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APPARATUS FOR PHASE TRANSFORMATION STUDY

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ABSTRACT

An apparatus has been developed for studying physical parameters of solids over a wide range of temperatures and magnetic fields and for carring out the thermal differential analysis. The apparatus is composed of an electronic measuring system and measuring cells (for specific application). The electronic measuring system consists of a commutator of measuring signals (CMS), two digital voltmeters (DV), a measurment control block, thermoregulators for keeping adiabatic conditions while measuring thermal values and a block connecting digital voltmeters with a printer or a micro-computer (DV-interface).

INTRODUCTION

The measurement of temperature dependences of physical parameters by conventional methods /1/ is usually time-consuming. It concerns, especially, the substances with phase transformations which are to be recorded. Here we report an experimental set up that provides investigation of temperature dependences of different physical parameters of materials with both continued variations of temperature and discrete temperature intervals to be made. The utilization of the micro-computer permits to perform the analysis of the obtained results and to eliminate possible measuring errors.

MEASURING SYSTEM

The set up consists of the electronic measuring system /2/ and measuring cells for specific applications. The operation procedure of electronic measuring system is as follows.

The timer of DV-interface (1, Fig.1) produces trigger pulses "beginning of the cycle". This pulse permits transmission of data acceptance sync pulses (DAP) to the CMS-switching pulses shaper (2) and transmits to CMS (3) control input. Thereby CMS switches from initial 00 channel to 01 channel and the measured signals of this channel transmit to DV (4,5) inputs. After switching CMS shapes the pulse which transmits to DV-triggering circuit (6). This

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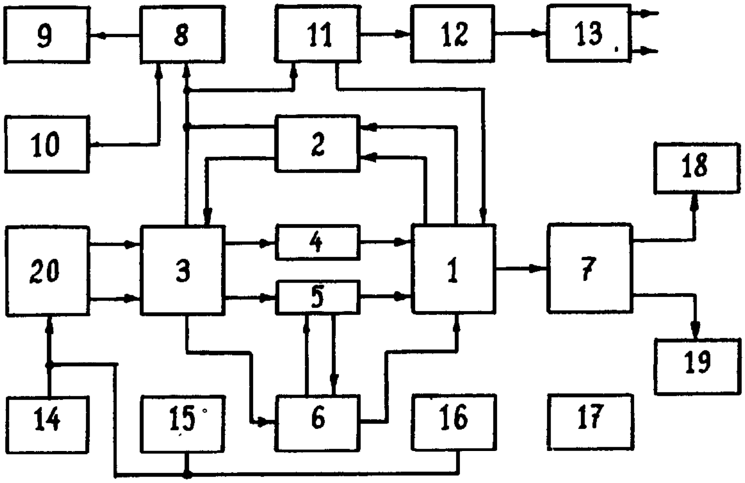

Fig. 1

circuits produces a series of pulses necessary for switching limits of DV and for measurment. On finishing the measurment DV shape pulses that switch circuit 6 over to the initial stste and this circuit shapes the pulse "end of measurment". The pulse passes through the DV-interface to the micro-computer and the data are introduced into the computer from DV. After the data input the micro-computer shapes the DAP pulse that while transmitting to circuit 2 switches CMS over to the next channel and the process of measurment is reiterated. Upon measuring the signals of all the channels CMS switches to the initial 00 channel and shapes the pulse "end of the cycle" that forbids the transmission of DAP pulses through circuit 2. This pulse transmits also to circuit of carrying in the current (8) and this circuit increases the current of the measuring cell current source (9). When the temperature of the measuring cell reaches the given value current throw off circuit (10) turns off the current of measuring cell heaters.

The system also includes: magnetic field switch-on circuit (11), scanning block of magnetic field (12) and current supply (13) necessary for investigation of the parameters in a magnetic field, as well as specimen current source (14), thermometers current source (15), thermoregulator block, power supply of the electronic system (17). The data introduced into micro-computer is processed and extracted to recorder (18), printer (19) and puncher.

