislocations on the (010) planes

The glide mechanisms of 1/2<101> partial dislocations can be theoretically supported as follows:

1. *Frank Criterion* (e.g., Sharp et al. 1994), 2. *Property of the (010) plane in the wadsleyite structure*, 3. *Short Burgers vector (Table 1)*, and *Chalmers-Martius criterion (Table 2)*. Length of Burgers vector and *d*-spacing are calculated using cell parameters of $(Mg_{0.9}, Fe_{0.1})_2SiO_4$ wadsleyite at ambient pressure-temperature conditions (Sawamoto and Horiuchi, 1990).

1. *Frank* Criterion

$$[001] \rightarrow \frac{1}{2}[101] + \frac{1}{2}[\bar{1}01]$$

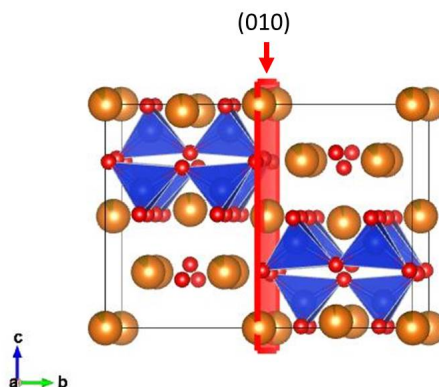$$\left|b_{Perfect}\right|^2 > \left|b_{Partial\,(1)}\right|^2 + \left|b_{Partial\,(2)}\right|^2$$

$$68.5 \text{ Å}^2 \qquad 50.6 \text{ Å}^2$$

$$(\text{cf. } \left|b_{Perfect}\right|^2 = 32.6 \text{ Å}^2 \text{ for } [100] \text{ dislocations})$$

where the lattice parameters is a = 5.7107(5) Å, b = 11.4675(9) Å, c = 8.2778(10) Å.

2. Property of the (010) plane in the wadsleyite structure

The stacking fault plane is not an Oxygen sub-lattice, but a defective stacking sequence of the Magnesium cations (orange largest balls), which indicates a red plane in the figure below. The crystal structure was drawn with software VESTA (Momma and Izumi 2011).

No shearing SiO_4 (blue) and large d-spacing of the (010) plane

American Mineralogist: November-December 2015 Deposit AM-15-115481
MIYAJIMA AND KAWAZOE: WBDF-TEM OF PARTIAL DISLOCATIONS IN DEFORMED WADSLEYITE

3

3. Short Burgers vector and *Chalmers-Martius* criterion (Cordier 2002)

TABLE 1. Length of Burgers vectors

b	$|b|$ (Å)
1/2⟨101⟩	5.03
[100]	5.71
1/2⟨111⟩	7.63
[001]	8.28
⟨101⟩	10.06
[010]	11.47

TABLE 2. $|b|$ / d_{hkl} ratio

Slip System	$|b|$ / d_{hkl}
1/2⟨101⟩(010)	0.44
[100](010)	0.50
[100](001)	0.69
[100]{011}	0.85
⟨101⟩(010)	0.88
[100]{021}	1.21
[010](001)	1.39
1/2⟨111⟩{101}	1.62
[010]{101}	2.44

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Momma, K., and Izumi, F. (2011) VESTA 3 for three-dimensional visualization of crystal, volumetric and morphology data. Journal of Applied Crystallography, 44, 1272-1276.

Sawamoto, H., and Horiuchi, H. (1990) Beta (Mg$_{0.9}$, Fe$_{0.1}$)$_2$SiO$_4$ - Single-Crystal Structure, Cation Distribution, and Properties of Coordination Polyhedra. Physics and Chemistry of Minerals, 17(4), 293-300.

American Mineralogist: November-December 2015 Deposit AM-15-115481
MIYAJIMA AND KAWAZOE: WBDF-TEM OF PARTIAL DISLOCATIONS IN DEFORMED WADSLEYITE

