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Operating instructions

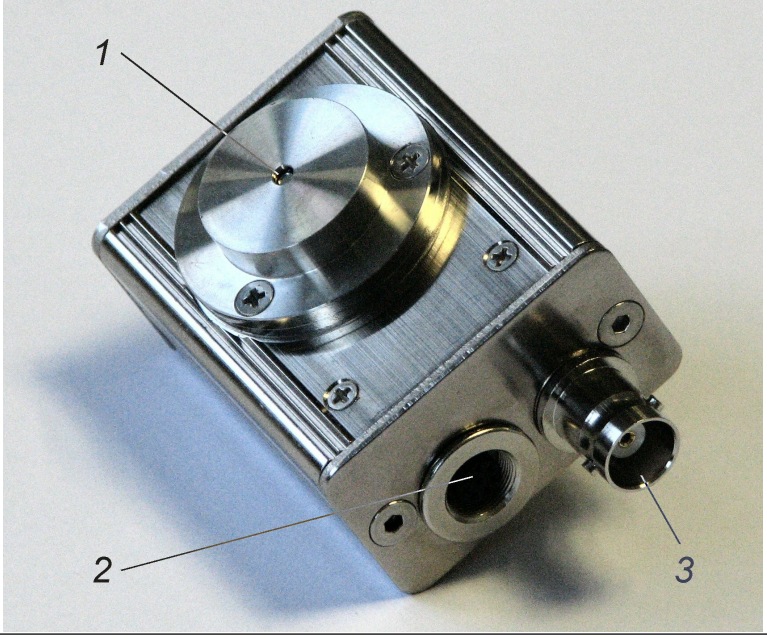

Fig. 1: 09058.30 X-ray energy detector.

CONTENTS

1 SAEFTY PRECAUTIONS

- Carefully read these operating instructions completely before operating this instrument. This is necessary to avoid damage to it, as well as for user-safety.
- Only use the instrument for the purpose for which it is intended.
- Only use the instrument in dry rooms in which there is no risk of explosion.
- Do not expose the instrument to moisture, liquids or dirt.
- Take care that the visible surface of the sensor diode is never dirtied or damaged.
- Do not touch the surface of the sensor diode with fingers or hard objects.
- Do not expose the X-ray energie detector to the direct unattenuated beam from the X-ray tube. High X-ray intensities can irreversibly damage the detector diode.
- Do not connect any equipment to the instrument other than that specified for it.

2 PURPOSE AND CHARACTERISTICS

The X-ray energy detector (Fig. 1) is part of an instrument system for generating energy spectra of ionizing radiation. This instrument system has been specifically designed for demonstration and practical work that fulfills needs in the teaching of Natural Science in schools and colleges.

The X-ray energy detector consists of a silicone p-i-n diode which has a guard ring structure and a bias of 66 V in the barrier region direction. The current that flows through the diode is amplified by a low-noise, charge sensitive amplifier (CSA) which functions according to the drain current feedback (dcf) principle.

Low energy X-ray photons have a high absorption probability in solids. Such a high intrinsic (i.e. almost non-doped, so only i-type conducting) region of the Si p-i-n diode has been chosen to ensure that an acceptable interaction probability with X-ray radiation is given.

Most X-ray photons interact with the solid by means of photoelectric effects, whereby they thereby transfer their complete pulse to an electron of the solid, predominately to one

of the valence band. When this interaction takes place within the intrinsic region, then the electron loses energy on its way through the crystal and generates, among others, electron-hole pairs until its energy is no longer sufficient to do this. The number of mobile charge carrier pairs is then proportional to the energy of the electron and so to the energy of the X-ray quantum.

The bias on the diode and on the guard ring structure of the electrodes ensure that as few as possible of these charge carriers can recombine before being drawn by the electrical field from the barrier layer to the electrodes, and also that the drift times which the charge carriers need to reach the electrodes do not differ very much from each other.

A charge pulse results that is proportional to the X-ray energy. This pulse is amplified by multi channel analyzer (MCA) 13727.99 to a signal that can be evaluated.

A small dark current always flows through the detector and is superimposed on the charge pulse. This dark current results from the heat generated by charge carriers in the intrinsic region – semiconductors are pyroconductors – and increases exponentially with the temperature. It doubles itself about every 10 K. The dark current is associated with a noise that, after amplification, can lead to unwanted signals with small pulse heights. This noise, which is superimposed on the signal looked for, interferes particularly, however, by varying the pulse height that belongs to a charge pulse of defined amount of charge – the peak in the pulse height spectrum appears to be widened. In addition, the amount of charge generated also disperses.

Both the absorption coefficient and the share of absorption by photoelectric effects increase in the direction of lower X-ray energies. Such detectors should therefore be mainly used for X-ray spectroscopy in low energy regions and with the occurrence of a large number of quanta.

3 FUNKTIONAL AND OPERATING ELEMENTS

1 *Detector diode*
Radiation inlet, sensitive surface.

2 *8-Pin-socket*
For connection of the 8-pin cable angled plug; for connection to the X-Ray-Energy Det. – socket of the MCA.