Switching field (20) is employed for connecting of different measuring cells.

The apparatus enables to investigate the temperature changes of heat release and heat absorption during thermal differential analysis as well as temperature dependences of thermal conductivity, thermopower, the Hall potential difference, magnetoresistance measured in longitudinal and transverse magnetic fields up to 5 Tesla, etc. Adiabatic conditions in the measuring cell are kept using the system of thermal screens and block of precision thermoregulators /3/.

RESULTS

Fig. 2 gives a thermogram of $CuInSe_2$ ternary semiconducting compound recorded with the apparatus. The crystals were obtained by a vertical Bridgman technique. The phase composition was checked by X-ray and chemical analyses. At 1259 K the compound starts to melt and at 1083 K there is a phase transition due to polymorphous transformation of the chalcopyrite crystal lattice to sphalerite structure /4/.

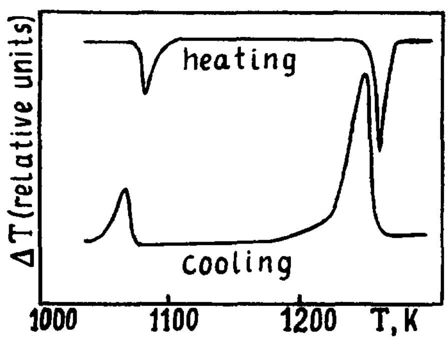

Fig.2

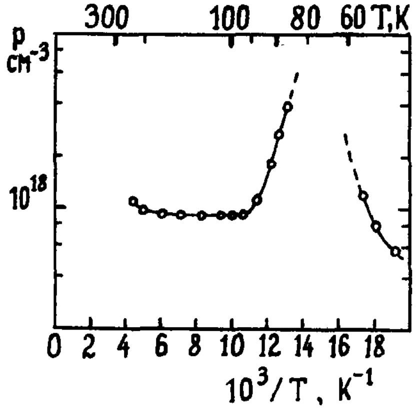

Fig.3

Fig.3 shows the concentration dependences of charge carriers (holes) on reciprocal temperatures for $CuInSe_2$ compound in the low temperature range obtained using the above mentioned apparatus. With temperature decreasing to 80 K the concentration of p changes insignificantly and with further temperature decrease an anomaly is observed. The anomaly in the range 60-80 K is probably due to the fact that at these temperatures the linear expansion coefficient of the crystal lattice parameters becomes negative /5/. In such a case the tetragonal distortion of crystal lattice changes and perhaps the rearrangement of energy bands of the compound occurs. It is also possible that the anomalous behaviour results from a strong interaction of the charge carriers with phonons that gives negative contribution to the Grüneizen parameter /5/. The change of hole scattering mechanisms in the anomaly range is clearly seen from the temperature dependence of their mobility μ in Fig.4. At $T > 100$ K the charge carrier scattering on ionized impurity takes place since $\mu \sim T^{3/2}$. At $T \simeq 80$ K the mobility drops to values lower 0.1 cm^2/V sec and at $T \simeq 60$ K μ starts to rise sharply what indicates the change of scattering mechanism of holes. At $T < 20$ K $\mu \sim T^{1/2}$, consequently the mechanism of charge carriers interactions with acoustic phonons is dominating. The singularity of the behaviour of μ in the range 20-30 K is probably due to the fact that linear expansion coefficient becomes positive again.

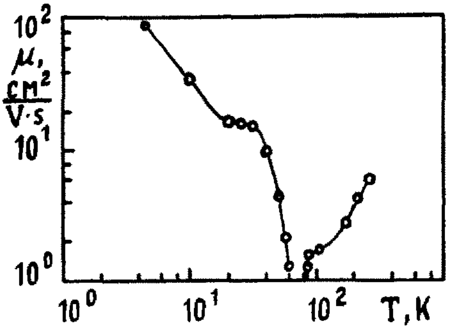

Fig.4

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