4

Sharp, T.G., Bussod, G.Y.A., and Katsura, T. (1994) Microstructures in Beta-$Mg_{1.8}Fe_{0.2}SiO_4$ Experimentally Deformed at Transition-Zone Conditions. Physics of the Earth and Planetary Interiors, 86(1-3), 69-83.
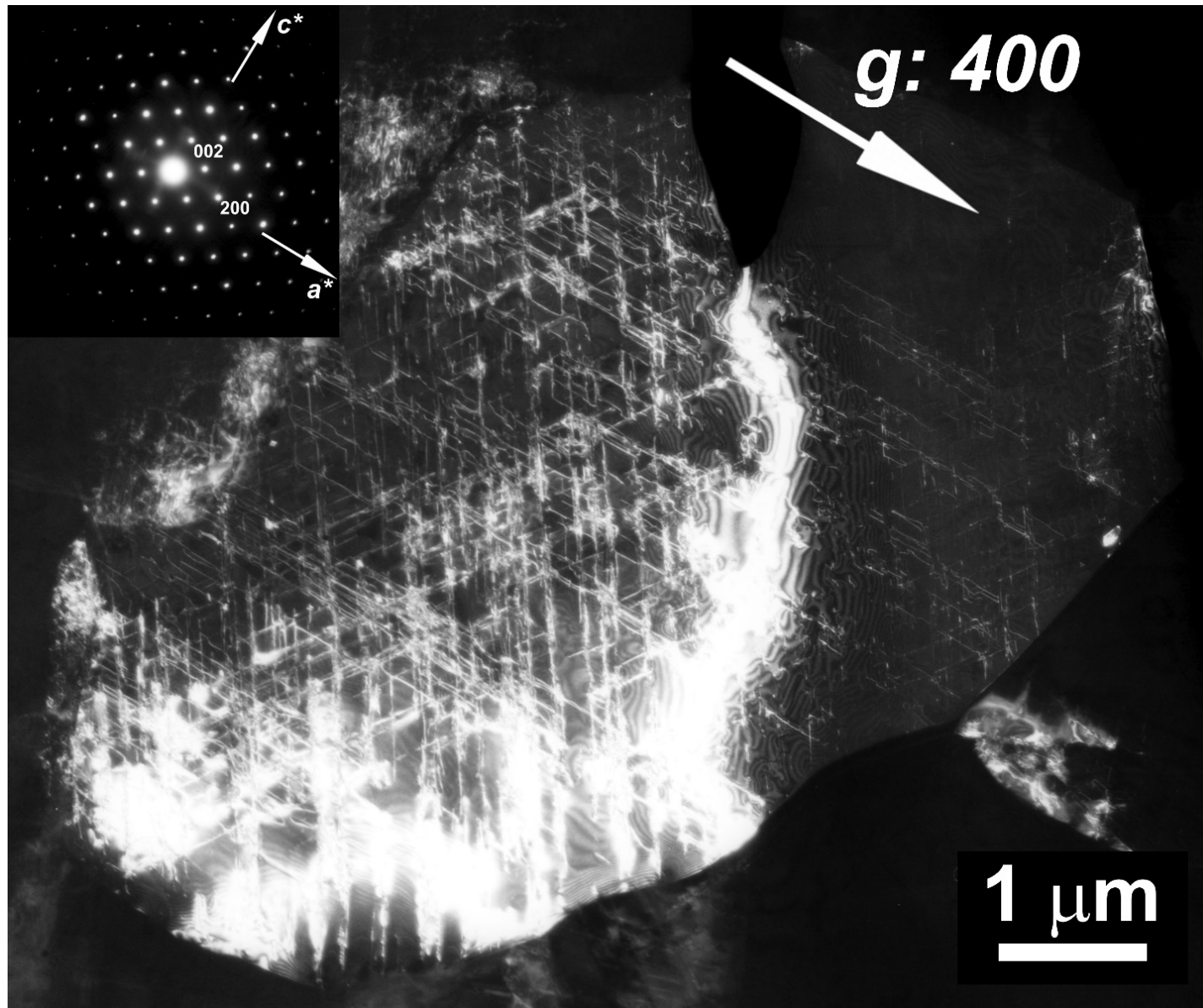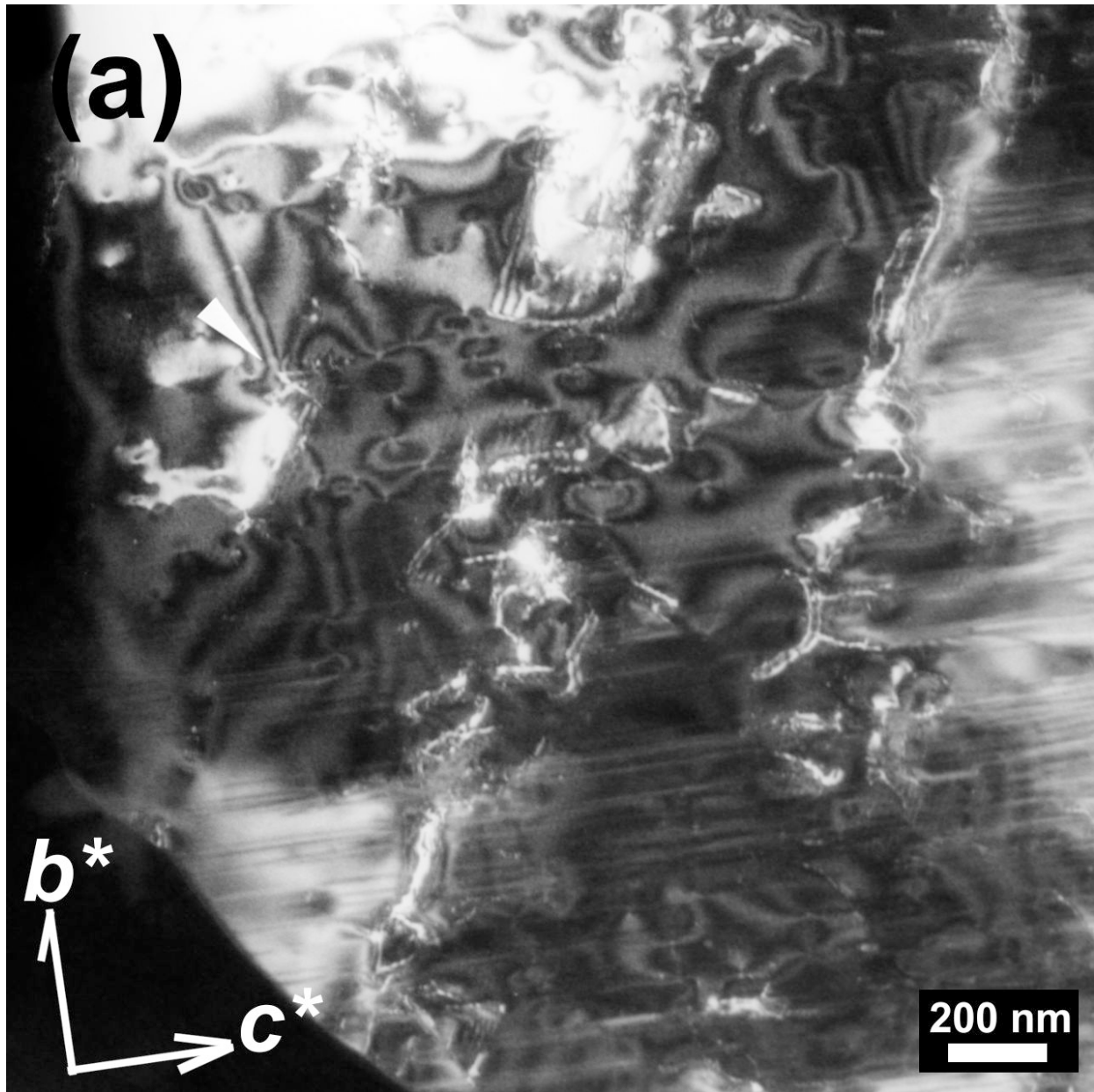
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MIYAJIMA AND KAWAZOE: WBDF-TEM OF PARTIAL DISLOCATIONS IN DEFORMED WADSLEYITE

