

PHOTOCATHODE.. what we understood

Marzo 2015



PHOTOCATHODE

The two most important persons to contact are:

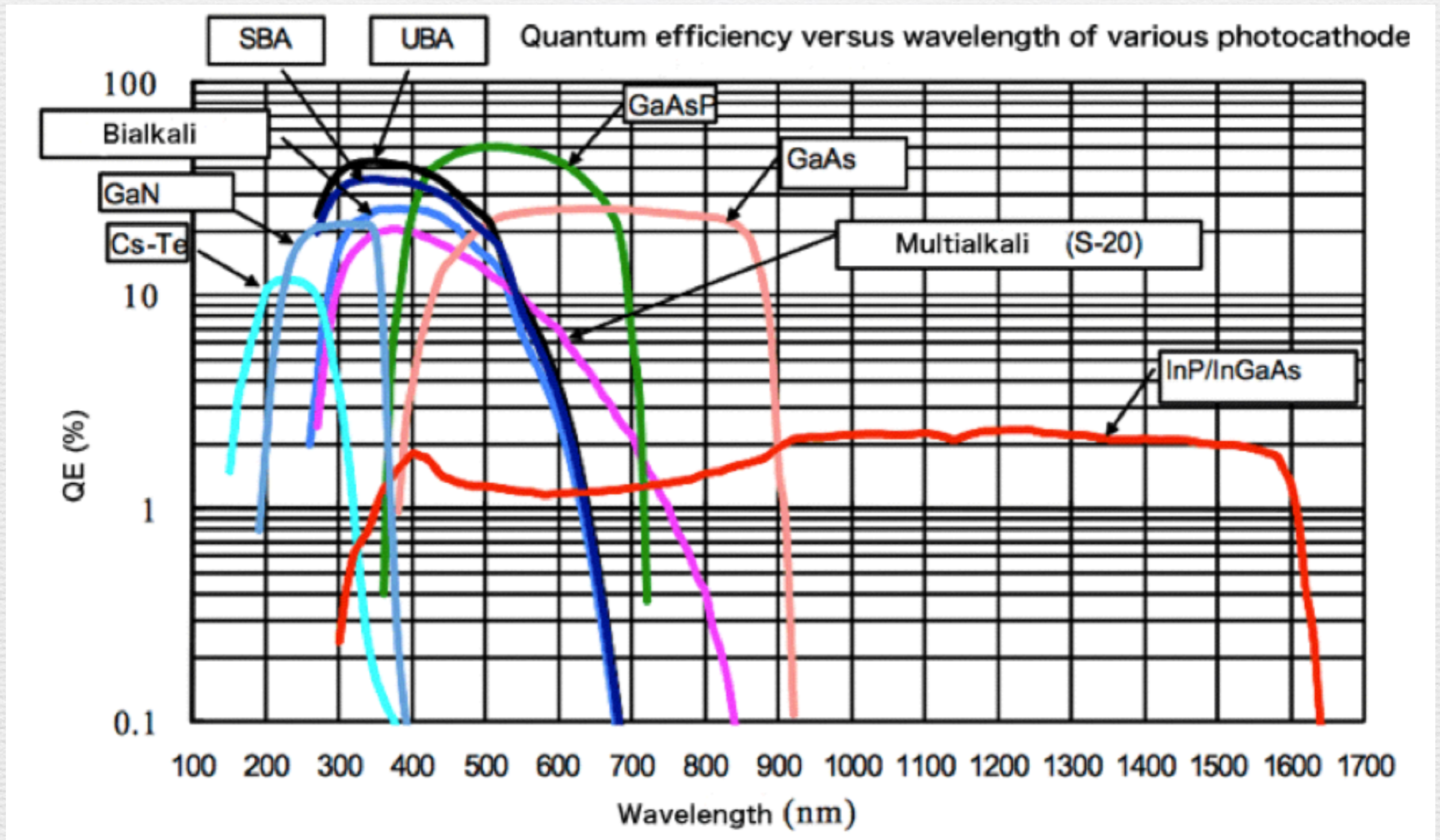
- **Breskin**

because is the most expert in bi-alkali photocathode..
and he manage to build a GEM with bi-alkali.. (I had
contact only with Alexey Lyashenk

- **Peskov**

because he used the CsSb

PHOTOCATHODE



PHOTOCATHODE

Bi-Alkali

We have built a system and developed techniques for bialkali photocathode production and their sealing in gas in an electron multiplier package. We have prepared a series of sealed bi-alkali gas photomultipliers with two Kapton GEMs. In the best case, the GPMT had a gain of 2×10^4 with Ar/CH₄ (95:5) at a pressure close to one atmosphere, with no ion-induced feedback. A photocathode sealed in a photodiode mode with Ar and no GEM is now stable for more than seven months. Gas sealed GPMTs are stable for more than two months with QE of more than 4%. The highest QE obtained for a sealed device is 13%; however, this device was stable only a few days. It is consistent with expected QE loss due to backscattering of electrons from the gas and to the high temperature of the sealing, which damages the photocathode. We developed a way to suppress ion feedback by a factor of at least 10^4 with a gating electrode, albeit at the cost of introducing some dead time on a μ s scale. However, the sealing process should still be improved. We have examined In/Bi as a lower temperature substitute to In/Sn. We have employed Cr/Cu-plated windows that appear to be superior to the currently used Cr/Ni/Au-plated ones.

