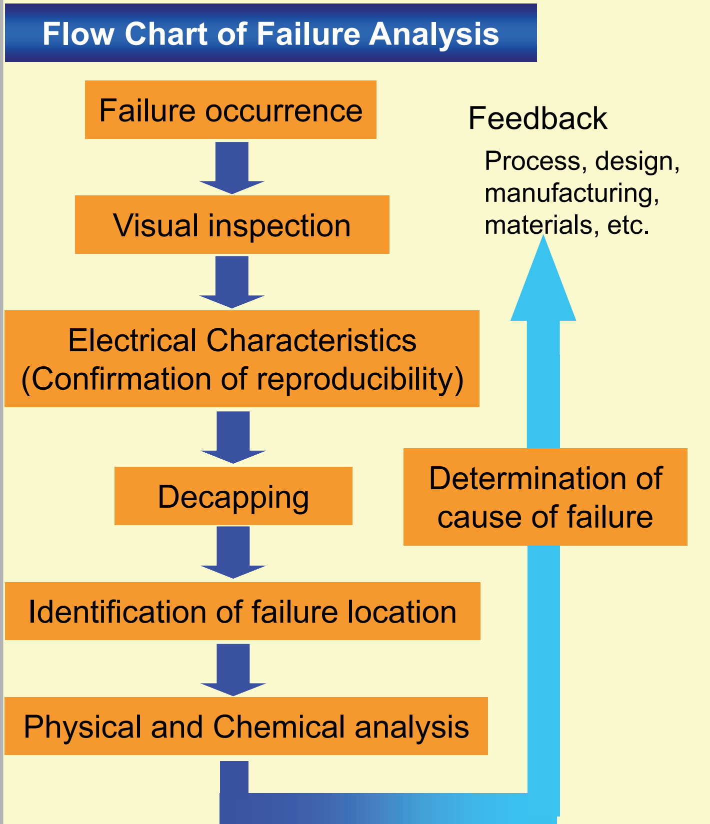
Failure Analysis Techniques for Semiconductor Devices

Physical and chemical analysis techniques are widely used for semiconductor failure analysis. The analysis of "invisible defects" is becoming important because of the requirement of high-level reliability.

Flow Chart of Failure Analysis



Techniques used in Failure Analysis

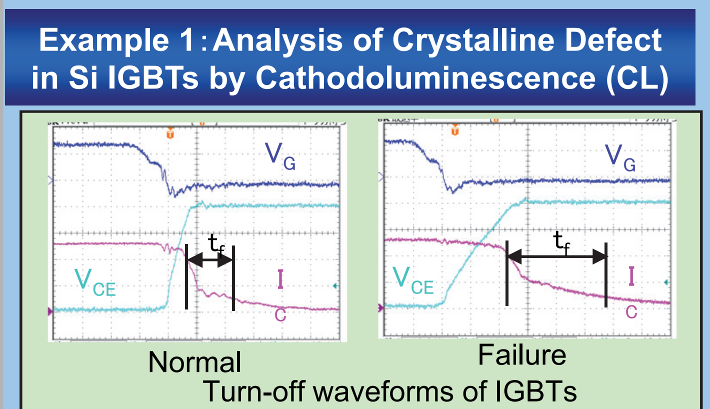
Identification of Defective Region

Package: Scanning acoustic tomographs (SAT), X-ray, X-ray CT, Thermal emission microscope, etc.
Chip: Photo emission microscope , OBIRCH, Voltage contrast, etc.
(Some methods are done with outsourcing.)

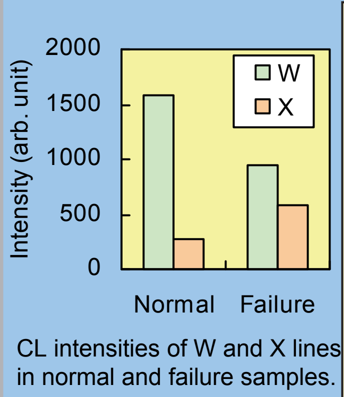
Physical and Chemical analysis

Morphological study: *TEM, EDX/EELS, SEM, EBSD*
Surface analysis: *SIMS, TOF-SIMS, XPS, AES, EPMA, RBS/HFS, AFM/SSRM/SCM*
Structural analysis: *FT-IR, Raman, PL, CL, ESR, XRD, GIXR, EXAFS, NMR*
Organic and inorganic analysis: *GC･GC/MS, LC/MS, NMR, GPC, ICP-AES, ICP-MS, XRF, IC*
Materials Characterization: *Mechanical and rheological properties, Thermophysical properties, Thermal analysis, DSC, TG-MS/TPD-MS*

Example 1: Analysis of Crystalline Defect in Si IGBTs by Cathodoluminescence (CL)



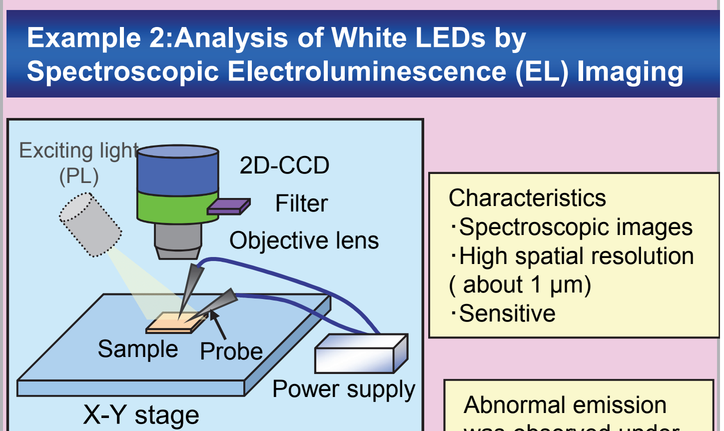
Turn-off waveforms of IGBTs



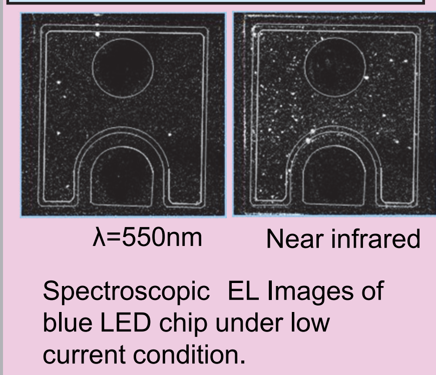
CL intensities of W and X lines in normal and failure samples.

CL measurements were done on the cross-section of IGBTs. Point defects were remarkably changed. The tetra-interstitials (X) were increased and the tri-interstitials (W) were decreased in the failure sample. We consider that the minority carrier lifetime in the failure sample is elongated by the degrease of total number of defects by the agglomeration of interstitials.

Example 2: Analysis of White LEDs by Spectroscopic Electroluminescence (EL) Imaging



Characteristics
･Spectroscopic images
･High spatial resolution (about 1 μm)
･Sensitive



λ=550nm   Near infrared

Spectroscopic EL Images of blue LED chip under low current condition.

Abnormal emission was observed under low current condition. The wavelength of the abnormal emission was near-infrared region or about 550 nm. We consider that the cause of abnormal emission can be categorized by the wavelength nondestructively.