Photoluminescence mapping of β-Ga_2O_3

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Abstract

Photoluminescence (PL) spectra of β-Ga_2O_3 include the intrinsic UV band and red emission due to Cr^{3+} impurities.[1] PL mapping with excitation wavelengths of 355 nm and 266 nm reveals the spatial distribution of these features with micron resolution. The PL maps reveal (1) striations in the red emission intensity, (2) bright UV emitters on the surface, and (3) damage induced by high-intensity laser pulses.

Method

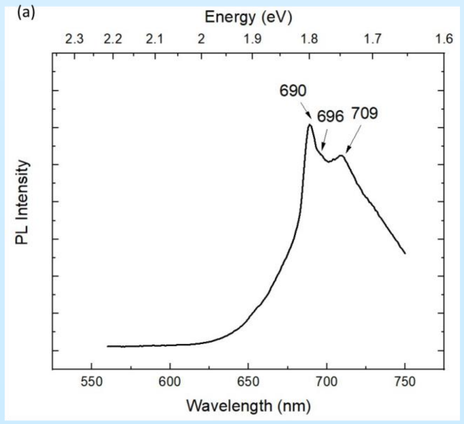
- Klar Mini Pro PL microscope with XYZ scanning
- Ocean Optics spectrometers
- System can cover deep-UV to near-IR (266 to 2500 nm)

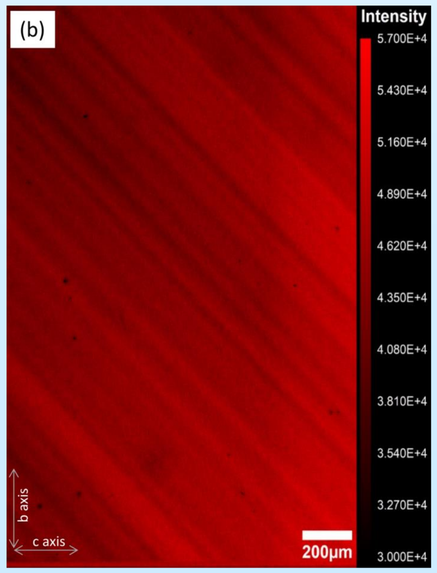
- T = 80 – 400 K
- This work: RT

Cr^{3+} red emission[2]

- (100) β-Ga_2O_3:Fe crystal, Czochralski grown (Synoptics)
- Unintentional Cr impurities
- 355 nm excitation
- Intensity of Cr^{3+} peak (690 nm) shows variations

Striations due to variations in [Cr] or the Fermi level

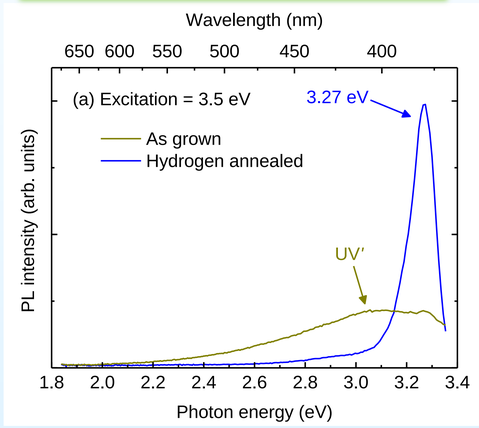


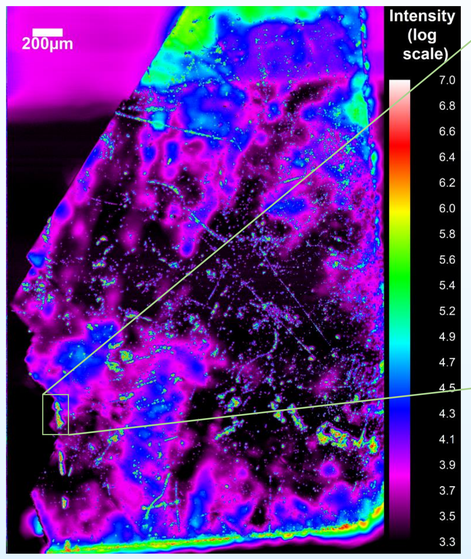


(a) PL spectrum of β-Ga_2O_3 crystal. (b) PL map of the 690-nm peak intensity.

