Photoemission Spectroscopic Study of Cesium Telluride Thin Film Photocathode

H. Sugiyama, K. Ogawa, J. Azuma, K. Takahashi, and M. Kamada.
Synchrotron Light Application Center, Saga Univ.

Motivation

It has been shown that Cs_xTe_y (cesium telluride) thin film photocathodes for RF guns have a high quantum efficiency and long lifetime under the drive. In fact, Cs_xTe_y thin film photocathodes have been used as RF gun photocathodes for over 10 years[1]. Why does Cs_xTe_y thin film maintain a high quantum efficiency to a damage by a grinding ion-bonbardment under an RF high voltage ? We take up the study of Cs_xTe_y characteristics to find a strong NEA method for the first step.

[1] S. H. Kong, J. Kinross-Wright, D. C. Nguyen, and R. L. Sheffield, J. Appl. Phys. 77 (11), 6031 (1995).

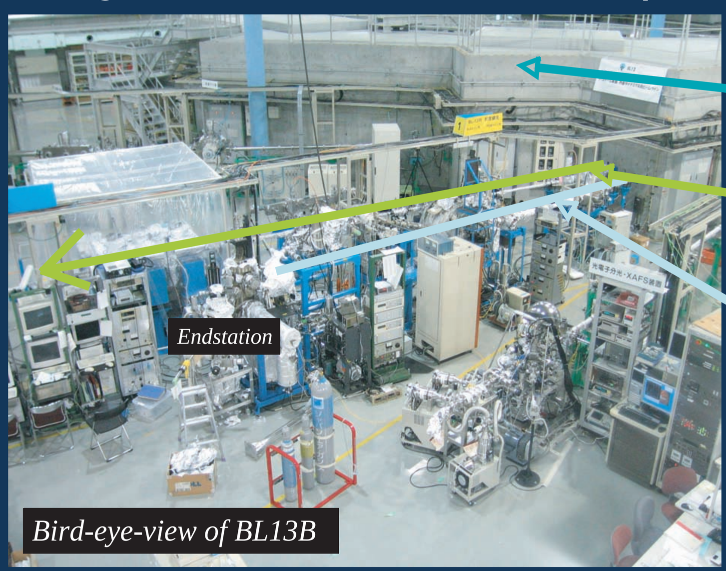
Purpose

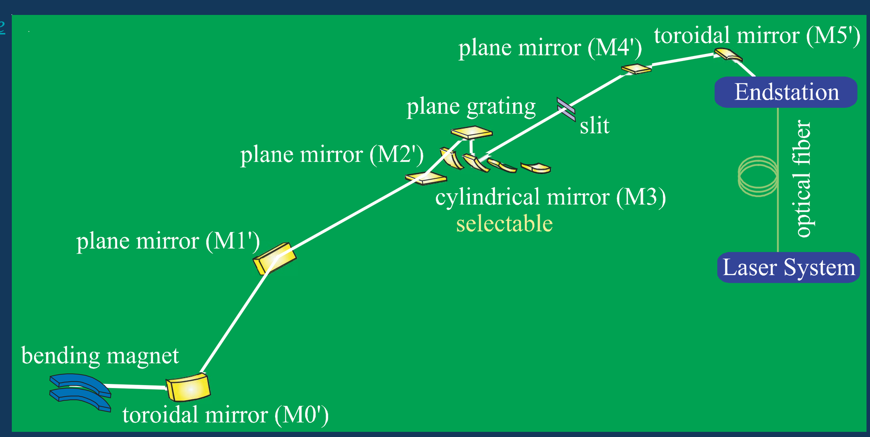
In this study, CsxTey thin films are formed by the established method with vacuum evaporation[2]. The photoemission spectroscopy of the films are measured using synchrotron radiation to focus attention on the part of secondary electrons. Those are considered the majority of photoemission to the photocathodes. The threshold energy or work function are measured from the measured spectra of secondary electrons and valence band maximum. Finally, the electron affinity of CsxTey is discussed for the purpose of this study.

[2] R. A. Powell, W. E. Spicer, G. B. Fisher, and P. Gregory, Phys. Rev. B 8, 3987 (1973).

