CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

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Project Number

34164

Project Title

Temperature Dependence of the Indirect and Direct Bandgaps in TlBr from Cathodoluminescence Spectroscopy

Abstract

Objectives/Goals

The temperature dependence of the indirect bandgap in thallium bromide (TlBr) has been determined using variable temperature (5 K to 300 K) cathodoluminescence. The spectra include transitions associated with both the indirect (2.66 eV at 5 K) and the direct (3.0 eV at 5 K) bandgaps.

Methods/Materials

Measurements were made on detector grade materials which are nominally undoped. Cathodoluminescence spectra were taken with the samples mounted in a JEOL 840A scanning electron microscope with a liquid helium flow variable temperature stage. The light was collected by a parabolic mirror, dispersed with a ¼ m grating monochromator and detected with a cooled photomultiplier tube with response over the range from 300 to 900 nm. Spectra were taken about every 20 degrees between 5 K and 300K.

Results

19 data points were recorded between 5K and room temperature. The data clearly shows that the indirect gap peak moves to higher energies as the temperature rises. Luminescence emission around 3.0 eV fits with previous observations. The peaks at 3.02 eV and 2.66 eV are consistent with the reported low temperature values for the indirect and direct bandgaps of TlBr. Least-squares fitting analysis in Matlab was used to fit to three commonly used semi-empirical models. It seems that the direct gap is not appreciably affected by temperature, contrary to the results of previous measurements of the direct gap.

Conclusions/Discussion

It is interesting to note that the temperature dependence of the luminescence peak associated with the direct bandgap shows a significantly weaker temperature dependence compared to that of the indirect gap. The indirect bandgap emission shifts to an energy of 2.86 eV at 300 K while the direct gap does not appear to shift to the extent predicted by earlier measurements of the exciton absorption edge, and in fact stays constant within the accuracy of the measurements. Future work will have to be done to explain the difference in behavior of the direct gap.

Summary Statement

The project determines how temperature affects the indirect and direct bandgaps in thallium bromide.

Help Received

I used lab equipment under the supervision and guidance of Dr. Nancy Haegel at the Naval Postgraduate School as part of the Science and Engineering Apprenticeship Program.