5

Figure S1. The WBDF image with *g* = 400 is taken from the same grain as that of the Figure 2.

American Mineralogist: November-December 2015 Deposit AM-15-115481
MIYAJIMA AND KAWAZOE: WBDF-TEM OF PARTIAL DISLOCATIONS IN DEFORMED WADSLEYITE

6

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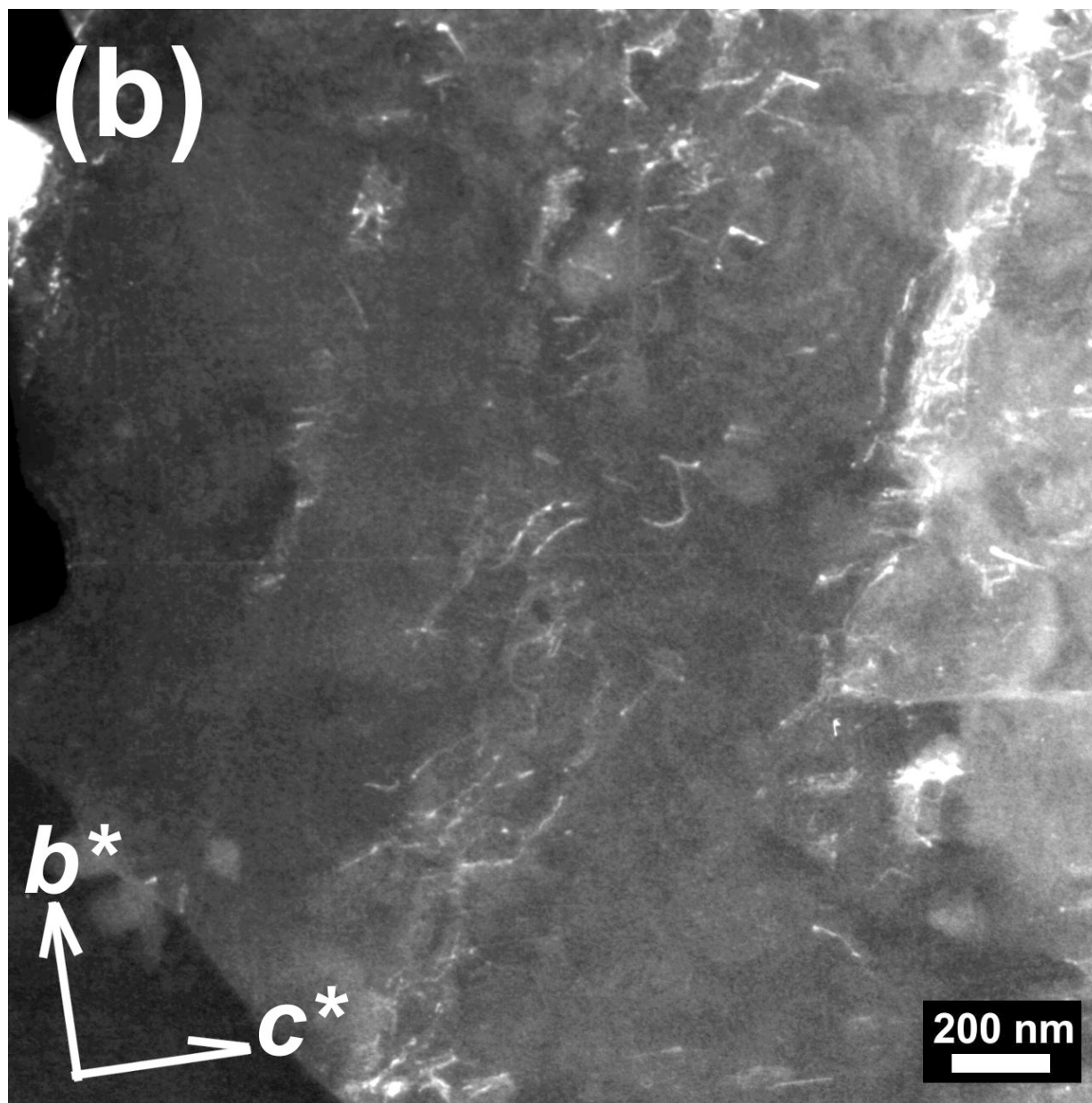MIYAJIMA AND KAWAZOE: WBDF-TEM OF PARTIAL DISLOCATIONS IN DEFORMED WADSLEYITE
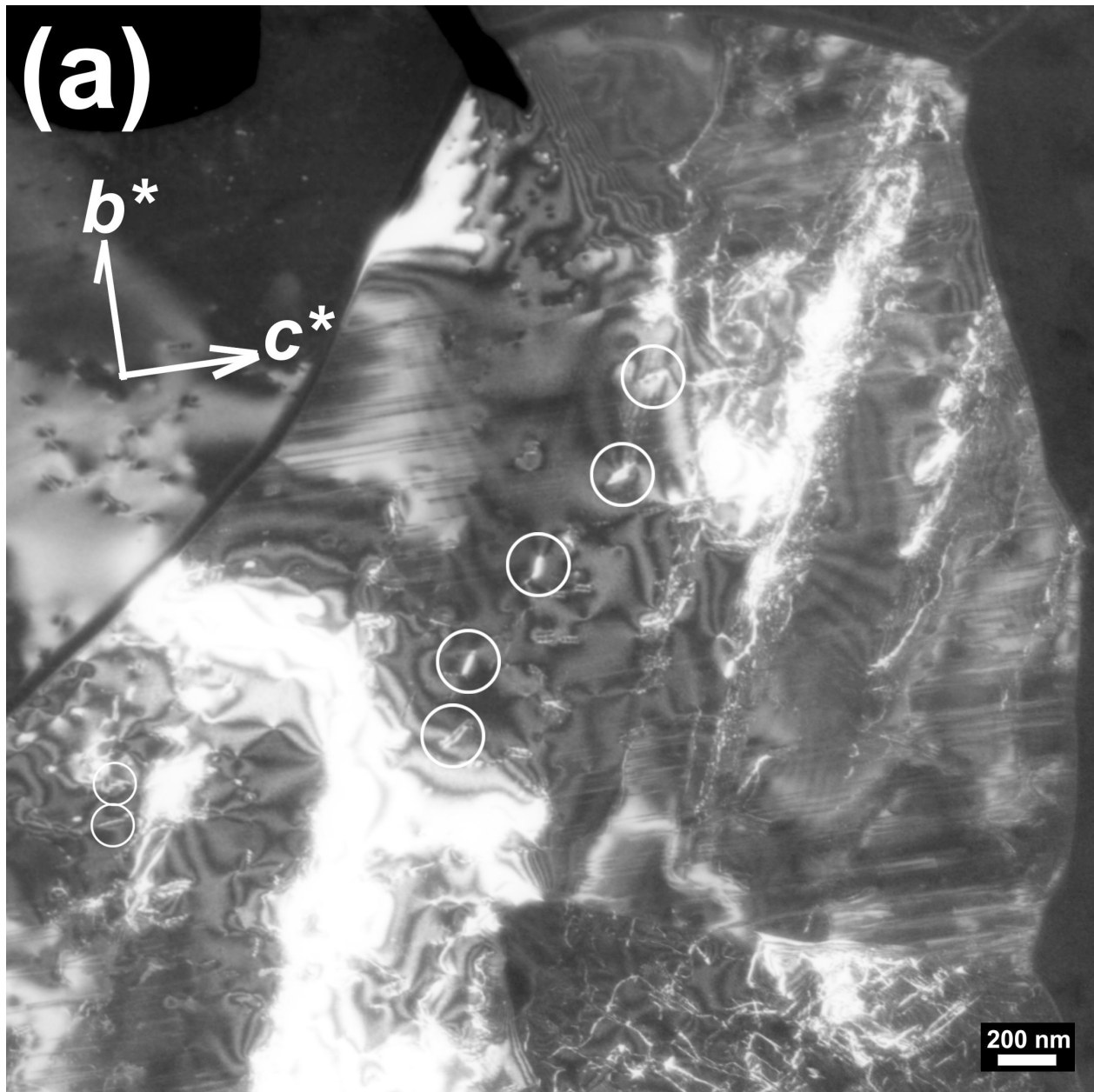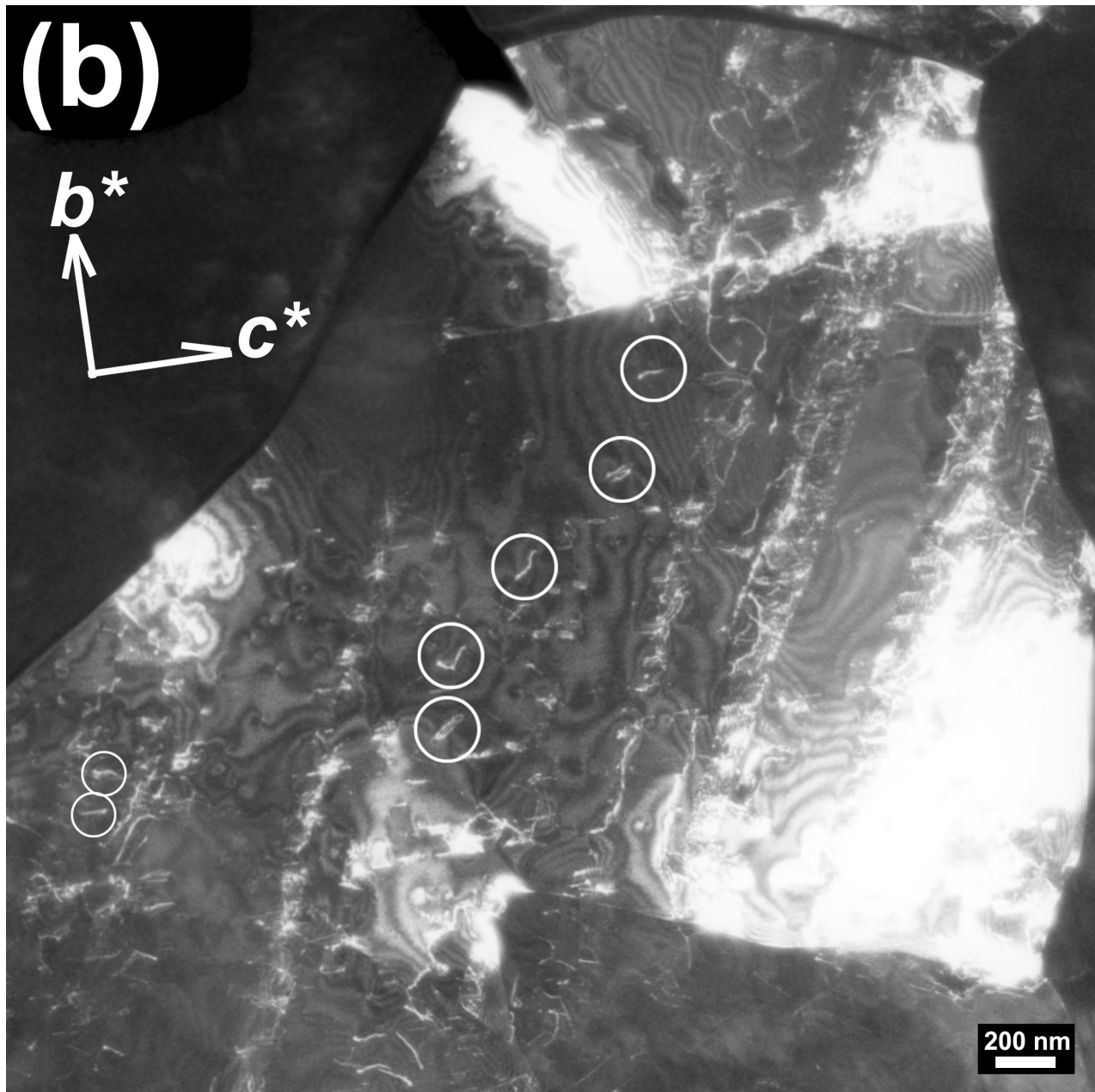
7