Though the results reached so far are very promising, the long-term operation of visible-light GPMTs has still to be demonstrated. Important parameters yet to be measured are the behavior at high counting rates and photocathode and GEM aging. While in the short term, bi-alkali photocathodes operated with Kapton GEMs seem to be stable, GEM production from UHV-compatible insulators such as glass, ceramic and silicon is being investigated since we cannot yet exclude the possibility, that on the time scale of the years the outgassing of Kapton causes PC degradation.

IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 50, NO. 4, AUGUST 2003

Methods of Preparation and Performance of Sealed Gas Photomultipliers for Visible Light

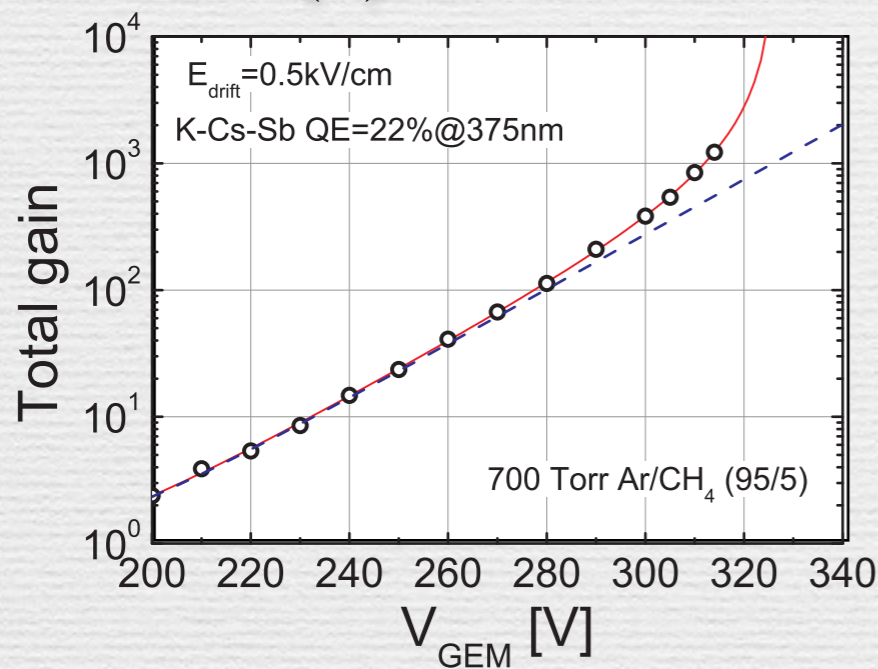
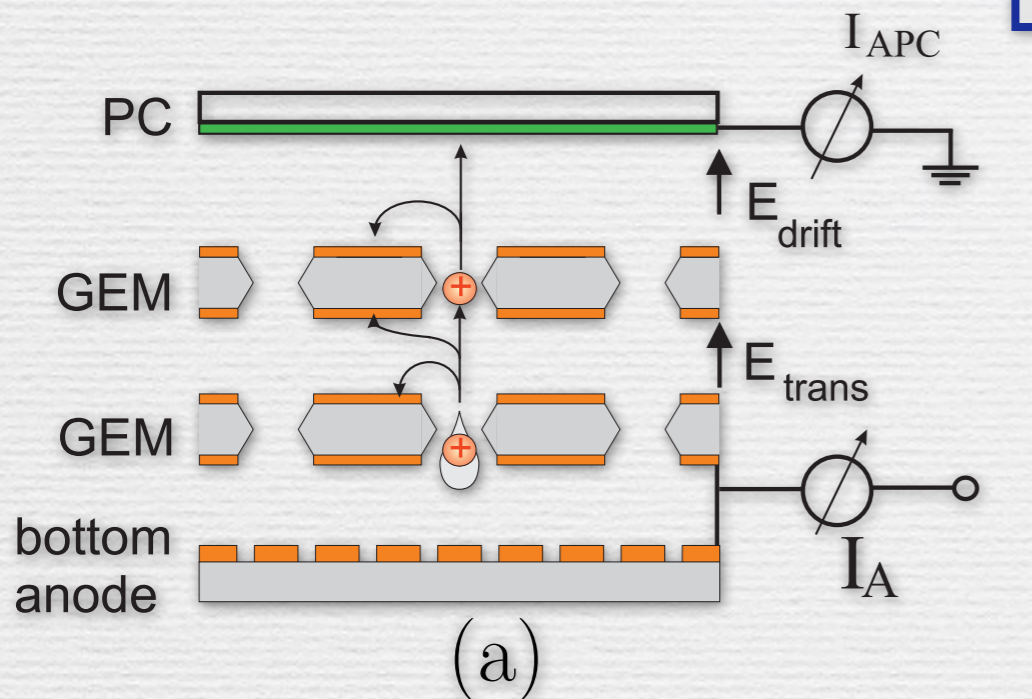
Marcin Balcerzyk, *Member, IEEE*, Dirk Mörmann, Amos Breskin, Bhartendu K. Singh, Elisabete D. C. Freitas, Rachel Chechik, Moshe Klin, and Michael Rappaport

1. Someone at one point made the setup;
2. The facility may not be alive any more;
3. The surface of the GEM were small;

[...] For further development of sealed GPDs with photocathodes for the visible range, there are several problems of both technical and physical character. In particular, the **sealing procedure** has not been developed yet, and as a result, in most cases, the K–Cs–Sb photocathode **lost efficiency due to high temperature necessary for the sealed** coupling of the package and the window. **This problem can be solved** by the transition to the sealing technology at room temperature used by a number of **companies** for production of vacuum photodetectors using the **method of photocathode transfer**.