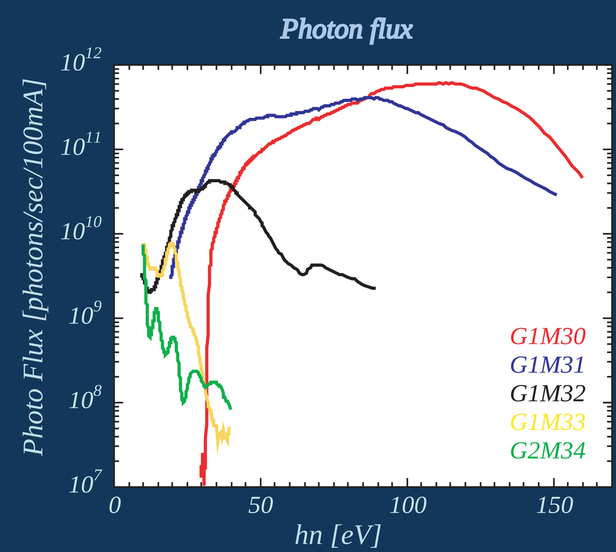
Equipment

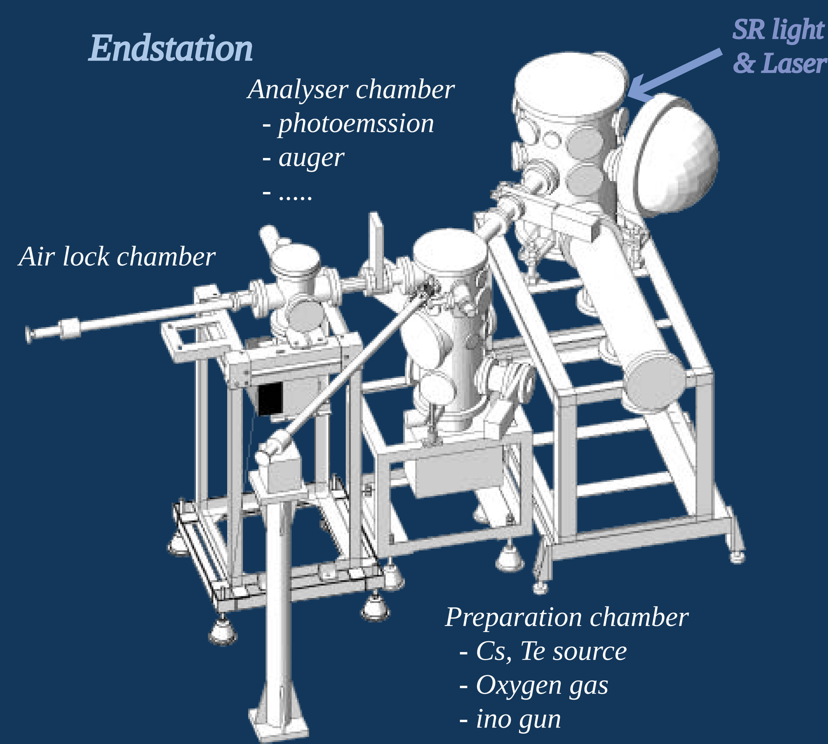
The Saga Univ.'s branch beam line : hn = few eV ~ 150 eV from bending magnet on 1.4 GeV synchrotron (SAGA-LS).