Figure S2. The WBDF image with (a) g = 004 and (b) g = 080 are taken from the same grain as that of the Figure 4b. The white arrow indicates the same dislocation in the Figure 4b.
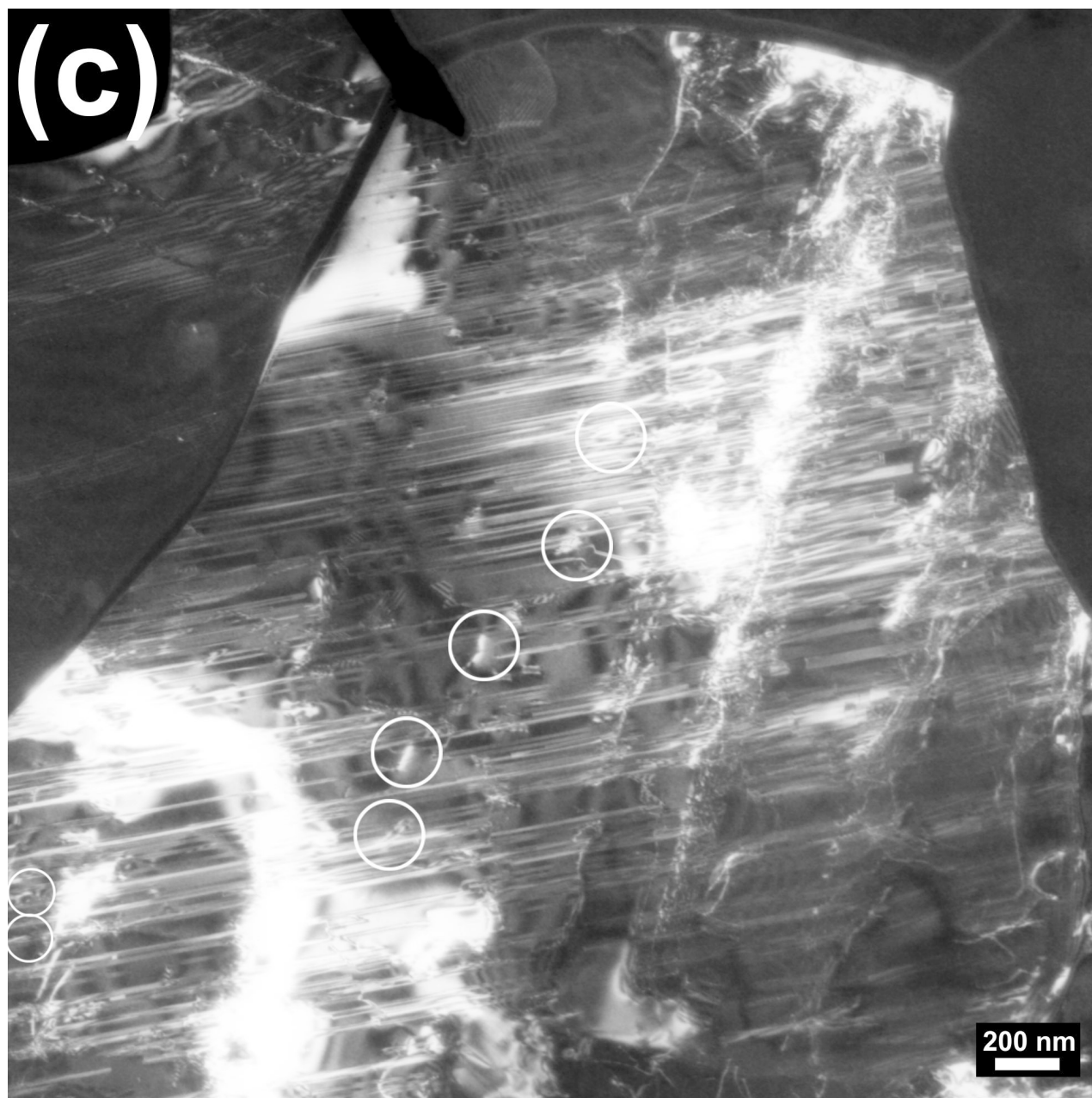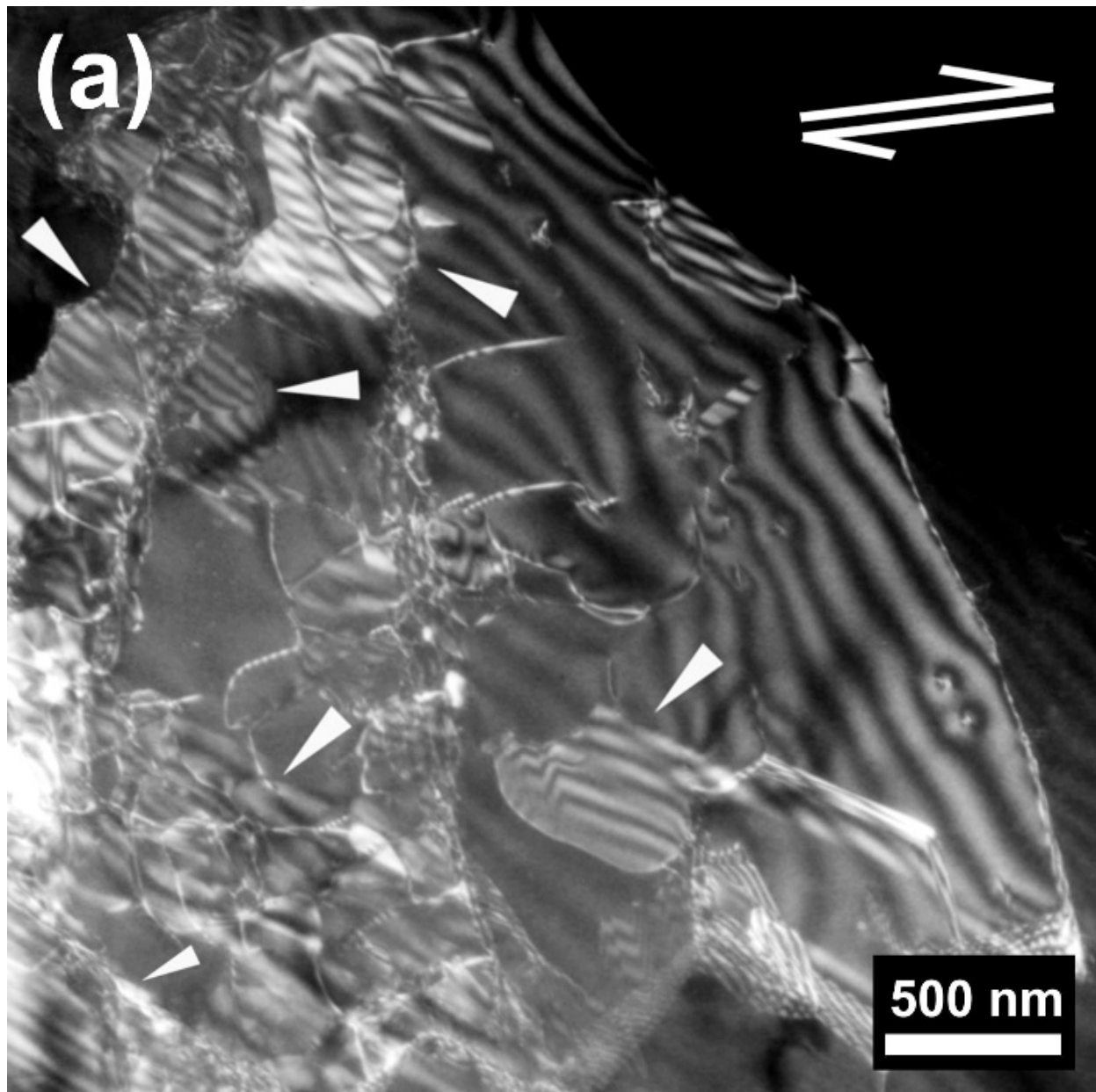
American Mineralogist: November-December 2015 Deposit AM-15-115481
MIYAJIMA AND KAWAZOE: WBDF-TEM OF PARTIAL DISLOCATIONS IN DEFORMED WADSLEYITE

