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ÖSSBAUER SPECTROMETER BASED ON PERSONAL COMPUTER EQUIPPED WITH THE $YAlO_3$:Ce SCINTILLATION CRYSTAL[1]

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A simple Mössbauer spectrometer based on a personal computer is described in the paper. The spectrometer is characterised by application of a mini transducer, a scintillation detector with $YAlO_3$:Ce crystal and data acquisition via the interrupt channel of the computer.

The system consists of a personal computer with 4 MB RAM, 170 MB hard disk, uble floppy disk drive, printer, colour monitor with the VGA graphic adapter, and data acquisition system. A velocity generator, driving unit with mini velocity transcer, scintillation detector, high voltage power supply, single channel analyser and ounting bench are included that have been manufactured in our laboratories.

Mössbauer spectra of 128, 256, 512, 1024 or 2048 channels can be accumulated the constant acceleration or constant velocity modes. Pulse height spectra can be llected in 64, 128 or 256 channels in the energy window scanning mode. The shape d amplitude of the velocity signal, the energy window of the single channel analyser, d the high voltage at the scintillation detector are controlled by a computer. The aximum input count rate is 10 MHz and the channel capacity is $2^{32} - 1$ counts.

Software is capable of the following. The programs can be run independently of e data acquisition because the data accumulation is performed by the interrupt chanl. The TURBO ASSEMBLER 3.2 language was used to write the resident interrupt ogram MOSSDRV that is used to accumulate spectra. The operator communicates ith the spectrometer via the main program MOSS that is written in the BORLAND ASCAL 7.0 language.

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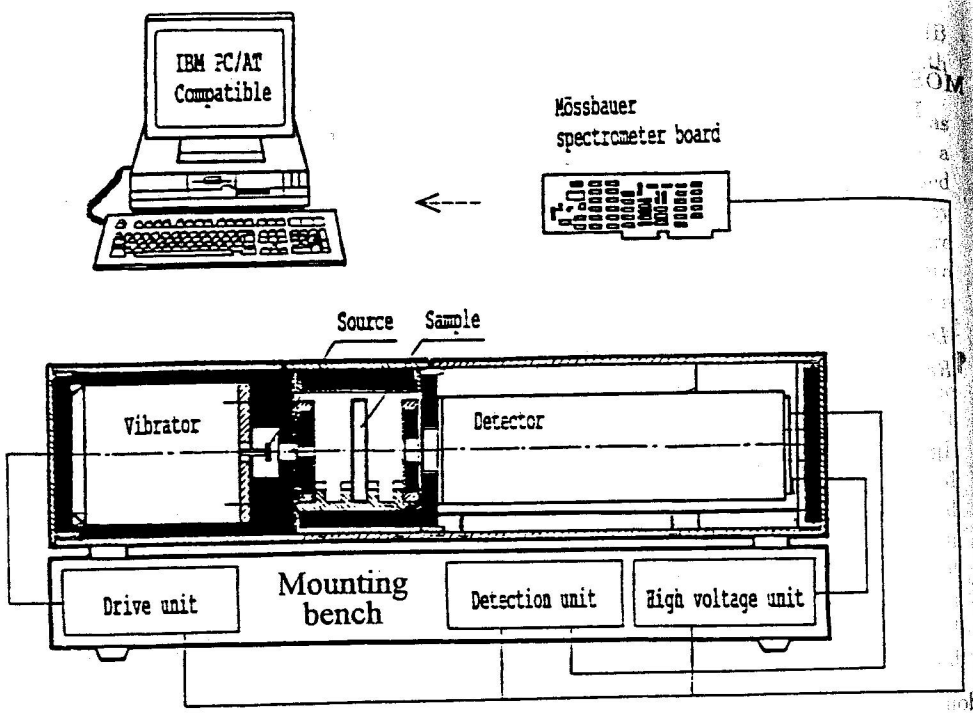

Fig. 1. Schematic drawing of the mounting bench.

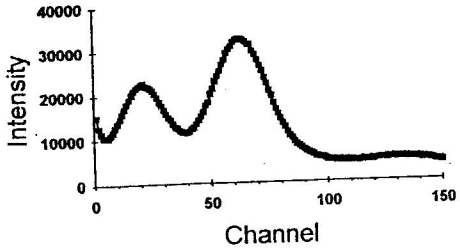

Fig. 2. Pulse height spectrum of gamma-radiation from a ^{57}Co source measured by a $YAlO_3$:Ce scintillator. Size 25x0.35 mm. Photomultiplier FEU-85.