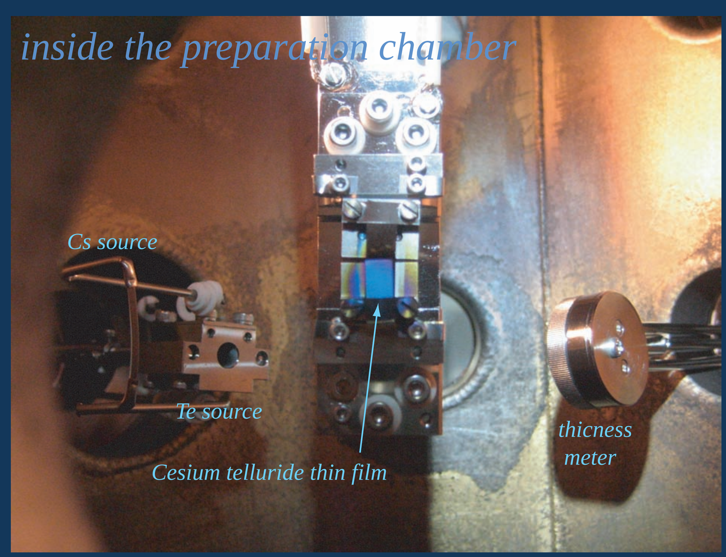


Schematic drawing of optics at the branch beam line



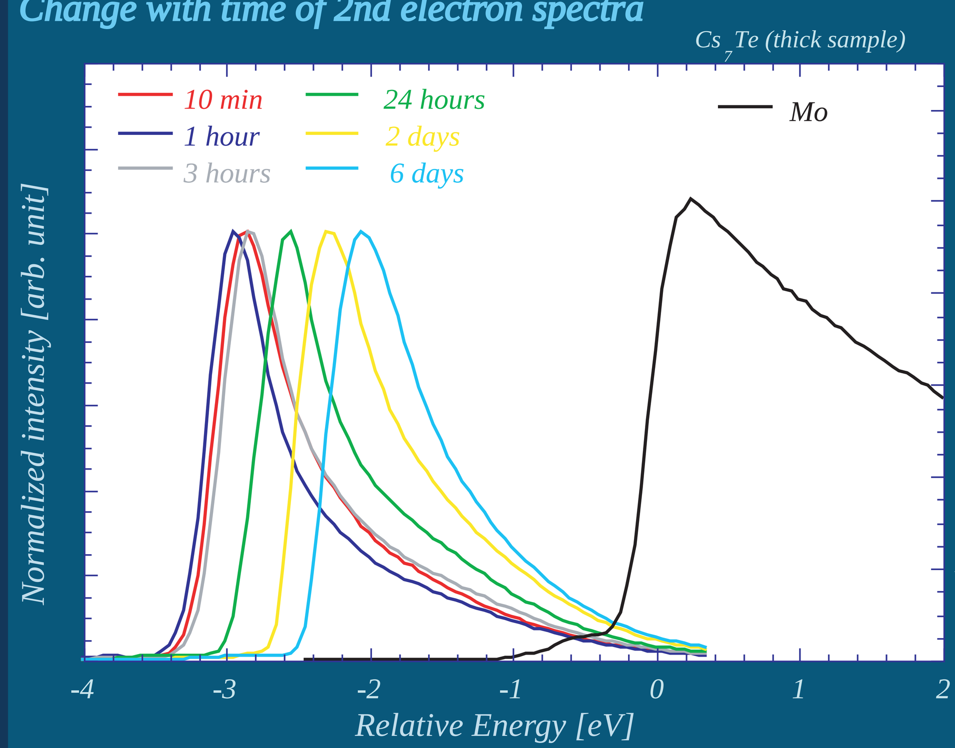


Sample preparation

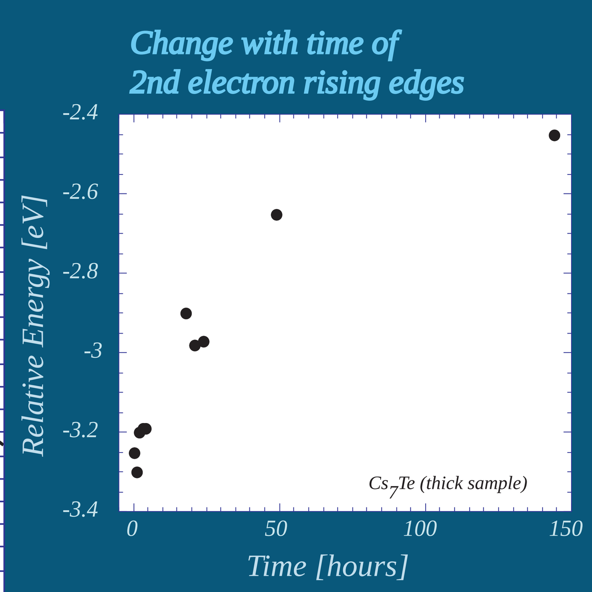


base pressure ~3×10^{-8} Pa
Mo substrate
Si heater, heating ~550℃ / 1 hour
Cs is deposited after Te deposition @RT