8

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MIYAJIMA AND KAWAZOE: WBDF-TEM OF PARTIAL DISLOCATIONS IN DEFORMED WADSLEYITE

9

Figure S3. The WBDF image with (a) g = 004, (b) g = 080 and (c) g = 013 are taken from the same grain as that of the Figure 4b. The white cycles indicate the same dislocations in all three images, which are potentially included in a type of dislocations with b = 1/2<111>.

American Mineralogist: November-December 2015 Deposit AM-15-115481
MIYAJIMA AND KAWAZOE: WBDF-TEM OF PARTIAL DISLOCATIONS IN DEFORMED WADSLEYITE

11

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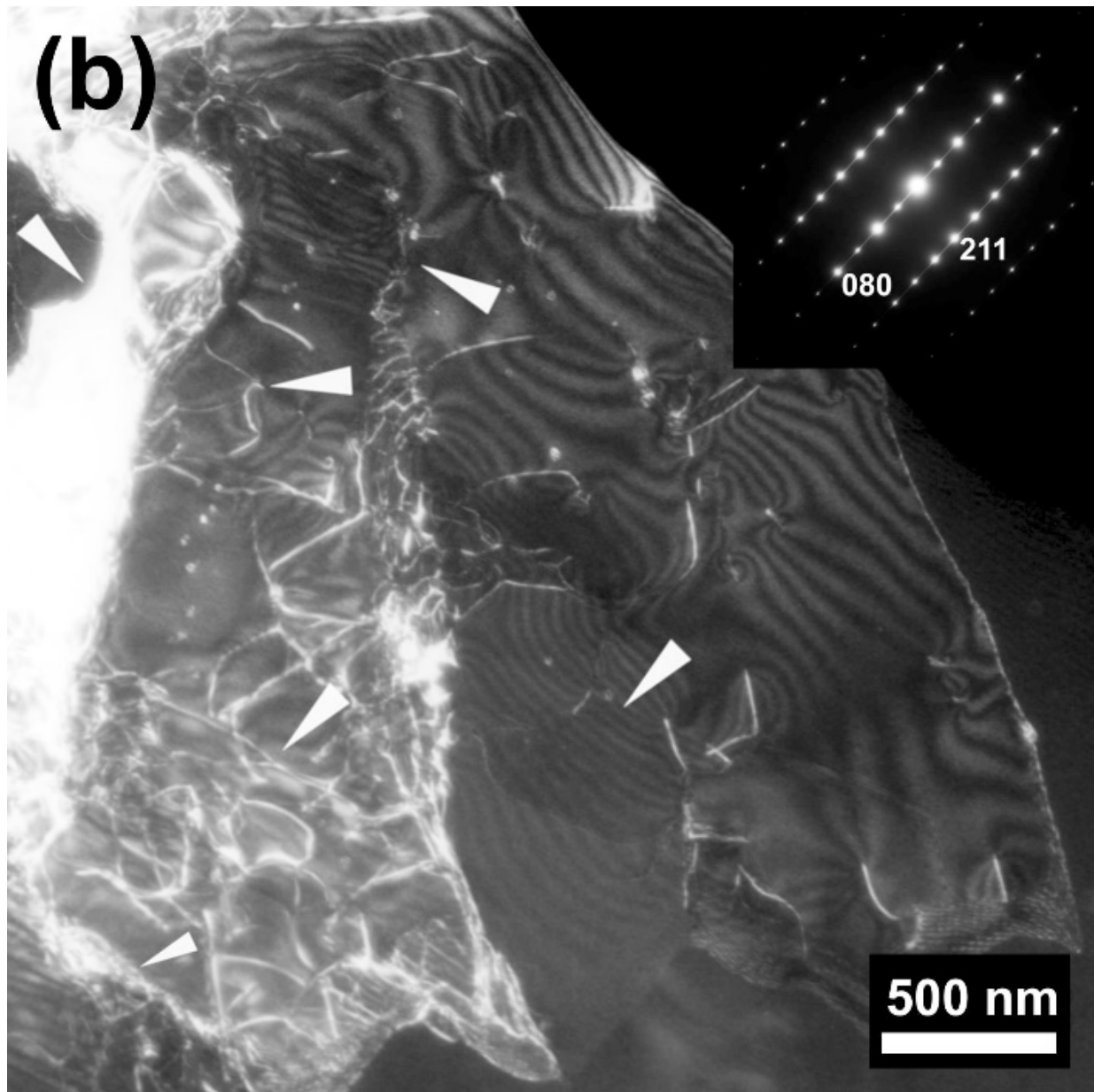
12

