Photoemission from a GaN/CsBr heterojunction photocathode

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CsBr films deposited on thin metal layers (Mo, Cr) have been shown[1,2] to meet the requirements of a photoelectron source for a multielectron beam system operating at photon energies (4.8 eV) below the CsBr band gap of about 7.3 eV. The mechanism for photoemission[3,4] shown in Figure 1 is consistent with electron emission to the vacuum level from intragap states centered at about 3.7 eV below the conduction band. These states were detected in the CsBr films utilizing photoluminescence measurements[3,4]. The Fermi level of the Cr substrate aligns with the intraband states, making possible electron transitions between the intraband states and the vacuum level. In addition, this alignment provides a return path to close the electric circuit. To achieve a higher photo-yield, we use a p-type GaN substrate to enhance photon absorption. Herein, we present experimental results on CsBr films deposited on thin (0.1 micron) GaN films MBE grown on sapphire. The GaN/CsBr structure has a higher quantum yield than the CsBr /Cr devices as shown in Figure 2. A model to explain the observed behavior is shown in Fig. 3.

At vacuum pressures <1 x 10^{-8} torr, the sample lifetime depends mainly on the current density which is proportional to the laser power density on the sample for a given photoyield. We have observed lifetimes of over 100 hours (with less than 50% reduction in photoyield) at a current density <15 A/cm^2 and a chamber pressure of 5 x 10^{-10} torr. Due to the high light absorption of the GaN film, a temperature rise over 100 C was calculated in the GaN film (.1 micron thick) when illuminated at high power density with a 257 nm laser (current density >40A/cm^2). This temperature rise causes degradation of the photoemission by increasing the photolysis and contamination rate. The lifetime under these high current density conditions is less than about 30 hours limited by the temperature rise. However, long lifetimes at high current density may be obtained with sample cooling. The results presented in the paper are very encouraging for the development of robust photocathode sources for electron beam applications.

References:

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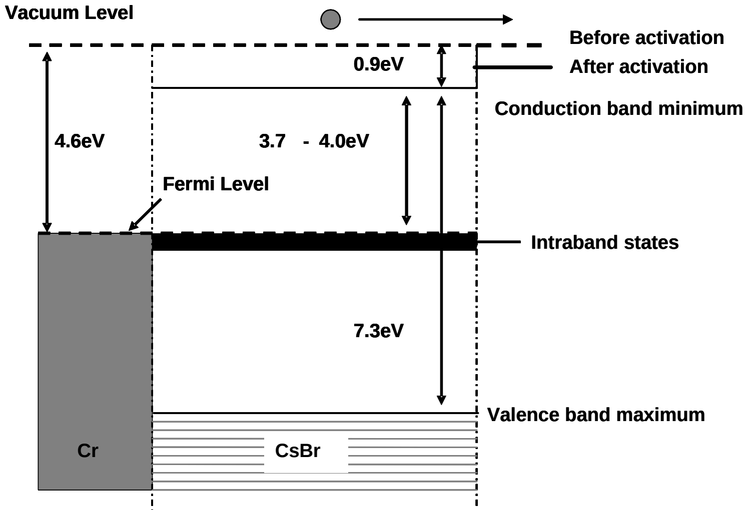

Figure 1. Model to explain photoemission in CsBr films with photon energy less than the bandgap.

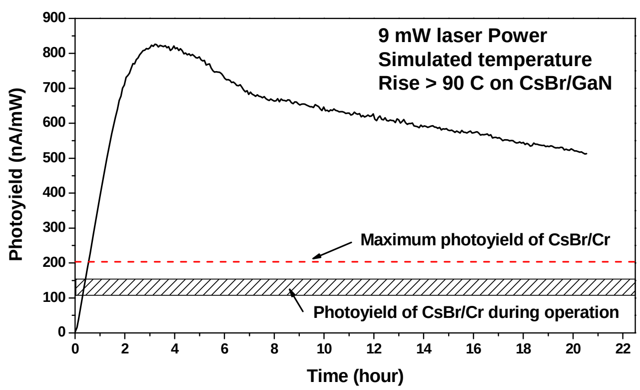

Figure 2. Results obtained in an GaN/CsBr photoemitter at a current density >40 A/cm^2.

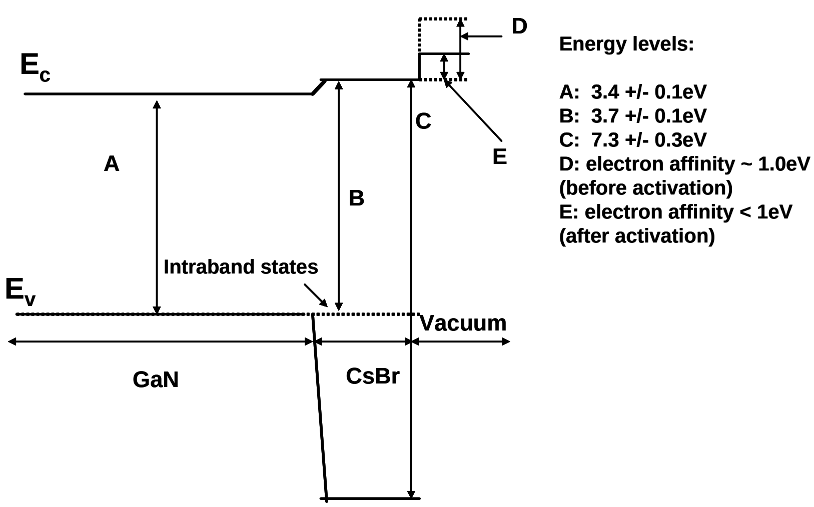

Figure 3. Model to explain photoemission of GaN coated with a 15 nm film of CsBr.