Study of KBr thin films for EUV and FUV sensitive photocathode devices

R. Rai, Triloki and B.K. Singh*
High Energy Physics Laboratory, Banaras Hindu University, Varanasi- INDIA

Introduction

Alkali halide (A-H) thin film photocathodes are incredibly used as a photon converter in the extreme ultraviolet (EUV, 10 nm $<\lambda<$100 nm) and far ultraviolet (FUV, 100 nm$<\lambda<$200 nm) spectral ranges. These photocathodes are persistently employed in astroparticle detectors, vacuum and gas-based photon detectors, in the detection of scintillation light, medical imaging, in a positron emission tomography etc. A-H photocathodes are also served as a protective layer in visible-sensitive photon detectors. In particular, KBr photocathode is a potential alternative in the astrophysics experiments such as FUSE (The Far Ultraviolet Explorer), the EUV spectrometer SUMER and an ultraviolet spectrometer, PHEBUS (Probing of Hermean Exosphere by Ultraviolet Spectroscopy) due to sensitivity in the FUV region only (¡160 nm). Owing to sensitivity in FUV region, it improves the ability to reject sources of radiation and background near ultraviolet (UV) wavelength. These properties of KBr are also advantageous for soft X-ray instruments [1].

Except of the vast application of KBr Photocathode, there is lack of knowledge about the parameters, which may affect the photon sensitivity. Therefore, in this work, we emphasized on the study of structural and morphological characteristics KBr photocathode, in order to correlate them with the quantum yield.

Experimental Detail

KBr 100 nm and 300 nm films have been deposited on stainless steel substrate using thermal evaporation techniques, under a high vacuum environment (order of vacuum 10^{-7} Torr). Immediately after the deposition, samples has been extracted into a vacuum desiccator under constant flow of Dry nitrogen gas (N2) and transported to the other characterization setup.

The Photocurrent measurement has been performed using a 234/302 VUV monochromator (McPherson, USA) under a vacuum environment (10^{-6} Torr). The UV induced photoelectrons ejected from the KBr photocathode has been collected by a Kiethey picoammeter in terms of photocurrent. To collected the ejected electrons from the photocathode, a +200 volt power has been applied to the grid using a high voltage power supply from CAEN (model : N 471).

The Crystallographic measurement of KBr films has been carried out using Brag brantano para focusing based X-pert Pro PANALYTICAL system.

The Morphological analysis of KBr films has been measured by scanning electronic microscopy (SEM) from Quant-200.

Photocurrent measurement

The Photocurrent of 100 nm and 300 nm thick KBr films has been measured in the spectral range of 110 nm to 200 nm with a 2 nm scan step size. The photocuurent as a function of wavelength is shown in Fig.1. The 300 nm film having higher value of photocurrent in comparison with the 100 nm. The maximum value of photocurrent obtained for the photons of wavelength at about λ=138 nm.

Crystallographic Study

The Crystallographic study of 100 nm and 300 nm KBr films have been studied by using X-Ray diffraction (XRD) technique. The XRD pattern of 100 nm and 300 nm KBr films

*Electronic address: bksingh@bhu.ac.in

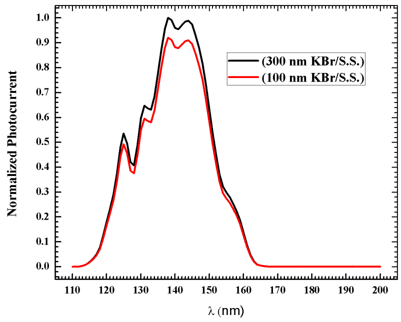

FIG. 1: Normelised photocurrent of 100 nm and 300 nm KBr films as function of wavelength (λ).

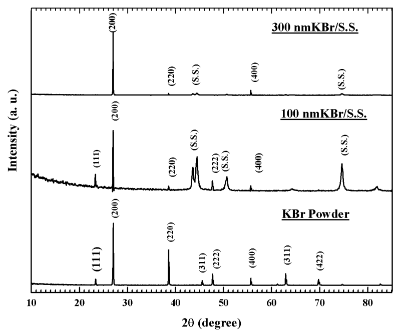

FIG. 2: XRD pattern of 100nm and 300 nm KBr thin films as well as of KBr powder.

as well as of powder sample are shown Fig.2. The XRD profile exhibits a most intense peaks on diffraction angle 2θ =26.99780 for 100 nm thick film and at 2θ = 27.00040 for 300 nm film and this peak position corresponds to (200) crystallographic plane and other peaks are found on (220) and (400) which attribute that both film (100 nm and 300 nm thick film) has crystalline face centered (FCC) structure. These peak positions are matched very well with ASTM card data (pdf no.-730831).

To examine length of coherent scattering domain, i.e. crystallite size the well known scherrer's equation has been employed [2]:

$$D = \frac{k\lambda}{\beta_{hkl}cos\theta} \quad (1)$$

Here, D is effective crystallite size normal to

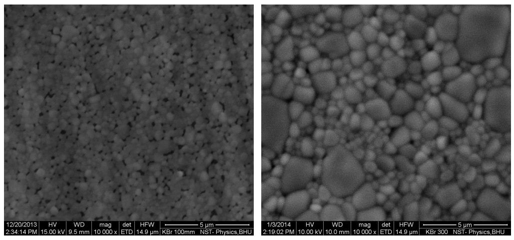

FIG. 3: SEM surface morphology image of 100 nm and 300 nm thick KBr films.

the reflecting plane, K is a shape factor (0.9), λ is the wavelength of CuKα radiation, β_{hkl} is the full width at half maximum and θ is the diffraction angle.

The estimated value of crystallite size is about 78 nm for 100 nm film, while 92 nm for 300 nm film.

Morphological Study

Fig. 3 shows Scanning electron microscopy (SEM) image of 100 nm (left panel) and 300 nm (right panel) KBr films deposited on stainless steel stub.

Morphological study reveal that the 300 nm thick film has more grain density and surface area coverage compared to 100 nm film. The average grain size is found to be about 390 nm and 566 nm for 100 nm and 300 nm KBr films respectively.

Conclusion

The Photoemission, crystallographic and morphological properties of 100 nm and 300 nm KBr films have been analysed. The EUV and FUV sensitive, 300 nm thick KBr film having hiegher value of photocurrent, crystallite size as well as grain size in comparision with the 100 nm film.

References

[1] R. Rai, et al., Nuclear Instruments and Methods in Physics Research Section A . **787**, 125-129 (2015).

[2] P. Scherrer, Nachrichten von der Gesellschaft der Wissenschaften zu Gottingen **26**, 98 (918).