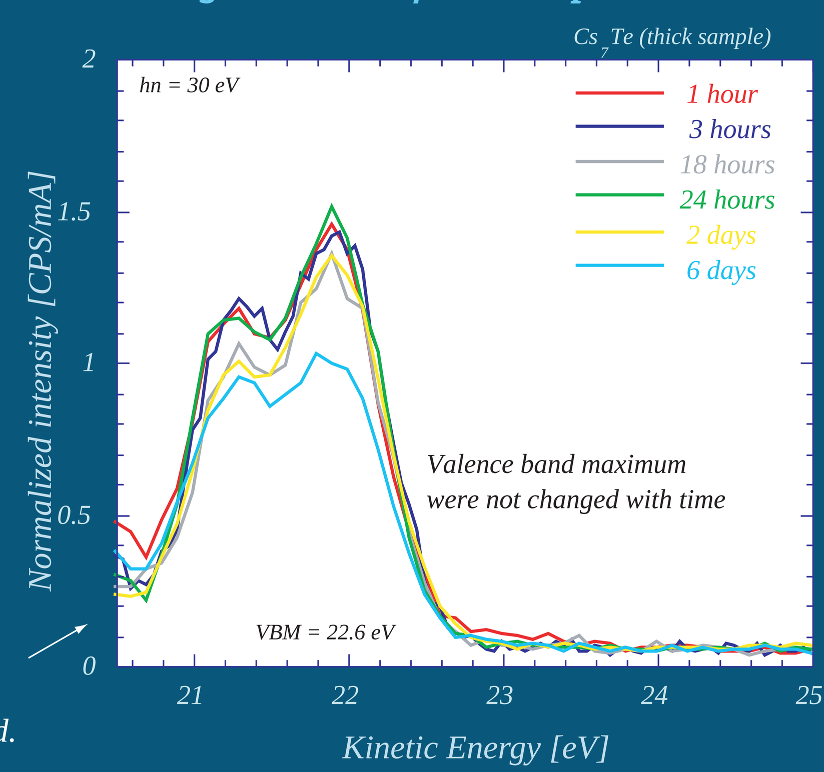
Photoelectron spectra



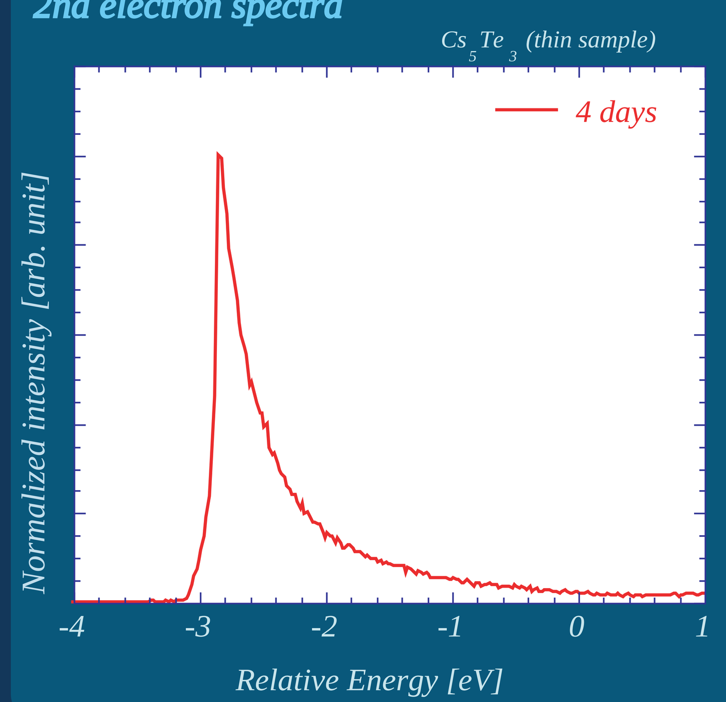
*Relative Energy is definded Kinetic Energy - bias.