PHOTOCATHODE

Bi-Alkali



(b)

Fig. 1. (a) A double-GEM GPM coupled to a semitransparent photocathode; (b) gain-voltage characteristics measured in this GPM (see conditions in the figure, QE refers to vacuum) with CsI (dashed) and K-Cs-Sb (open circles) photocathodes. The divergence from exponential with K-Cs-Sb is due to ion feedback.

Efficient ion blocking in gaseous detectors and its application to gas-avalanche photomultipliers sensitive in the visible-light range

A. Lyashenko^{a,*}, A. Breskin^a, R. Chechik^a, J.M.F. dos Santos^b, F.D. Amaro^b, J.F.C.A. Veloso^{b,c}

^a Department of Particle Physics, The Weizmann Institute of Science, 76100 Rehovot, Israel

^b Physics Department, University of Coimbra, 3004-516 Coimbra, Portugal

^c Physics Department, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal

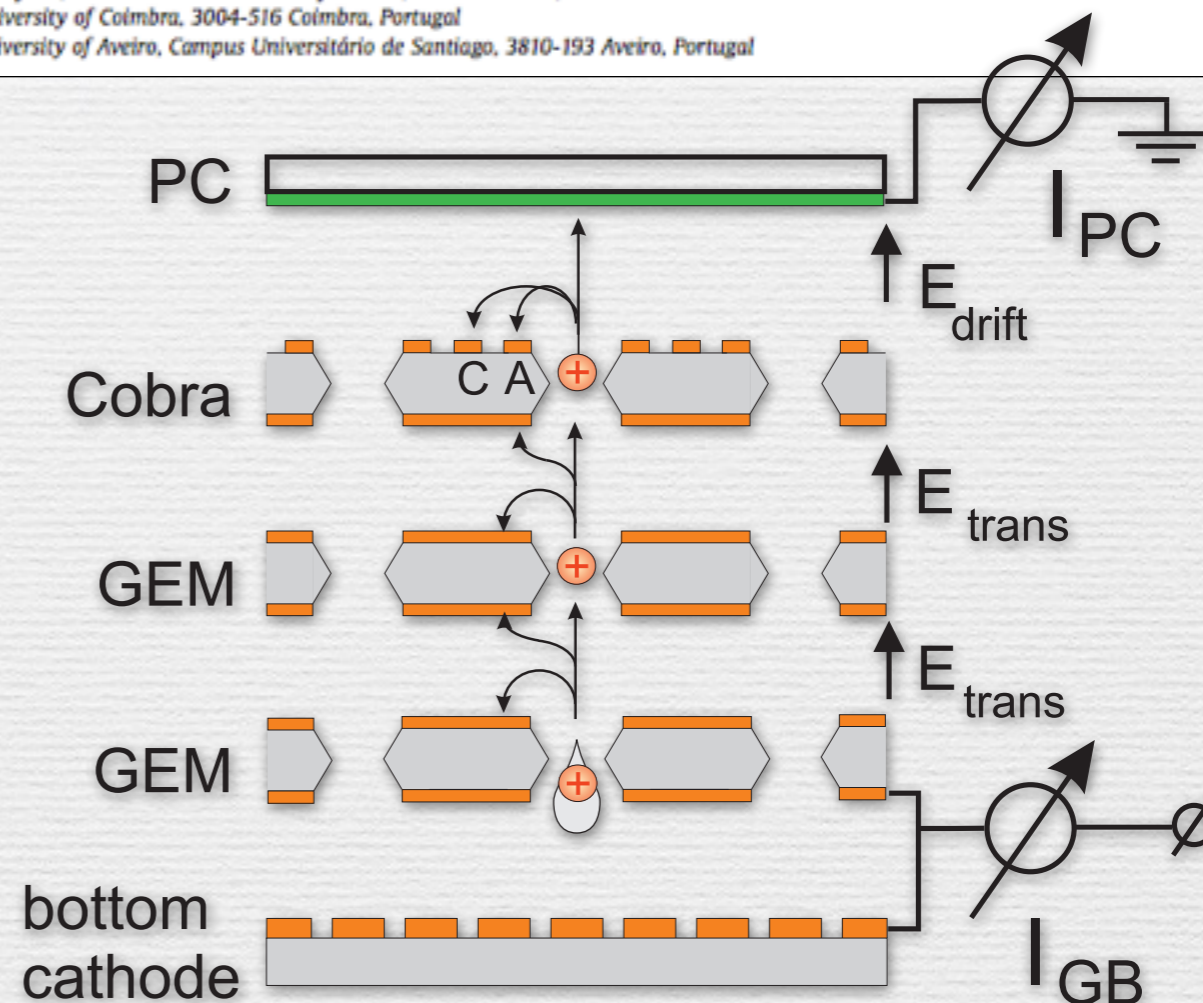


Fig. 4. (a) Scheme of cascaded Cobra/2GEM GPM with a semi-transparent photocathode; possible avalanche ions paths are also shown.

PHOTOCATHODE protective coating

Removable organic protective coating for alkali-antimonide photocathodes:

antimonide visible light photocathodes against deterioration by exposure to impurities, during handling or storage in poor vacuum or gas. The photocathodes are coated with a $\sim 1 \mu\text{m}$ vacuum-deposited hexatriacontane film (HTC) subsequently removed by low-temperature sublimation.

