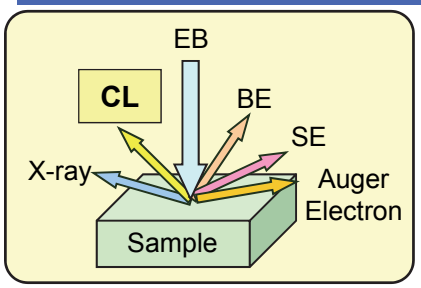
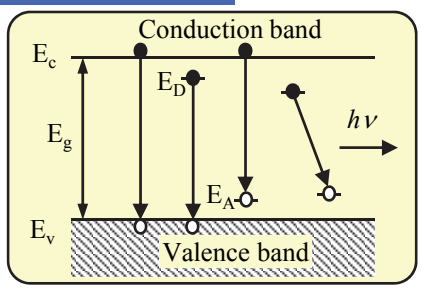
Defect-characterization in semiconductor devices by Cathodoluminescence (CL)

Cathodoluminescence is a emission of light as a result of electron bombardment.“ Cathodoluminescence (CL) spectroscopy " is a powerful method for evaluate defects in semiconductor devices. We introduce some applications of CL analysis to various materials and devices (Si, SiC, Diamond, GaN).

1. Features of Cathodoluminescence analysis

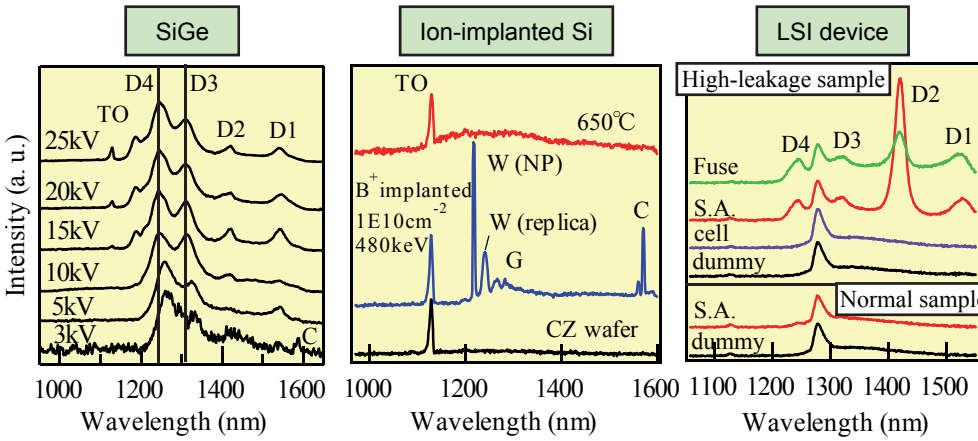




Microscopy
1. Easy to decide location (SEM).
2. CL image compatible with SE images.
3. Nondestructive depth-resolved analysis.

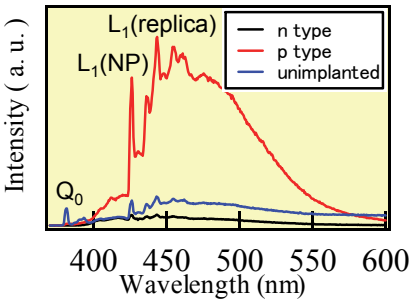
Spectroscopy
1. Type and status of defects.
2. Energy level of defects.
3. Semi-quantitative analysis.

2. Analysis of Si devices



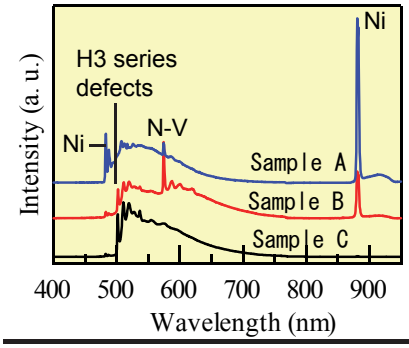
Various defects (point defects, dislocations, etc...) are introduced during semiconductor manufacturing processes.
CL analysis is an easy and high sensitive method for the optimization of the manufacturing processes.
[Assignments]
- TO: Band to band transition
- D1,D2,D3,D4:Dislocations
- W: Si_i
- G: C_s-Si_i-C_s
- C: C_i-O_i

3. 4H-SiC: Evaluation of induced defects by ion implantation.



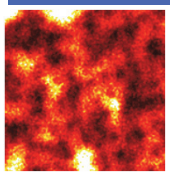
It is very important to control of an ion-implantation process for SiC power devices. Evaluation of ion implantation process can be performed by Q_0 line (band to band transition) and L_1 line (defect by ion implantation).

4. Diamond: Evaluation of defects and impurities.

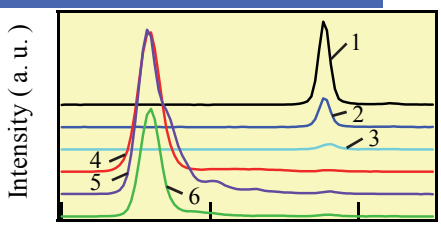


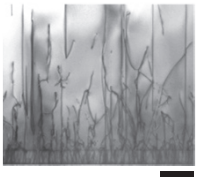
The band gap of diamond is 5.5 eV (225 nm) . The emissions originating from various impurities (Ni, N, etc.) and defects (vacancy, dislocation, etc.) is observed at 1.38～3.10 eV (400～900nm).

5. GaN on SiC: Evaluation of defects and crystallinity.

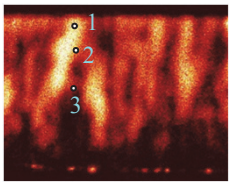


CL image of GaN (plan view)

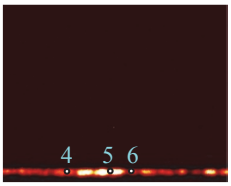




TEM image of GaN (sectional view)



CL image of GaN (sectional view)



CL image of buffer layer (sectional view)

Cross-sectional CL microscopy and spectroscopy is effective for optimization of the manufacturing processes.
The crystallinity of a buffer layer and the defect in a GaN layer can be evaluated by cross-sectional CL measurement.

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