Applications of electron channeling contrast imaging for characterising nitride semiconductor thin films in a scanning electron microscope

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Keywords: SEM, dislocations, ECCI and nitrides

We are now all familiar with the bright blue, green and white LEDs that light up our electronic appliances; decorate our streets and buildings and illuminate airport runways. However, the ultimate performance of these nitride semiconductor based LEDs is limited by extended defects such as threading dislocations (TDs), partial dislocations (PDs) and stacking faults (SFs). If we want to develop LEDs to be an effective replacement for the light bulb, or have sufficient power to purify water; we need to eliminate these defects as they act as scattering centers for light and charge carriers and give rise to nonradiative recombination and to leakage currents, severely limiting device performance. The capability to rapidly detect and analyze TDs, PDs and SFs, with negligible sample preparation will represent a real step forward in the development of more efficient nitride-based semiconductor devices.

In our presentation, we will describe the use of electron channeling contrast imaging (ECCI) – in a field emission scanning electron microscope – to reveal and identify defects in nitride semiconductor thin films [1, 2]. In ECCI vertical threading dislocations are revealed as spots with black-white (B-W) contrast (see Fig. 1). We have developed a procedure which exploits the change observed in the direction of this B-W contrast for screw, edge and mixed dislocations, on comparing two electron channeling contrast images acquired from symmetrically equivalent crystal planes. This enables us to unambiguously differentiate between screw, edge and mixed dislocations (see Fig. 2) [3]. We will also demonstrate the use of ECCI to reveal and characterize basal plane stacking faults in nonpolar nitride semiconductors. Finally we will discuss our on-going research to compare electron channeling contrast images with cathodoluminescence hyperspectral data from exactly the same micron-scale region of a sample, allowing us to investigate the influence of defects on the light emission from nitride semiconductors.

References

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[4] Acknowledgements: We would like to thank our collaborators from across Europe for providing us with samples. This work was carried out with the partial support of the EU under the ITN RAINBOW (http://rainbow.ensicaen.fr/), grant agreement No: PITN-GA-2008-213238 and EPSRC grant No: EP/D058686/1.

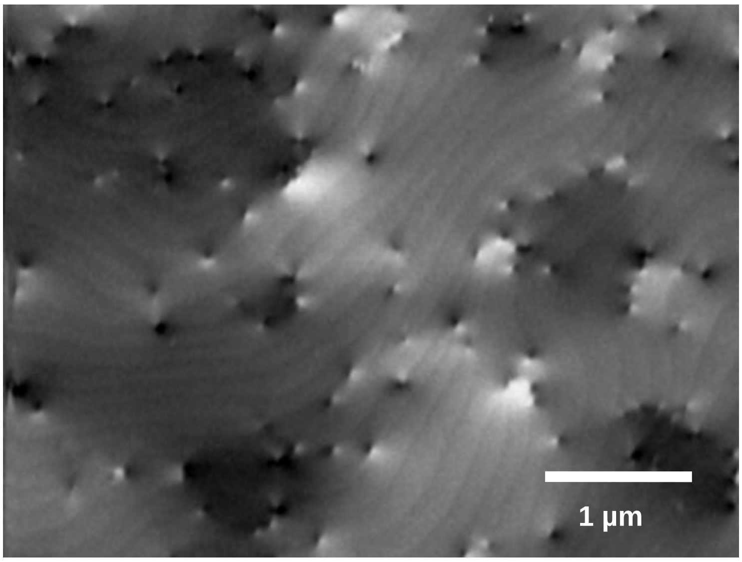

Figure 1. Electron channeling contrast image. The black-white spots reveal dislocations threading to the surface, the lines are atomic steps on the surface of the sample.

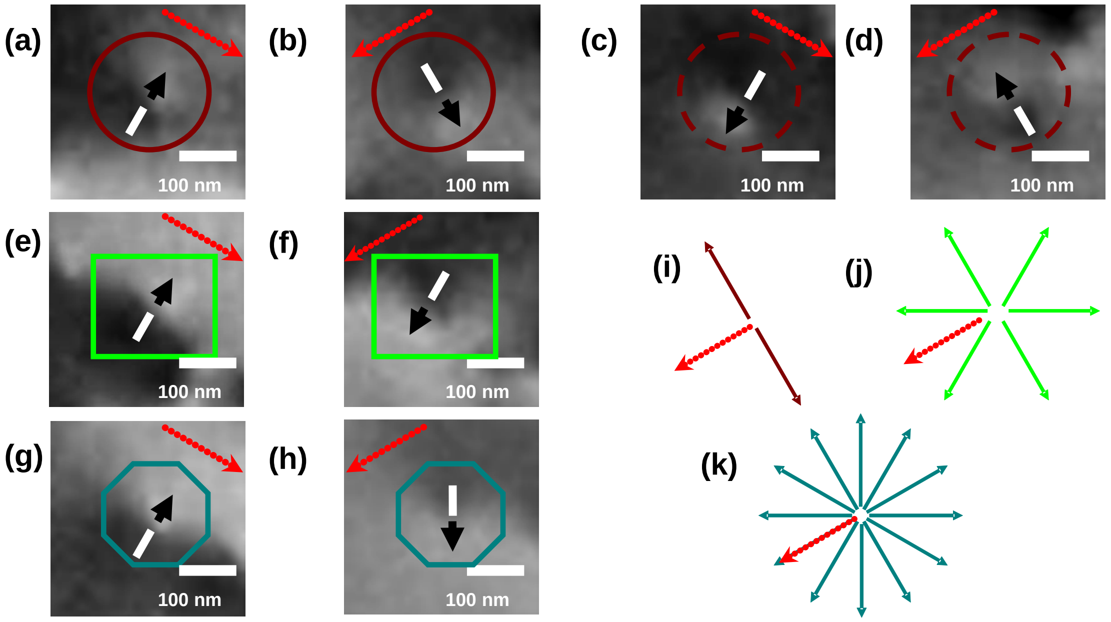

Figure 2. Possible B-W contrast directions for TDs: High magnification electron channeling contrast images showing B-W contrast directions for screw (a-d), edge (e-f) and mixed (g-h) dislocations. (i-k) shows the possible directions of the B-W contrast of screw (i), edge (j) and mixed dislocations (k) for a ***g*** of (3 1 -4 -3). The dotted arrows denote the direction of ***g*** [left to right (-1 -3 4 -3) and right to left (3 1 -4 -3)].