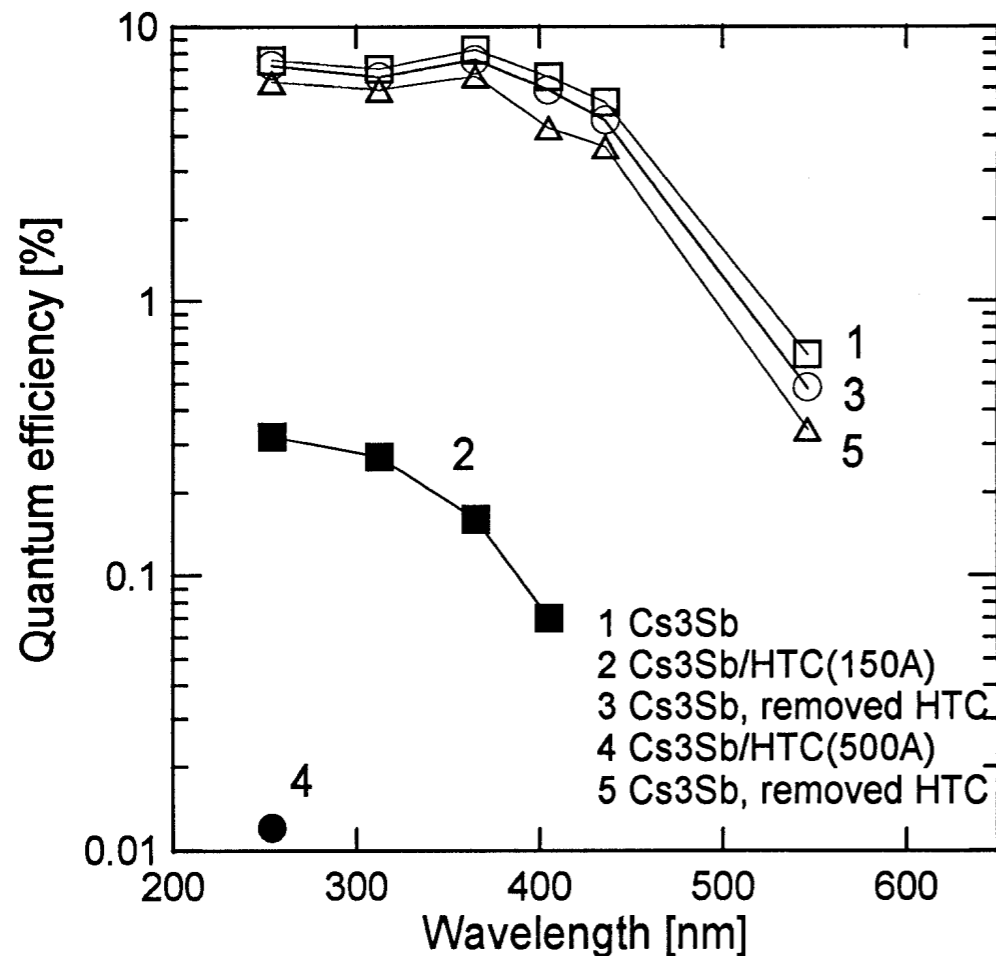


Fig. 4. Effect of two HTC deposition-and-removal cycles on the Cs_3Sb quantum efficiency, as function of wavelength, for thin (150 and 500Å) HTC films.