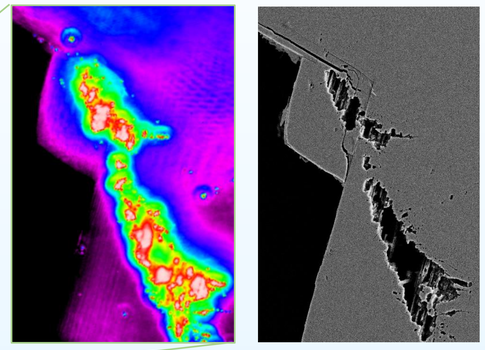
Bright UV emitters[3]

Bright emission at 3.27 eV localized at "pits" on the (010) surface.





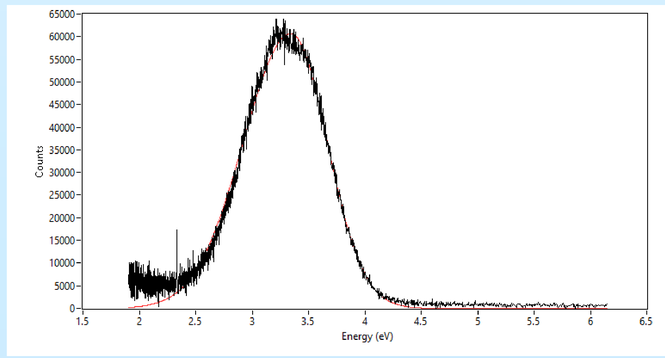
PL SEM



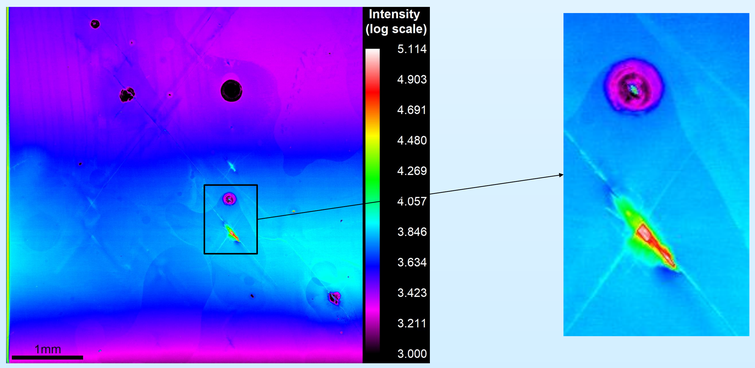
PL map of the 3.27-eV peak intensity. The sample was edge-defined film-fed grown (Tamura) and hydrogenated at 900°C. As shown above, the emission occurs at surface pits.

Laser damage

- MBE-grown (010) β-Ga_2O_3 (Speck & Krishnamoorthy, UCSB), homoepitaxy
- Irradiated with 1064 nm, 3 ns pulses
- Damage threshold = 10 J/cm^2
- PL excitation 266 nm



UV band emission from β-Ga_2O_3 epilayer.



PL map of the UV-band intensity for a damaged β-Ga_2O_3 epilayer. Circular "conchoidal" fracture and a cracked structure are shown.

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Cr^{3+} impurities: AFOSR Grant FA9550-21-1-0078
Laser damage: LLNL Contract DE-AC52-07NA27344, LDRD Project 22-SI-003

1. M.D. McCluskey, "Point defects in Ga_2O_3," *J. Appl. Phys.* **127**, 101101 (2020).
2. C. Remple, J. Huso, and M.D. McCluskey, "Photoluminescence and Raman mapping of β-Ga_2O_3," *AIP Advances* **11**, 105006 (2021).
3. J. Huso, M.D. McCluskey, Y. Yu, Md. M. Islam, and F. Selim, "Localized UV emitters on the surface of Ga_2O_3," *Scientific Reports* **10**, 21022 (2020).