The block diagram of the spectrometer is shown in Fig. 1. The mini transducer, scintillation detector, source and absorber are placed in the metallic tube (diameter 65 mm, length 300 mm) on the mounting bench. A transducer control unit, single channel analyser, amplifier and the high voltage power supply are located in the base of the mounting bench.

The driving system consists of an electromechanical mini transducer, an electronic

peak number	non-linearity [%]
1	-0.066
2	0.028
3	0.066
4	0.009
5	0.009
6	-0.047

Table 1. Estimated non-linearity of the driving system.

Table 2. Comparison of the YAlO3:Ce and NaI(Tl) scintillators.

Parameter	$YAlO_3$:Ce	NAI(Tl)
Effective atomic number	36	50
Density ρ [g/cm^3]	5.55	3.67
Scintillation efficiency [%]	40	100
Optical refractive index	1.94	1.85
Emission spectral maximum λ [nm]	347	410
Decay time τ [ns]	25± 2	230
Light output temperature coefficient T = 300K [%/K]	0.39	0.22÷ 0.95
Hardness [Mho]	8.5	2
Melting point [°C]	185	651
Hygroscopic	no	yes

control system and a digital reference velocity generator. The mini transducer [1] of the double-loudspeaker type is characterised by low dimensions (diameter 48 mm, length 62 mm) and low weight (360 g). The weight of the driving rod is 6.5 g . The barium ferrite magnets are used in the transducer. A driving coil is made of copper wire (diameter 0.07 mm) and its resistance is about 50 Ω. The velocity pickup coil is made of 0.05 mm diameter copper wire (the resistance of the velocity pickup coil is about 240 Ω). Polyamide threads are used as the suspension springs leading to the absence of parasitic resonance. The resonance frequency of mini transducer is about 45 Hz.

The main parameter characterising the Mössbauer spectrometer quality (particularly the driving system) is the non-linearity of the velocity scale. Results of the non-linearity study are shown in Table 1. The six lines of α-Fe experimental spectrum were approximated by the Lorentzian functions and the non-linearity of all lines has been calculated by means of the least squares method fitting the following function

$$\mathrm{non}(i) = \frac{x(i) - av(i) - b}{v(6) - v(1)}$$

where i (= 1 to 6), $x(i)$, $v(i)$, a, b are line number, experimental position of the line, theoretical position of the line and parameters from least square method, respectively.

The yttrium - aluminium perovskite crystal doped with cerium ($YAlO_3$:Ce or YAP) grown by the Czochralsky method, is used as scintillation detector. Adequate physical and chemical properties, relatively low cost of the components and well-developed

technology make it rather promising as a detector of ionising radiation [2]. Scintill
characteristics of $YAlO_3$:Ce in comparison with NaI(Tl) are show in the Table 2.
can see that $YAlO_3$:Ce has a decay time that is one order of magnitude shorter
that of NaI(Tl), and therefore this allows for rather high counting rates. The sc
lator thickness was optimised for ^{57}Co and ^{119}Sn sources and it equals 0.35 mm.
efficiency ratio for two detectors [3] is

$$\frac{Q_1}{Q_2} = \frac{\eta_1}{\eta_2}\frac{I_{01}}{I_{02}}\frac{1+1/S_2}{1+1/S_2}$$

where η is the counting efficiency of the detector for Mössbauer radiation within
selected energy window, I_0 is the intensity of the Mössbauer line in the solid
of acceptance, $S = \eta I_0 \exp(-\mu\rho)/I_b$ stands for a "spectroscopic selectivity". Her
stands for the background count rate from the non-resonant γ-quanta and μ stand
the mass absorption coefficient of the resonant radiation and ρ describes density o
scintillator. Calculations and measurements give the counting efficiency of 80 %
the selectivity $S \cong 3-4$ for 0.35 mm thickness $YAlO_3$:Ce scintillator in the case of
keV ^{57}Co radiation and the efficiency ratio $Q_{YAP}/Q_{NaI(Tl)} \approx 7$.

The photomultiplier FEU-85 is used in the scintillation detector [4]. The ph
cathode diameter of the photomultiplier is 25 mm, the number of dynodes is 11
its spectral characteristic is of the S6 type. A high speed amplifier and a high s
amplitude selector were made for detector with $YAlO_3$:Ce crystal [5]. The pulse he
spectrum of ^{57}Co source is shown in Fig. 2. The intensity of 6.3 keV peak X-ray
left one) has been decreased by the 1.5 mm organic glass absorber.

The above described Mössbauer spectrometer based on personal computer is a
cost spectrometer, that can be used in research and teaching laboratories and in
trial applications as well.

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