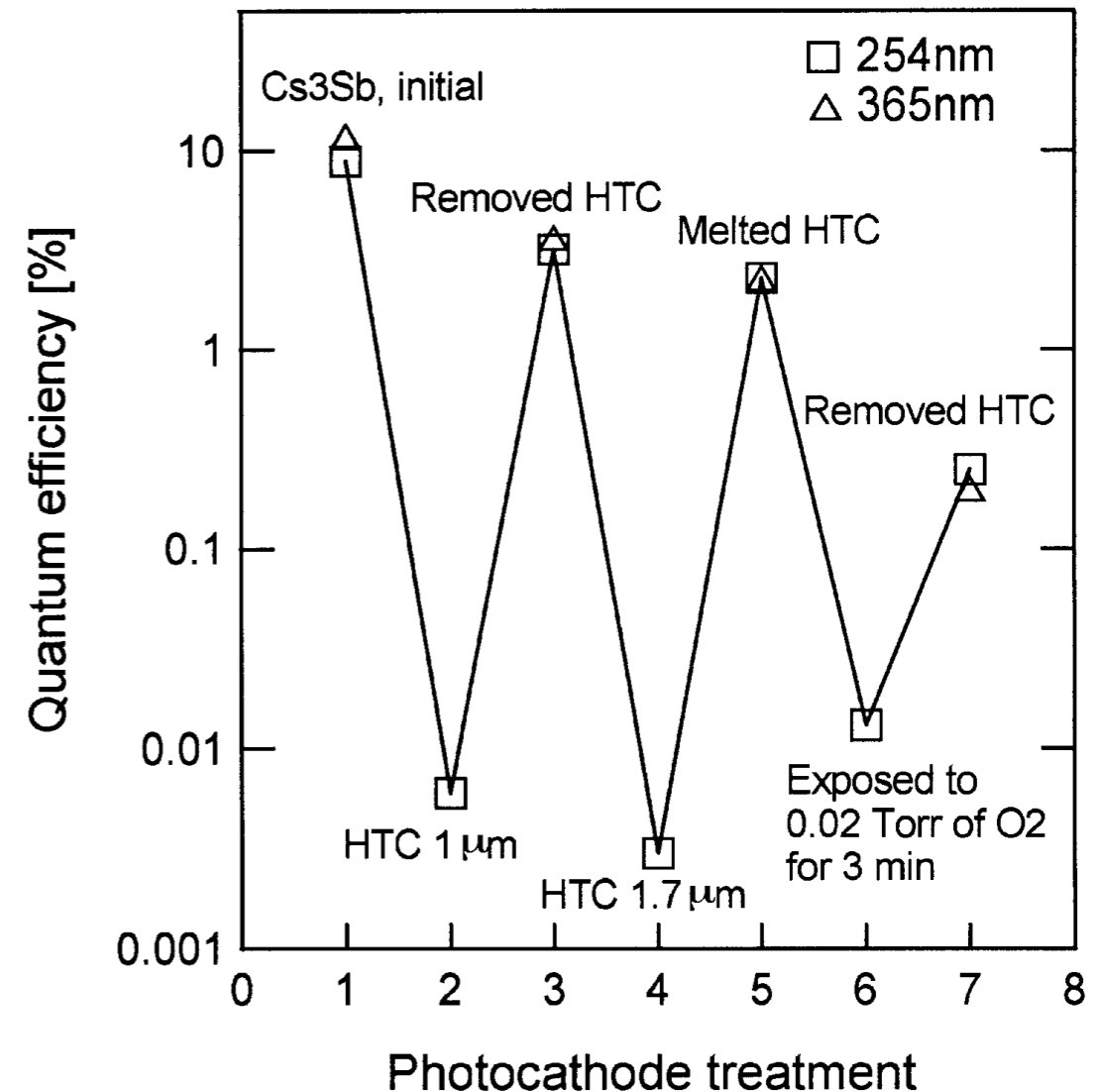


Fig. 5. Treatment of a Cs_3Sb photocathode with thick HTC films. The quantum efficiencies at 254 and 365 nm, measured after the following treatments: (1) initial Cs_3Sb deposition, (2) coating with $1 \mu\text{m}$ thick HTC, (3) HTC removal, (4) coating with $1.7 \mu\text{m}$ thick HTC, (5) HTC melting, (6) exposure to 0.02 Torr of oxygen for 3 min, (7) HTC removal, are shown.

PHOTOCATHODE

Graphene

"...the graphene serves as a transparent shield that does not inhibit photon or electron transmission