



HAL
open science

in-situ TEM observations of irradiation damage in boron carbide

Guillaume Victor, Yves Pipon, Nathalie Moncoffre, Nicolas Bérerd, Claude Esnouf, Thierry Douillard, Aurélie Gentils

► **To cite this version:**

Guillaume Victor, Yves Pipon, Nathalie Moncoffre, Nicolas Bérerd, Claude Esnouf, et al.. in-situ TEM observations of irradiation damage in boron carbide. Fourth Workshop On TEM With In Situ Irradiation (WOWISI-4), Mar 2016, Orsay, France. hal-02188768

HAL Id: hal-02188768

<https://hal.science/hal-02188768>

Submitted on 18 Jul 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

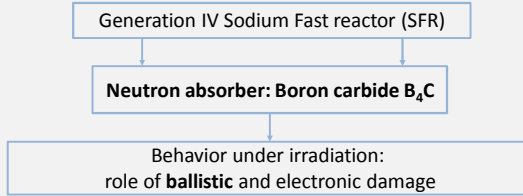
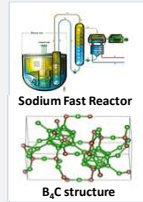
L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

In situ TEM observations of irradiation damage in boron carbide

G. Victor¹, Y. Pipon¹, N. Moncoffre¹, N. Béreud¹, C. Esnouf², T. Douillard², A. Gentils³

¹ Université de Lyon, UCBL, Institut de Physique Nucléaire de Lyon, Villeurbanne, France
² Université de Lyon, INSA de Lyon, MATEIS UMR CNRS 5510, Villeurbanne, France
³ CSNSM, Université Paris-Sud, CNRS/IN2P3, Université Paris-Saclay, Orsay, France

General Background

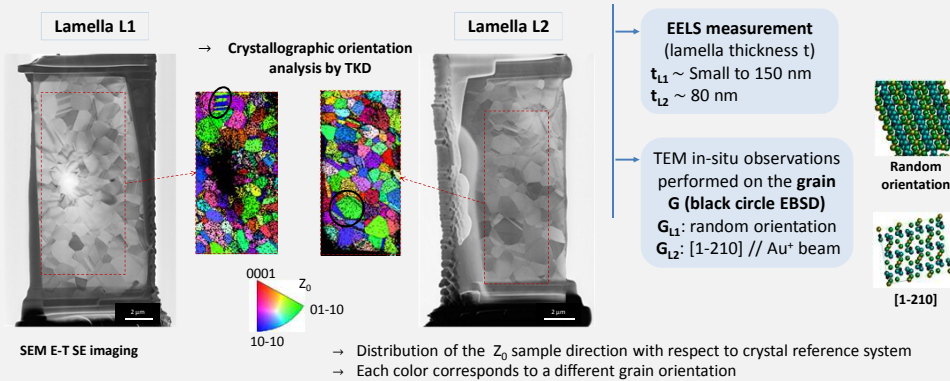


Aim of the study

- Observe the **formation of ballistic damage** induced by heavy ions (Au^+) irradiation
- Observe the **crystallographic orientation effects** on the damage formation
- Identify the **amorphisation threshold** (comparison with recent results of D. Gosset et al. *)

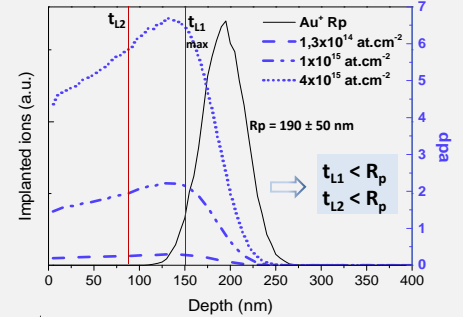
Experimental protocole

→ Lamella preparation using the **Focused Ion Beam (FIB)** technique



Irradiation conditions simulated by SRIM:

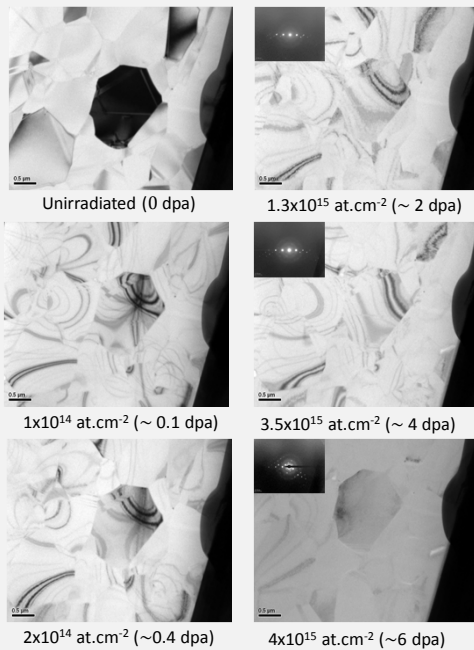
- 1 MeV Au^+ ions at RT
- Fluence: from 1×10^{13} to 4×10^{15} at.cm⁻²



Damage (dpa) and Au^+ ions implantation profiles

Main results

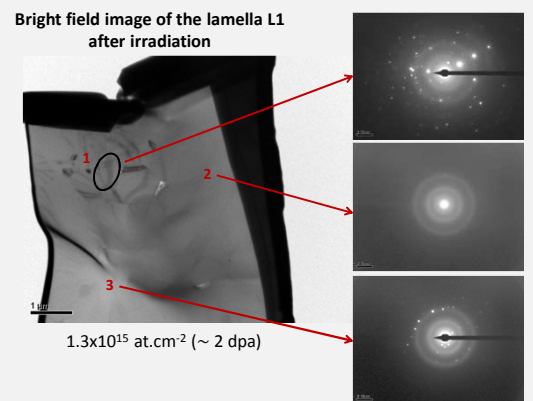
Irradiation of lamella L2 (Bright field)



Damage formation:

- 0 to 2×10^{14} at.cm⁻² : 0 to 0.4 dpa
Local curvature of the sample due to an important stress induced in the material
- 1.2×10^{14} at.cm⁻² : ~ 0.2 dpa
Appearance of « black dots »
- 1×10^{15} at.cm⁻² : ~ 1.6 dpa
Growth of the « black dots » until observation of larger stress field of :
→ Dislocation loops ~ 20 nm
- $2.5 \times 10^{15} < \phi < 4 \times 10^{15}$ at.cm⁻² :
 $4 < x < 6$ dpa
Amorphisation threshold

Irradiation of lamella L1:



Diffraction patterns:

- In the area observed in-situ under constant electron beam irradiation - **1**
- In a thick part of the lamella (~ 150 nm) - **2** → After irradiation
- In a thin part of the lamella (< 100 nm) - **3**

Observations - Conclusion

No crystallographic orientation effect:

→ defects created homogeneously in the whole lamella, whatever the grain orientation

Effect of the electron beam :

→ Self-healing of the material under electron beam combined with the ballistic effect of the ion beam

Effect of the ion implantation:

→ Amorphisation at fluences 2-3x lower when presence of Au atoms:
 1.3×10^{15} instead of 3- 4×10^{15} at.cm⁻²

*Reference: D. Gosset et al., Nucl. Instr. Meth. Phys. Res. Sect. B, 365 (2015) 300-304

Acknowledgments

The authors wish to thank the NEEDS Project for financial support and all the JANNU-S-Orsay technical staff for their assistance during the irradiation