Figure S4. Typical dark field TEM images of non-deformed wadsleyite (run M0187 in Kawazoe et al. 2013). (a) $\mathbf{g} = \bar{2}\,\bar{1}\,\bar{1}$, stacking faults are visible, (b) $\mathbf{g} = 0\,\bar{8}\,0$, invisible. Some planar areas in the grain display fringe contrast of stacking faults (indicating white arrowheads) with partial dislocations at the ends, but they are not a glide configuration in contrast to Figure 4b where the (010) stacking fault planes are sub-parallel to a shear direction. The inset in the (b) is the nearest zone axis. The two-sided arrow on the upper right in (a) indicates a potential bulk shear direction.

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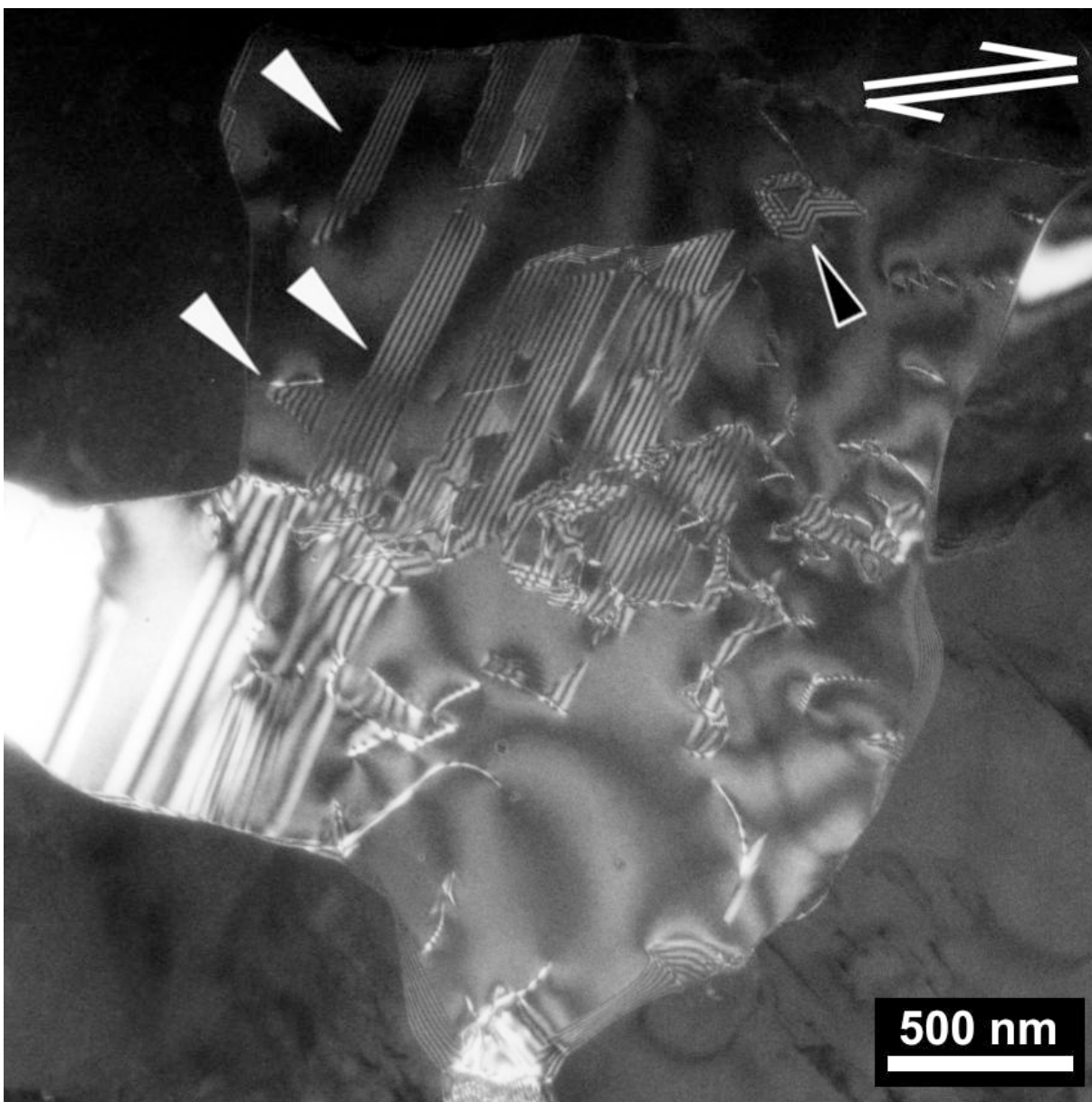MIYAJIMA AND KAWAZOE: WBDF-TEM OF PARTIAL DISLOCATIONS IN DEFORMED WADSLEYITE

13

Figure S5. Dark field TEM image of non-deformed wadsleyite (M187), indicating a number of ledges (indicating black arrowheads) on the stacking faults (white arrowheads). The both side arrow on the upper right indicates a potential bulk shear direction.