but isolates the photosensitive film of the photocathode from reactive gas species, preventing contamination and yielding longer lifetime."

But I don't know so much else..

PHOTOCATHODE Cs_3Sb

Photocathodes: Cs_3Sb

Designation: S-11

Activation steps:

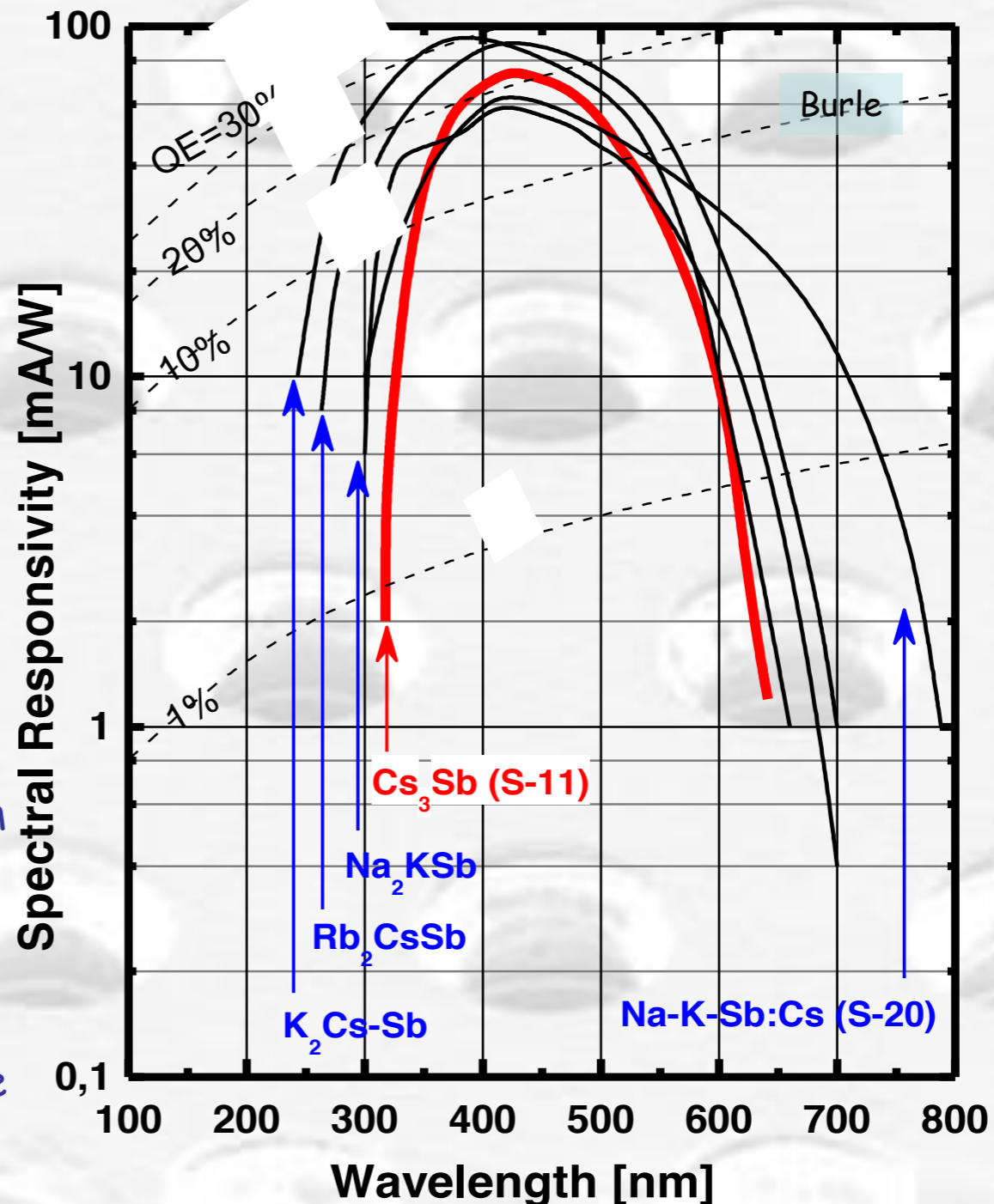
1. Evaporation of **Sb** at 180-200°C onto a substrate until it loses ~20% of its transparency
2. Exposure to **Cs** at 150-180°C until the maximum of photocurrent is reached.
3. Post-treatment if needed (removing of excess of **Cs** by baking at ~200°C)

