Influence of film deposition rate on morphological and photoemissive behavior of KBr photocathode for astrophysics application

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Introduction

The KBr thin films are widely employed in manufacturing the Extreme Ultra Violet (EUV) sensitive photocathode devices for particle and astrophysics application [1–3]. These UV-photon devices require a photocathode with stable and uniform quantum efficiency (QE). Therefore, it is very important to optimize the technology for the production of large surfaces area KBr photocathode with stable and high QE. In connection to this, it is vital to explore all parameters, which might be affected the surface morphology and the long-term behavior of photocathodes. The influence of humidity and substrate on its photoemission and structural behaviour have already been studied [4, 5]. Deposition rate is one of the important element, which can affect the photoemissive and morphological properties of photocathodes and it can be interesting to assess the film crystallinity for the different deposition rates. Therefore, in current work we have presented a study on the influence of deposition rate on morphological and photoemissive behavior of KBr photocathode.

Experimental Details

KBr thin films are deposited by the thermal evaporation technique in high vacuum (4×10^{-7} Torr) stainless steel chamber of 18" diameter . The deposition rate of films has been controlled and monitored by a current control unit (Morefield, UK) and a thickness/rate monitor (Sycon, USA) respectively. The KBr films of thickness 500 nm have been grown with two different deposition rate ≤ 3 nm/sec and ≤ 10 nm/sec on the stainless steel substrate. After the film preparation, it has been quickly transferred into a vacuum desiccators, containing fresh silica gel. During the sample transfer, a nitrogen gas was continuously flushed to avoid the interaction with water vapor present in humid air. The prepared samples are transported to the morphological and photocurrent measurement set-ups.

Morphological investigation has been performed by acquiring the scanning electron microscopy (SEM) images of 500 nm thick KBr film. This SEM setup is operated at 10 kV accelerating voltage. The Photoemission measurements are carried out using a VUV monochromator (McPherson, USA) in vacuum environment (5×10^{-4} Torr). For the photocurrent measurement a high voltage (200 V) applied to the KBr film using a high voltage power supply (CAEN n417A). The D_2 lamp is used to generate a UV light between 120 to 200 nm spectral ranges. During the Photoemission measurement, a reference PMT (Hamamatsu model: 658) has been used to monitor the stability of light source.

Results

Figure 1 illustrates the SEM images of 500 nm KBr film deposited with two different deposition rates. The film deposited at slow deposition rate exhibits the fairly uniform with continuous granular structure and have a full substrate area coverage. The average grain size is found to be about 500 nm. However, the surface area of the film deposited with fast deposition rate is mainly formed by a cubi-

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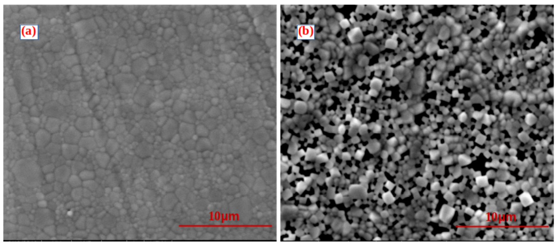

FIG. 1: SEM images of 500 nm thick KBr photocathode with (a) $\leq$ 3 nm/sec (b) $\leq$ 10 nm/sec deposition rate.

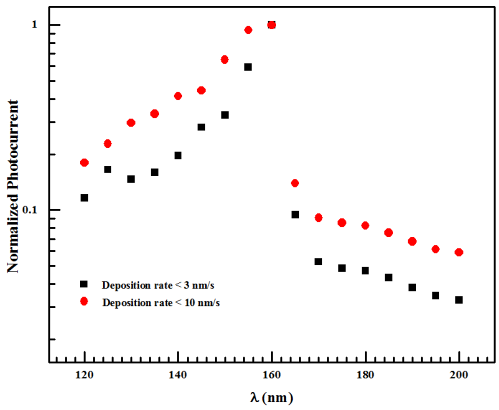

FIG. 2: Normalized photocurrent of 500 nm KBr photocathode as function of wavelength.

cal shapes. The rectangular or cubic shape may be observed due to recrystallization results from nucleation of KBr molecules because of relatively high deposition flux rate. The surface area coverage is also decreased for film deposited at $\leq$ 10 nm/sec rate. But, some bright spots are found on the film surface which indicates that the ionic conductivity of KBr molecules have been increased with deposition rate and more secondary electron are generated after the interaction of primary SEM beam.

Figure 2, shows the normalized photocurrent of KBr photocathode deposited at $\leq$ 3 nm/sec and $\leq$ 10 nm/sec deposition rates. The film deposited at rate ($\leq$ 10 nm/sec) indicates the higher value of photocurrent than the slowly deposited film. The peak, at 160 nm is found due to maximum intensity of D_2 lamp at this wavelength. Enhancement in photocurrent with deposition rate may be observed due to increment in the mobility of KBr molecules. Also the film deposited at fast rate have the lower possibility of contamination during deposition. Since the evaporated KBr crystals have the less time to interaction with residual water vapor and other gases, present in the evaporation chamber. This results in the film with fewer impurity and affect the photoemissive behavior of the film .

A slow deposition rate results a very uniform film growth with a highly ordered grain morphology and a 100% substrate surface area coverage. The surface area of the film deposited at the fast rate is manifested by cubical structure of varied sizes. From our observation, we suggest that the photocathode prepared at the fast evaporation rate is a more effective photoconverter than the slow rate deposited one.

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