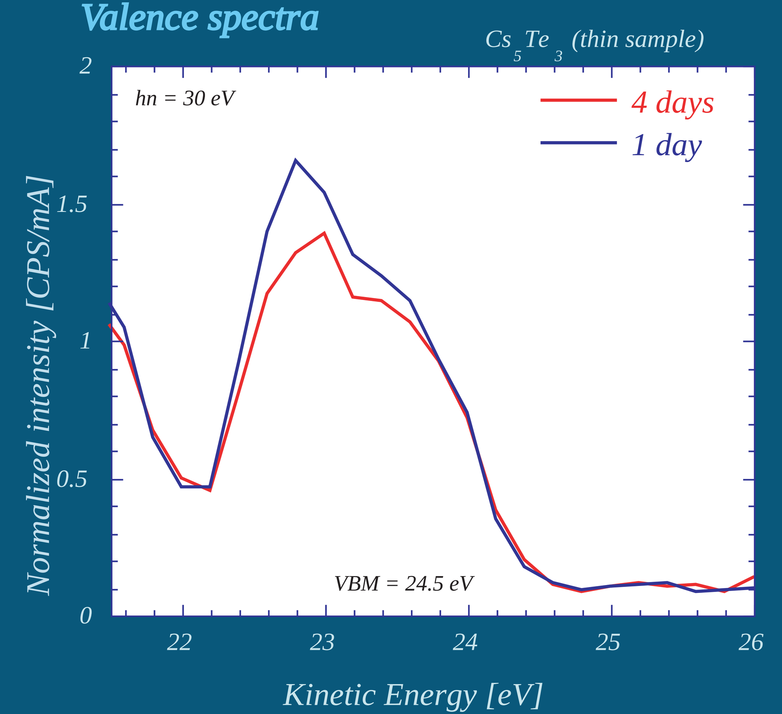


The threshold energy (Eth) was changed.

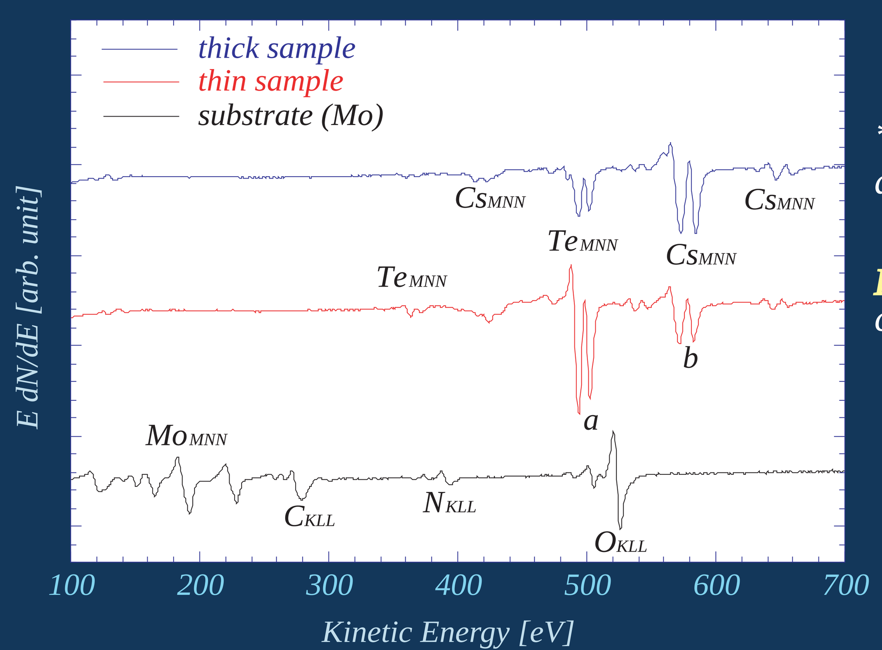


"1 hour" to "6 days" show the time from the deposition over.