Activation time: 30-60 min

PC characteristics (typical):

- Wavelength of max response: $\lambda_{max} = 370-400nm$
- Luminous sensitivity: 100-120 $\mu A/lm$
- Responsivity at λ_{max} : 65-75 mA/W
- QE at λ_{max} : 20-25%
- Dark emission current at 25°C: $\leq 0.1 fA/cm^2$
- Surface resistance at 25°C: $3 \cdot 10^7 Ohm/square$

Large area: YES



Alexey
Lyashenk
(Breskin)



PHOTOCATHODE Cs_3Sb

Photocathodes: Cs_3Sb

Designation: S-11

Activation steps:

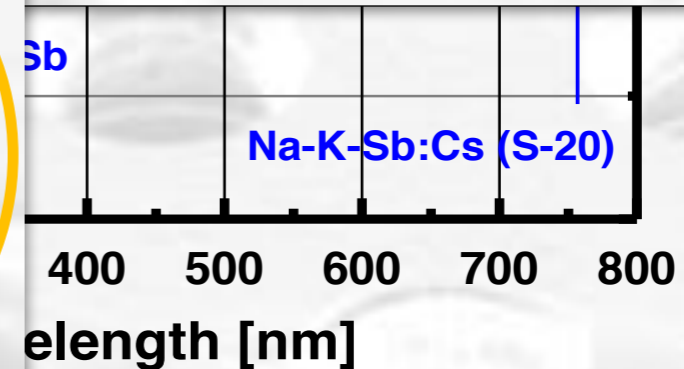
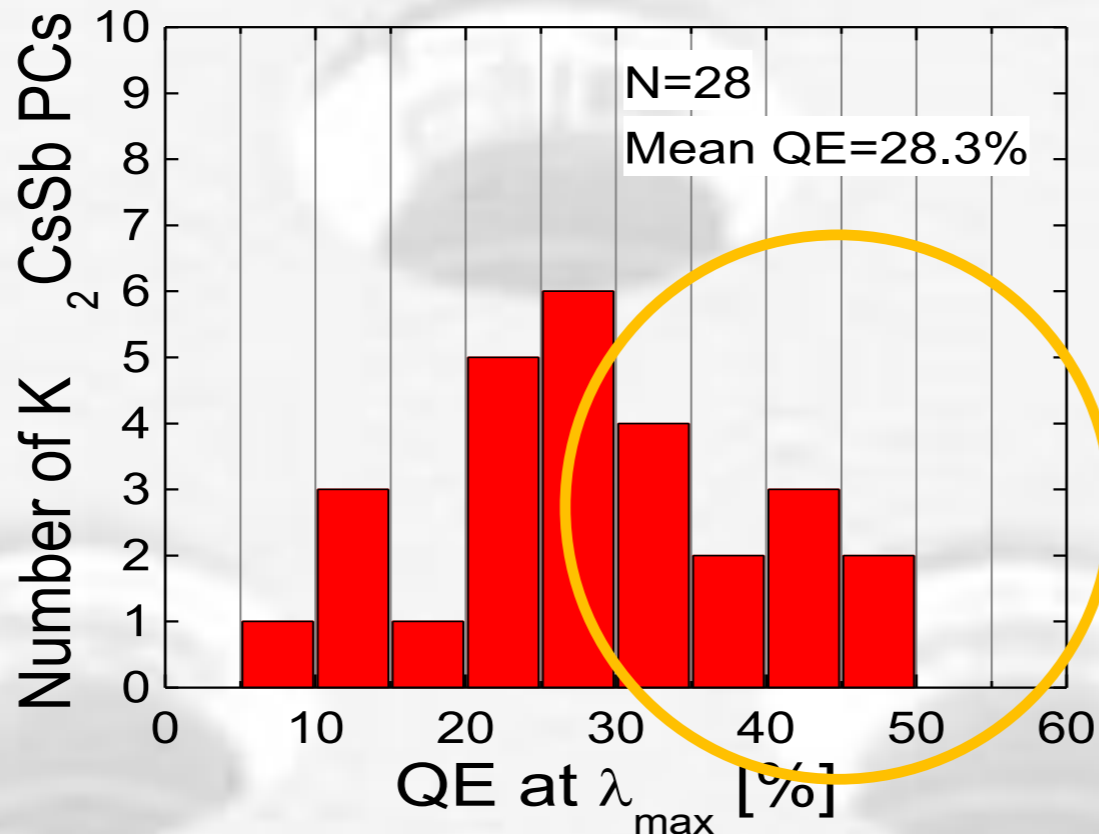
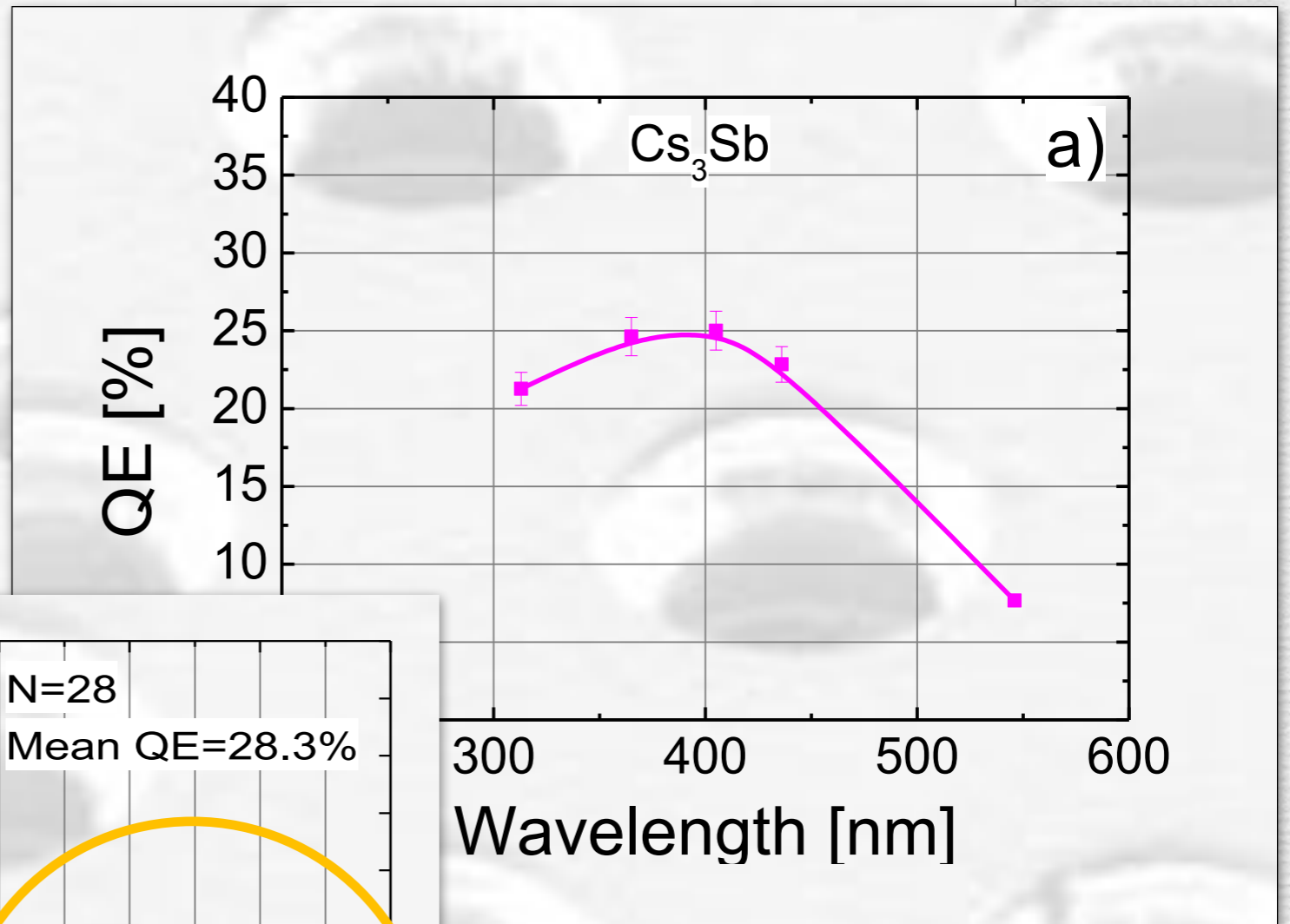
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3. Post-treatment if needed (removing of excess of **Cs** by baking at ~200°C)

