Line Defects in Single Crystal CeB_6 Electron Emitters

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Abstract

Electron emitters are essential components in many microscopy systems, including scanning electron microscopes, transmission electron microscopes, and scanning Auger microscopes. One feature of good electron emitter materials is a low surface work function. CeB_6 is one such material. Line defects seen in CeB_6 affect the work function of the emitting surface, causing the emitted electrons to have a wider spread of energies. This causes chromatic aberration, reducing the resolution of the microscope systems. The purpose of this research is to find the source of these line defects in the CeB_6 emitter fabrication process. It was suspected that defects were in the form of oxides deposited from water contamination. This study confirms that the defects do contain more oxygen than other areas of the surface. The source of this oxygen has yet to be determined.

Background

The work function is the minimum energy needed to remove an electron from the surface to use in electron microscope systems. Crystal defects contribute to chromatic aberration by having different work function than surrounding material. By having a different work function electrons leave at different velocities and are focused at different distances, adversely affecting resolution in microscopy systems.

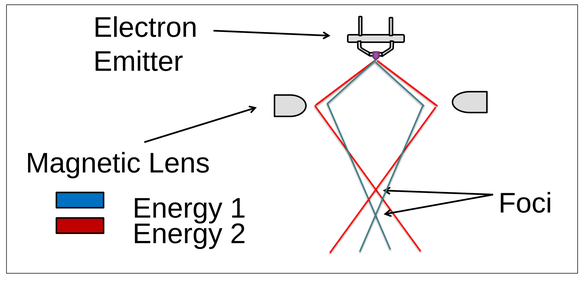
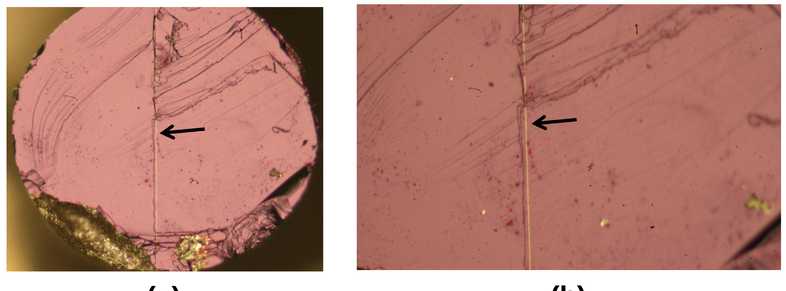


Figure 1 Schematic showing chromatic aberration in an electron microscope. Electrons of different energies focus at different locations, reducing the resolution of the microscope.

Crystal Defects



(a) (b)

Figure 2 Optical microscope image of a line defect, visible as a white line, in a CeB_6electron emitter. (a) Line defect at 50x zoom. (b) Spot defects at 100x zoom.

Surface Analysis

The technique for analyzing these surface defects was time of flight secondary mass spectrometry or TOF-SIMS. Samples are bombarded with ions which eject secondary ions which are then detected by a time of flight detector[1].

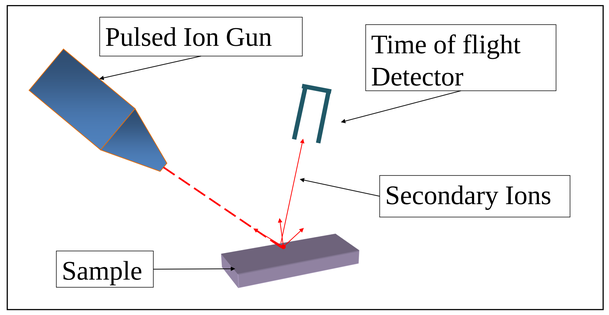


Figure 3 Schematic of a typical TOF-SIMS system..

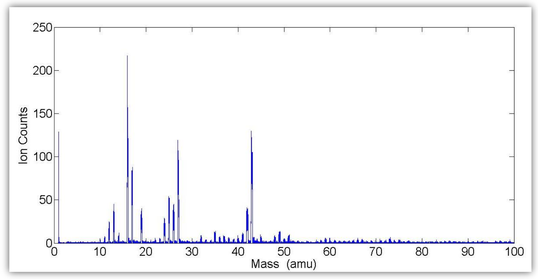


Figure 4 TOF-SIMS mass spectra for single pixel in TOF-SIMS image.