3 *BNC-socket*
For connection of the BNC cable angled plug; for connection to the input socket of the MCA or other evaluating unit.

4 *Indicator lamp (LED)*
Lights up after correct connection to the MCA, when this is switched on.

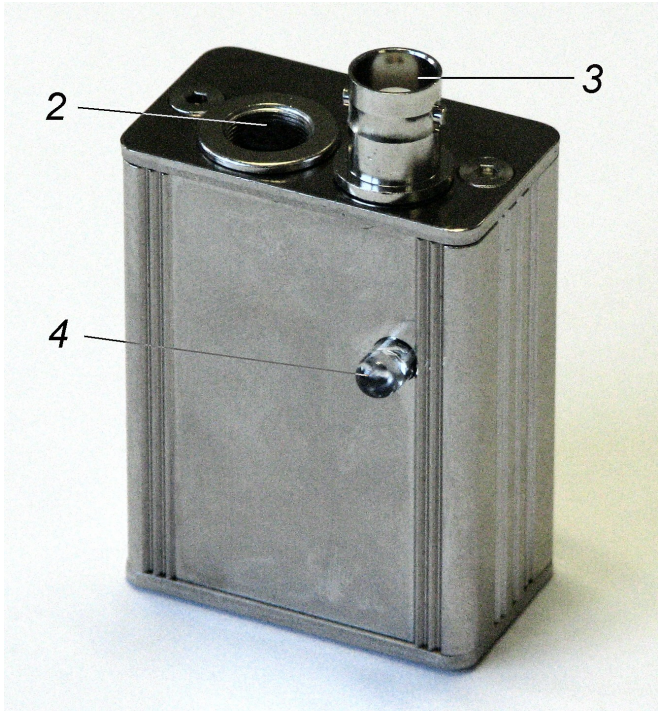

Fig. 2: Back side of the X-ray energy detector.

4 HANDLING

The X-ray energy detector has been designed for use with multi channel analyzer (MCA) 13727.99. This supplies not only the operating voltage required for the preamplifier that is integrated in the X-ray energy detector, but also the bias of 66 V for the detector diode.

The operating voltage and the bias are made available at the eight pin socket of the MCA but, as they can destroy amplifier inlets, always switch off the MCA before connecting the X-ray energy detector.

Only switch the MCA on when all cable connections have been made.

A special eight-pin cable has been prepared for the connection of X-ray energy detector 09058.30 to the MCA. This cable has an angled plug at one end and a straight plug at the other end.

When X-ray basic unit 09058.99 is to be used, first fit the cable end with the straight plug in and out through the cable passage at the back of the X-ray basic unit (see Fig. 3).

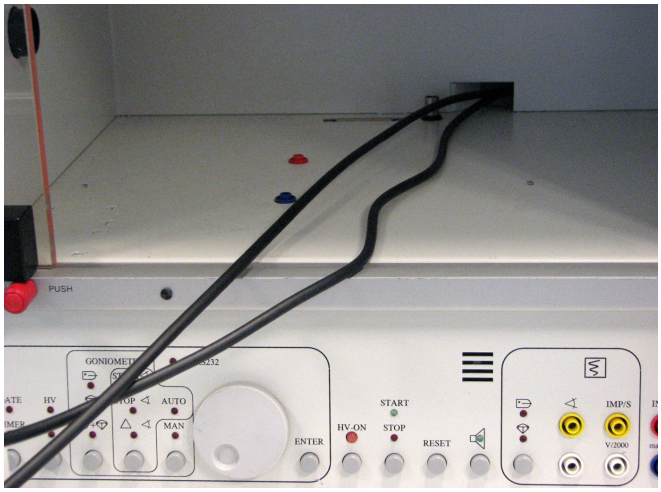

Fig. 3: The cable passage of the X-ray basic unit 09058.99.

Now prepare to plug the end of the special cable with the straight plug into 8-pin socket of the switched-off MCA, but, before plugging it in, ensure that the catch-lug is correctly positioned, then plug it in and screw the union nut tight. Now correspondingly connect the angled end to the detector. Only switch the MCA on after these connections have been properly made.

With proper connection of the detector, the indicator lamp at the back of it lights up and the required bias and operating voltages are applied to it.

The signal output of the detector is now to be connected to the MCA input using the BNC cable with the angled plug, leading it through the cable passage of the X-ray unit as described above if appropriate. Connect the angled plug to the X-ray energy detector, then connect the straight plug to the MCA.

