Precision Measurement of CsI Quantum Efficiencies ◇

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The quantum efficiency (QE) of solid CsI photocathodes is of crucial importance for the efficient ring image recognition in Cherenkov photon detectors (RICH). QE values of CsI quoted by various groups [1] [2] and deduced from our earlier measurements [3] show variations within a factor 2. Commonly attributed to different preparation methods, these discrepancies could also result from a questionable calibration of the reference detectors used. We have started a TUM-PTB collaboration to determine precisely quantum efficiencies in the VUV and soft X - ray region applying the new electrical substitution radiometer (ESR) [4] operated by the PTB as the primary radiometric standard at the synchrotron radiation source BESSY.

GaAsP photodiodes have proven to be suitable reference detectors [4] showing negligible ageing in sensitivity. The spectral responsivity of the GaAsP diode used was calibrated with the ESR prior to and after our CsI QE-measurements. When scanning the photodiode with a 0.25 mm pinhole aperture, rather large variations of locally detected photocurrents were found. However, as the calibration with the ESR uses the full beam size ($\sim 3 \cdot 2\,mm^2$), these inhomogeneities did not severely affect the precision of the average QE determination.

Several CsI samples on stainless steel substrates were produced in our target lab and at CERN [5]. Three different techniques of vapour deposition have been applied: (I) e^- beam heating (see ref. [3]); (II) laser plasma ablation deposition [6]; (III) joulean heating (CERN samples). The samples were handled and transported in a chamber at pure argon atmosphere containing less than 1 ppm of oxygen and water. They were mounted on a target wheel together with the GaAsP diode and could be individually positioned behind a 2 mm diameter entrance aperture and a grid for application of a 100 V extraction voltage.The chamber was installed with the entrance aperture centered at the focus of the normal-incidence monochromator beamline for detector calibration in the radiometry laboratory of the PTB at BESSY. In order to avoid irradiation damage of the CsI samples, the storage ring e^- beam current was reduced to $I_{beam} \leq 80\,\mu A$ resulting in an average photocurrent of about $I_{pc} \leq 100\,pA$.

Fig. 1 shows some of the results obtained for 2 batches of samples. The QE curves show a significant dependence on the substrate temperature prior to and during evaporation with an optimum value at about $T_{substr} = 100\,^oC$ (sample 41-1). Laser plasma deposited samples reach comparable values but still lack reproducibility (samples 41-4, 48-4). No significant difference is found for e^- beam and joulean heating evaporated cathodes. Sample 41-1 has been stored for one month at purified nitrogen atmosphere and shows a considerable QE degradation of about 10%.

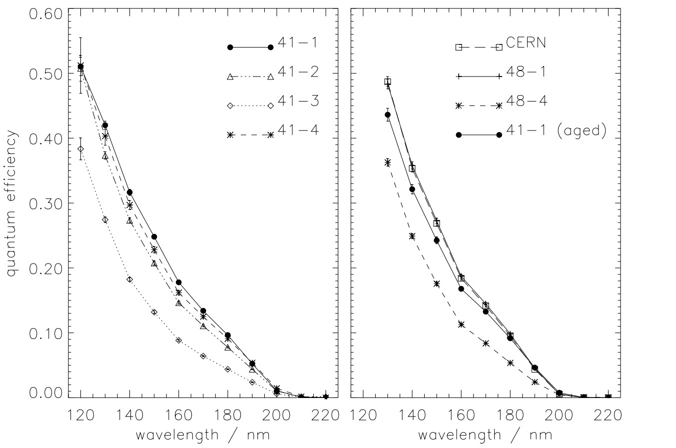

Fig. 1: Quantum efficiencies of CsI photocathodes. Samples 41-1,2,3, and 48-1: e^- beam at T_{substr} = 100, 250, 20, 250 ^oC, resp.. Samples 41-4, 48-4: laser plasma at $T_{substr} = 20\,^oC$, CERN: joulean heating.

The precision of the data for one sample is dominated by the uncertainties in the reference detector calibration (see table 1). The gross relative uncertainty obtained for the CsI QE is below 3 % in the 140 nm to 190 nm spectral range. Larger errors were obtained for $\lambda < 140\,nm$, as the available radiant power was reduced by a MgF_2-filter in the beamline, and for $\lambda > 190\,nm$ due to the low CsI-photocurrent.

♯ samples	source of error	$\Delta(QE)/QE$
1	calibration of GaAsP diode	0.7% − 1.2%
	inhomogeneity of GaAsP diode	1.5%
	variation of radiant flux	0.3%
	calibration of current meas.	0.1%
	dark current correction	≤ 0.1%
	statistics of current meas.	0.5% − 1.5%
	rel. reproduceability	1%
	total	2.1% − 2.7%
14	variation within charges	5%
	total	5.4% − 5.7%

Table 1: Contributions to the errors of the CsI quantum efficiency in the 140 nm to 190 nm spectral range.

For the first time the QE of CsI photocathodes have been determined guaranteeing traceability to a primary radiometric standard. Relative uncertainties in the few percent range constitute a significant progress. Within the spectral range of interest the uncertainty of the absolute QE values is better than 10^{-2} !!

References

[1] J. Seguinot et al., NIM **A297** (1990) 133
[2] A. Breskin et al., NIM **A360** (1995) 411 and ref. therein
[3] P. Maier-Komor et al., NIM **A362** (1995) 183
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[5] Courtesy of A. Braem, CERN
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