Structural analysis of expanded stacking faults in 4H-SiC bipolar devices

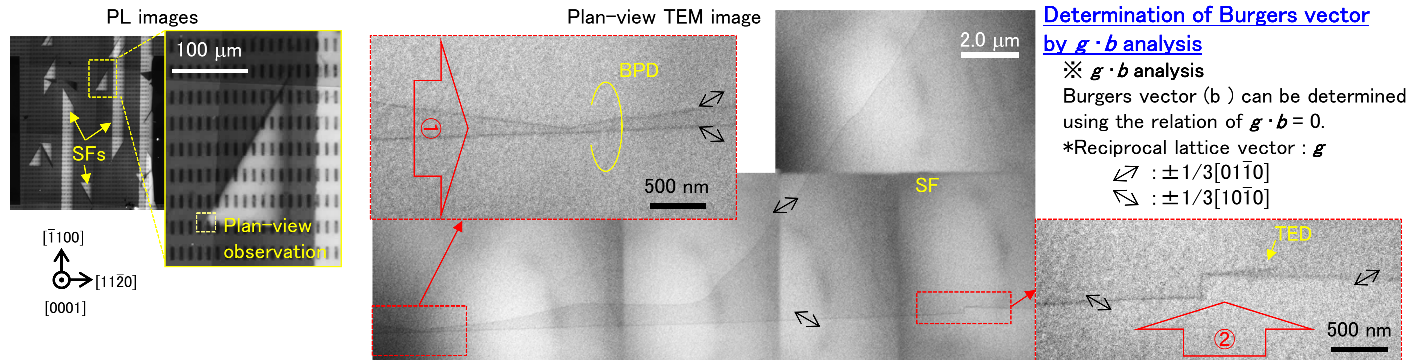
Silicon carbide (SiC) is the next candidate in power semiconductor materials. A forward-current degradation in 4H-SiC bipolar devices is one of the most crucial issue. The degradation caused by the expansion of stacking faults (SFs). We introduces structural analysis of the SF expansion origin using S/TEM observation.

【Sample】4H-SiC pin diode (4° off-cut, Epitaxial layer: 10 μm)

Reference:
S. Hayashi, et. al., Appl. Phys. Express **10**, 081201 (2017).
S. Hayashi, et. al., Jpn. J. Appl. Phys. **57**, 04FR07 (2018).
S. Hayashi, et. al., Appl. Phys. Express **12**, 051007 (2019).

1. Plan view TEM observation of SF expansion origin

◆ The area near a 1SSF expansion origination point was observed by plan-view TEM.



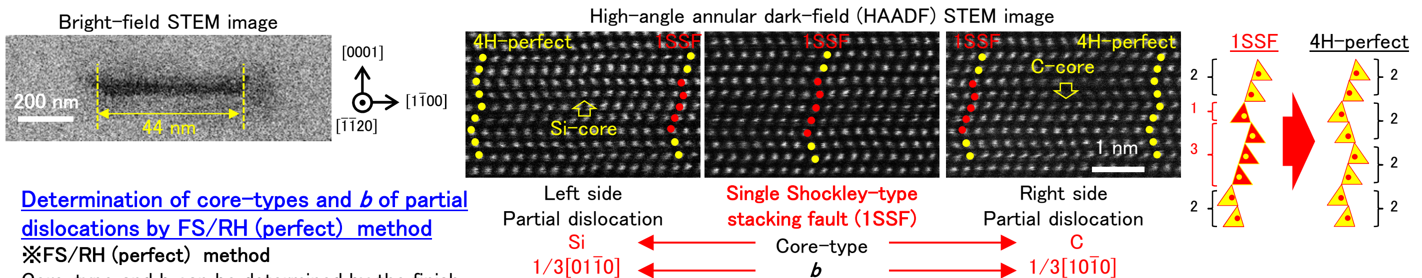
Determination of Burgers vector by *g*·*b* analysis

※ *g*·*b* analysis
Burgers vector (b) can be determined using the relation of *g*·*b* = 0.
*Reciprocal lattice vector : *g*
⤢ : ±1/3[011̄0]
⤡ : ±1/3[101̄0]

Both ① basal -plane dislocation (BPD) and ② threading edge dislocation (TED) were observed.
⇒ The SF expanded from BPD converted into TED near the epi./sub. interface.

2. Observation of the cross section ① near BPD

◆ Core-types and *b* of partial dislocations were investigated by cross-sectional STEM observation in high-spatial resolution.



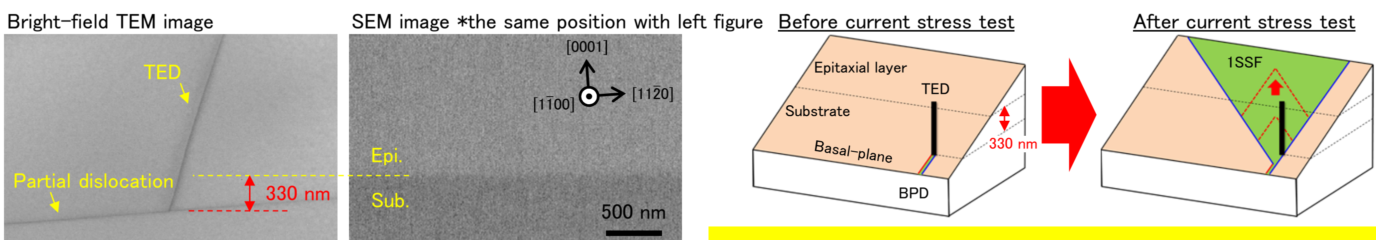
Determination of core-types and *b* of partial dislocations by FS/RH (perfect) method

※FS/RH (perfect) method
Core-type and b can be determined by the finish-start / right-hand (FS/RH) method using a Burgers circuit on an atomic column image.

The *b* of BPD is *b* =1/3[112̄0] , and BPD are composed of 1SSF and two Shockley partial dislocations of Si- and C-core.

3. Observation of the cross section ② near TED

◆ Depth of BPD-TED conversion was investigated by combination of cross-sectional TEM and SEM images.



BPD-TED conversion depth was measured by TEM and SEM images of same cross-section.

The origin was BPD converted into TED in substrate.
1SSF expanded by migration of Si-core partial dislocation

A combination between plan-view and cross-sectional view S/TEM observations yields us some information about expansion mechanism of stacking fault!

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Toray Research Center, Inc.