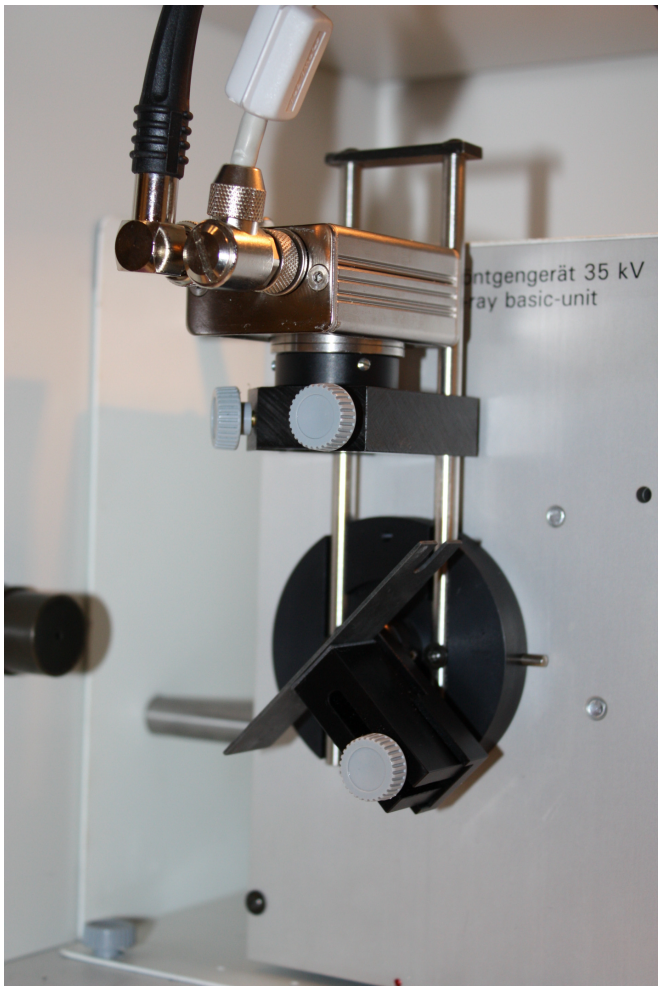

Fig. 4: Fitting the X-ray energy detector to the goniometer.

The X-ray energy detector can be fitted in the counting tube attacher of goniometer 09058.10 of the X-ray basic unit with the help of the adapter ring (Fig. 4). Secure the energy detector in the holder of the swivel arm of the goniometer. Both of the right-angle plugs should be directed towards the observer. Lay the two cables with sufficient length so that the goniometer can be swivelled freely over the entire swivelling range.

Warning! Switch the X-ray basic unit off at the mains switch at the back of it before plugging the goniometer plug in or unplugging it! When it is plugged in a switched-on condition, the instrument could be subject to damage caused by the sudden charging of the capacitors of the stepping motor.

As the energy resolution of the X-ray energy detector is dependent on the temperature, we recommend that you avoid having any unnecessary source of heat on in the set-up. The illuminating lamp in X-ray basic unit 09058.99 should therefore remain switched off.

The peak positions in the pulse height spectrum depend on the detector bias. All amplifiers exhibit a thermal drift, even when it is small. For this reason, the MCA should be switched on at least a quarter of an hour before the start of the experiment, so that all voltages and amplifications have stabilized by then and no intermingling of spectra because of peak migration occurs.

The peak positions also depend to a certain extent on the counting rate. Measurement should be made of as constant as possible high counting rates. The maximum counting rate of MCA 13727.99 is 2000 s^{-1} which should be taken into consideration and is not be exceeded.

The energy resolution is also dependent on the counting rate. Low counting rates give the highest resolution.

Caution! Never put the X-ray energy detector into the direct unattenuated beam of the X-ray tube. The detector is intended for taking up fluorescent, diffracted or scattered X-rays. It is not intended for X-rays of high intensity which may be present in the direct beam from an X-ray tube. High intensity X-rays may damage the detector diode crystal irreversibly increasing the electric conductance of the crystal. This will increase dark current and detector noise. The noise from dark current limits the energy resolution of the detector which will be degraded if the crystal gatheres radiation damages. The MCA does not correctly process counting rates exceeding 2000 counts per second so using high intensities is useless.

5 TECHNICAL SPECIFICATIONS

Sensitive surface	0,5 mm^2
Bias	66 V
Preamplifier supply	+5 V, -5 V, 30 mA max.
Measurement range	2 keV ... 58 keV
Energy resolution	400 eV (FWHM) bei 5.9 keV
Dimensions	76 mm x 42 mm x 38 mm
Weight	91 g
Maximum counting rate	20000 cps

6 EXTENT OF DELIVERY

X-Ray energy detector in a housing with preamplifier
8-Pin cable with angled plug
BNC Cable with angled plug
Adapter ring for the counting tube attach of the goniometer

7 MATERIAL

X-ray basic unit, 35 kV	09058.99
Plug-in Cu tube for x-ray unit	09058.50
Goniometer for x-ray unit 35 kV	09058.10
Multi Channel Analyzer - Extended Version	13727.99
Software Multi-Channel-Analyzer	14452.61

8 NOTE ON THE GUARANTEE

We guarantee the instrument supplied by us for a period of 24 months within the EU, or for 12 months outside of the EU. Excepted from the guarantee are damages that result from disregarding the Operating Instructions, from improper handling of the instrument or from natural wear.

The manufacturer can only be held responsible for the function and technical safety characteristics of the instrument, when maintenance, repairs and alterations to the instrument

are only carried out by the manufacturer or by personnel who have been explicitly authorized by him to do so

9 WASTE DISPOSAL

The packaging consists predominately of environmentally compatible materials that can be passed on for disposal by the local recycling service.

Should you no longer require this product, do not dispose of it with the household refuse. Please return it to the address below for proper waste disposal.

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