Auger electron spectra

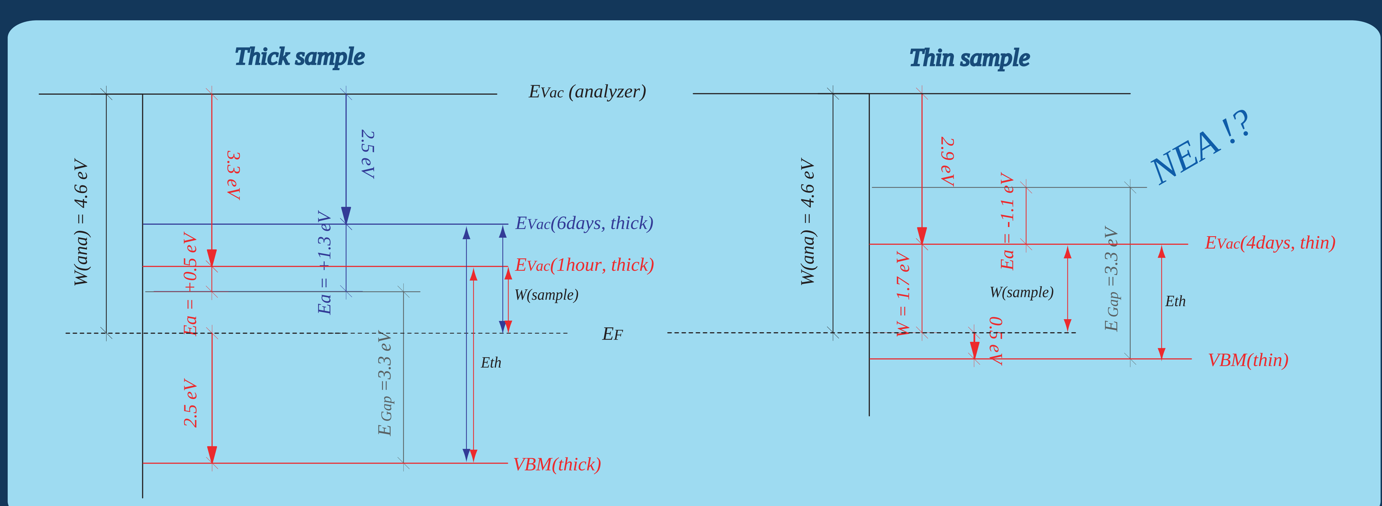


*Auger electron spectroscopy was measered after photoemission measurement was over.

Elemental ratio
cross section ratio @MNN Cs : Te ~ 1 : 5
thick sample peak ratio b : a ~ 7 : 5,
∴ x : y ~ 7 : 1
thin sample peak ratio b : a ~ 1 : 3,
∴ x : y ~ 5 : 3

Discussion

Energy diagram



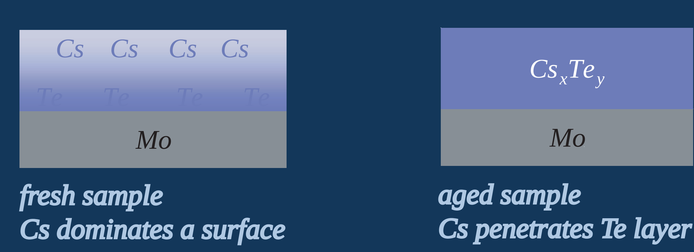
n-type ? p-type ?

Is there a vacancy formation without doping ?

Change with time

Cs is deposited after Te deposition on the fabrication method. A fresh sample has a Cs rich surface. Cs penetrates Te layer with time. Cs indicates the famous property to reduce an Ea[3].

[3] J.J. Scheer and J. van Laar, Solid State Commun. 3, 189 (1965).



The energy gap (Egap) value of the reference's 3.3 eV [2] was used.
Electron affinity (Ea) means from conduction band minimum to vacuum level (Evac).
The assumption of the constant Egap comes from the fact that VBM is not changed.

Thick sample (Cs_7Te) : **Ea were changed from 0.5 eV (1 hour) to 1.3 eV (6 days).**
Thin sample (Cs_5Te_3) : **Ea was - 1.1 eV (4 days).**

[2] R. A. Powell, W. E. Spicer, G. B. Fisher, and P. Gregory, Phys. Rev. B 8, 3987 (1973).

Summary

Cs_7Te and Cs_5Te_3 samples were fabricated by the vacuum evaporation.
The photoemission spectroscopy of Cs_7Te sample was carried out for 6 days, and the change with time were observed at the part of 2nd electrons. The Eth were changed 3.8 eV to 4.6 eV. The changes were considered as the changes of the Ea.
The photoemission spectroscopy of Cs_5Te_3 sample was carried out as a test.
The sample showed possibility NEA. The thin sample will be studied closely hence.