Activation time:

PC characteristics (typical):

- Wavelength of max
- Luminous sensitivity
- Responsivity at λ_{max}
- QE at λ_{max} : 20-25%
- Dark emission current
- Surface resistance

Large area: γ



PHOTOCATHODE

CsSb

“It was observed earlier [11] that a rather stable operation of the SbCs and GaAs(Cs) photocathodes can be achieved in ordinary experimental conditions (initial vacuum 10^{-6} , heating only to 100C during the outgassing) with a getter inside the detector and at very low light flux (equivalent charge flux to the cathode cfA/cm^2). In our previous work [11] a Cs layer, evaporated on the glass surface, was used as a getter.

[11] V. Peskov et al., Preprint Fermilab-Conf.-93/35 1, 1993

FERMILAB-Conf.-94/140
June 1994

Gaseous detectors of ultraviolet and visible photons

V. Peskov

Fermi National Accelerator Laboratory, USA

A. Borovik-Romanov

Institute for Physical Problems, Russia

T. Volynshikova

Institute of Metallurgy and Alloys, Russia

Presented at Symposium on Radiation Measurements and Applications. May 16-19, 1994.

The University of Michigan, Ann Arbor, Michigan

PHOTOCATHODE Cs_3Sb

Lifetime test of photoemission from Cs_3Sb photocathode coated with W or Cr film

Takayoshi Kimoto^{a,*}, Yoshihiro Arai^b, Xiaobing Ren^a

A B S T R A C T

Applied Surface Science 284 (2013) 657–670

Cs_3Sb photocathodes were fabricated at 8–16 °C with sandwiched layers of Sb, Cs, and Sb deposited onto the fine tips of three cathodes at 15 °C. After examining the influence of the cathode tip temperature on the changes in the quantum efficiencies of the Cs_3Sb photocathodes during and after additional Cs depositions, we performed lifetime tests of the three Cs_3Sb photocathodes using a 405-nm semiconductor laser and 488-nm Ar ion laser. The decrease in the photocurrent with time was more rapid with the 488-nm laser irradiation than with the 405-nm laser irradiation, and continuous laser irradiation caused a much more rapid decrease in photoelectrons with time than intermittent laser irradiation did. We deposited a 0.32–0.64-nm-thick W film or a 0.43-nm-thick Cr film onto the Cs_3Sb photocathode during the lifetime test at $0.9\text{--}1.0 \times 10^{-7}$ Pa. We found that the passive WO_3 or Cr_2O_3 film, which was formed at a reduced vacuum level of 1.6×10^{-7} Pa or during the continuous 405-nm laser irradiation, increased the lifetime of the Cs_3Sb photocathode by effectively protecting its surface against oxidation and evaporation of Cs. This protection effect was most effective at approximately 90 °C.

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[..] For example, the quantum efficiency of a Cs

PHOTOCATHODE

CsSb

Photoemissive, Photoconductive, and Optical Absorption Studies of Alkali-Antimony Compounds

W. E. Spicer

Phys. Rev. 112, 114 – Published 1 October 1958

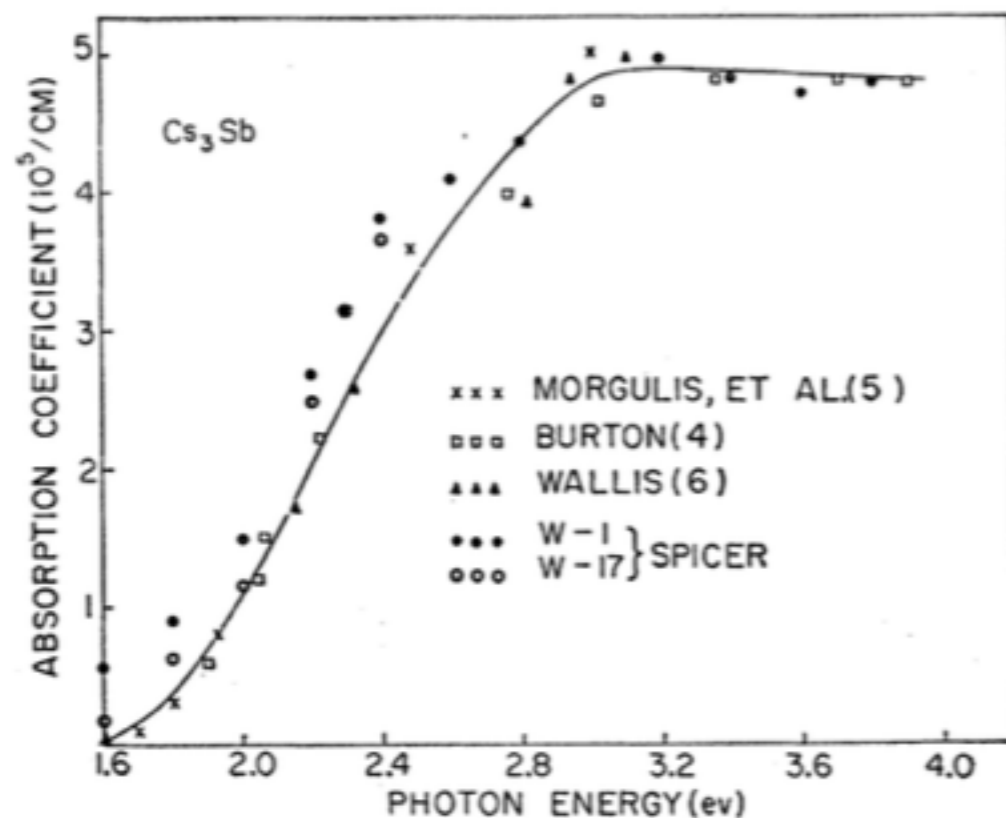


FIG. 1. Cs_3Sb absorption coefficients obtained by various workers. A coefficient of $10^5/\text{cm}$ at 3.0 eV was assumed in the present work.

TABLE I. Values for band gap (E_g) and electron affinity (E_A). Conductivity type was determined from photoemission measurements. Peak quantum efficiency was obtained from measurements on a number of samples.

Material	Type	E_g (ev)	E_A (ev)	Peak quantum efficiency measured
Na_3Sb	<i>n</i>	1.1	2.0-2.4	0.02
K_3Sb	<i>n</i>	1.1	1.1-1.8	0.07
Rb_3Sb	<i>p</i>	1.0	1.2	0.10
Cs_3Sb	<i>p</i>	1.6	0.45	0.25
$(\text{NaK})_3\text{Sb}$	<i>p</i>	1.0	1.0	0.30
$[\text{Rb}](\text{NaK})_3\text{Sb}$	not measured	1.0	0.70	...
$[\text{Cs}](\text{NaK})_3\text{Sb}$	<i>p</i>	1.0	0.55	0.40

No idea of what does means all this..

LHCb HPD

- LHCb hybrid photo-diode use a large photo-cathode;
- the fabrication of the HPD requires vacuum evaporation of the bi-alkali photocathode and the sealing of the base plate with the silicon sensor. The evaporation facility consists of a large (300 l) vacuum tank with specially tailored heating jacket, used for bake-out at 250 C, in order to reduce water vapor and to achieve $1e-9$ mbar prior to the evaporation. The vacuum quality is monitored using a residual gas analyzer for envelope cleaning via ion and electron bombardment, for Sb and K, Cs evaporation sources and for the base plate. The HPD envelope is held by a rigid support structure at the centre of the tank and is surrounded by a heating element for precision control of the envelope temperature.