Field of view: 55.6 × 55.7 μm²

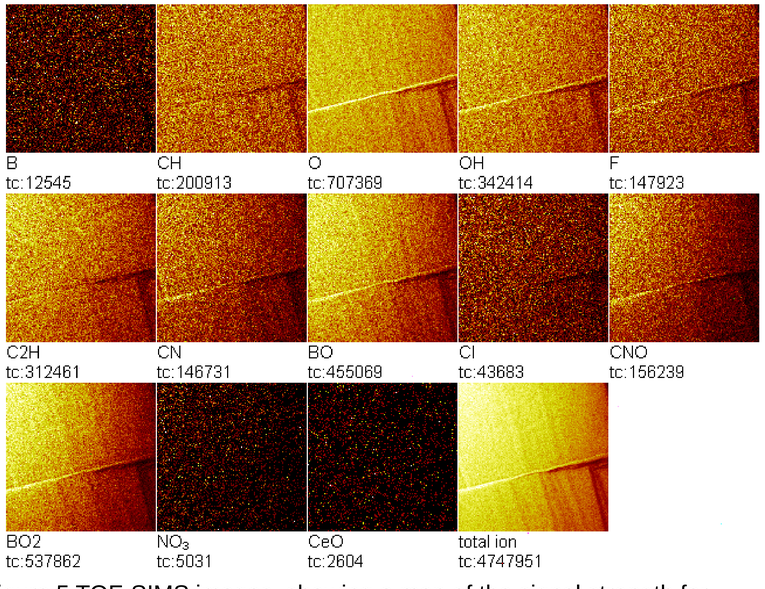


Figure 5 TOF-SIMS images, showing a map of the signal strength for prominent peaks in the spectrum. Note that the overall signal is stronger from the line defect, likely due to topographic effects.

Results

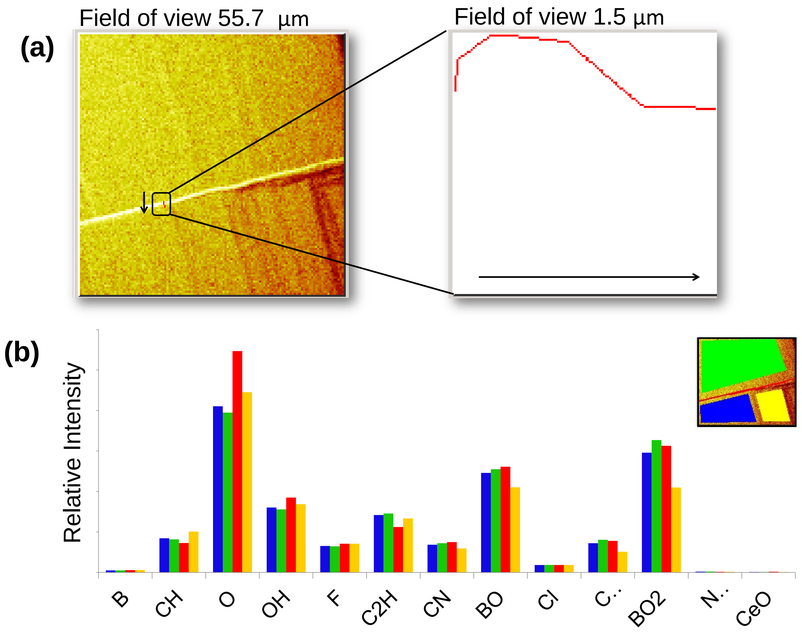


Figure 6): (a) Map of the TOF-SIMS signal strength for O_2. (b) Signal strength for each prominent peak in the spectrum, for distinct regions of the image. The regions and color scheme are indicated in the inset. These data are normalized by the total ion signal in that region. This helps distinguish true differences in composition from effects that increase overall ion yield (such as topographic features).

Future Work

Further explore the cause of the line defects. It is suspected the water contamination depositing oxides during fabrication process but this needs to be confirmed. Possible future experiments include baking the bulk material under vacuum before production to see if this removes water and defects.

Acknowledgements

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References

[1] Friedbacher, Gernot. *Surface and thin film analysis a compendium of principles, instrumentation, and applications*. Weinheim: Wiley-VCH Verlag, 2011. Print.
[2] Balakrishnan, G., Lees, M., & Paul, D. (2003). Growth of large single crystals of rare earth hexaborides. Journal of Crystal Growth, 256(1-2), 206-209.

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