These methods for measuring the thermal conductivity coefficient of semiconductor specimens can be used in industrial conditions for rapid determination of the thermal conductivity coefficients of large numbers of semiconductor stages directly in the process of thermobattery construction.

NOTATION

T, temperature, K; κ, thermal conductivity coefficient, $W \cdot m^{-1} \cdot K^{-1}$; α, heat liberation coefficient, $W \cdot m^{-2} \cdot K^{-1}$; Q, thermal flux, W; ℓ, length, m; D, diameter, m; $p = a D$, perimeter ($a = 4$ for square sections, $a = \pi$ for round sections); $s = bD^2$, area, m^2; ($b = 1$ for square sections, $b = \pi/4$ for round sections); x, coordinate, m. Subscripts: m, medium; sp, specimen; ref, reference.

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MEASURED SPECIFIC HEATS OF HEXAN-1-OL AND 3-METHYL-2-BUTANOL OVER WIDE TEMPERATURE RANGES

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The specific heat c_p has been measured for hexan-1-ol and 3-methyl-2-butanol at 227-363 and 218-371 K correspondingly. The measurements for the first are compared with data from other sources.

Various industrial tasks can be handled more efficiently from reliable data on the specific heats of important liquids such as n-alcohols and iso-alcohols, which can also provide more economical organization in the chemical, medical, and perfumery industries.

Table 1 collects the measurements on the specific heat of hexan-1-ol in the liquid state at or near atmospheric pressure. Below 290 K, the experimental c_p in [1] are lower than those in [2] by from 2.3 to 5.6%. Above 290 K, the [3-11] data are in agreement within the over-all error (±2.4%) of the independent measurements [4, 5].

There are no published c_p for liquid isoamyl alcohol (3-methyl-2-butanol).

We have measured c_p for hexan-1-ol at 227-363 K and for 3-methyl-2-butanol between 218 and 371 K for the liquids in equilibrium with the saturated vapor. The substances were of 99.9% purity. The c_p were measured by stepswise heating in an adiabatic calorimeter (temperature step about 4-5 K), which was made by the Khabarovski branch of the All-Union Technical Physics and Electronics Research Institute. The apparatus and methods have been described in detail [12, 13].

One determines c_p from a known mass of material and known heat equivalent for the empty calorimeter by measuring the amount of heat supplied to the calorimeter together with the

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TABLE 1. Papers on Specific-Heat Measurement for Liquid Hexan-1-ol

Source	Year	% main component	Temperature, K	Method	Error, %
Kelley	1929	99,5	229—290	Adiabatic calorimeter	±1,0
Hutchisson, Bailey	1959	Not stated	298,15	Mixing calorimeter	Not stated
Kalinowska, Woycicka	1973	>99.5	303,15	»	»
Grigor'ev, Yanin, Rastorguev	1979	Pure	304—385	Adiabatic calorimeter	±0,9
Arutyunyan	1981	AR	293—393	Mixing calorimeter	±1,5
Kalinowska, Woycicka	1984	>99,9	229—301	Adiabatic calorimeter	Not stated
Bravo, Pintos, Baluja	1984	>99,0	298,15	Mixing calorimeter	»
Zegers, Somsen	1984	99,5	298,15	»	»
Costas, Patterson	1985	98,0	283—313	»	»
Tanaka, Toyama, Murakami	1986	98,0	298,15	»	»
Vasely et al.	1989	99,95	298—318	»	±0,5

initial and final temperatures. The temperature sensor was a TSPN-2A platinum resistance thermometer (R_0 = 100.267 absolute Ω, α = 0.003925), which was made and calibrated at the All-Union Technical Physics and Electronics Research Institute. The temperatures were calculated from the SSR-64 standard table for 12-273.15 K [14] with supplementation of SST-64 for the range 273-373 K with appropriate corrections. The error in measuring the temperature was ±0.01 K. Tables 2 and 3 give the measured c_p. The maximum relative error in measuring c_p with fiducial probability 0.95 is ±0.5%. Least-squares fitting gave the following equations:

hexan-1-ol

$$c_p = 2{,}37095 - 0{,}851173\cdot 10^{-1}(T/100) - 0{,}195794\,(T/100)^2 - 0{,}639224\cdot 10^{-2}(T/100)^3 + 0{,}530459\cdot 10^{-1}(T/100)^4 - 0{,}859433\cdot 10^{-2}(T/100)^5 \qquad (1)$$

and 3-methyl-2-butanol

$$c_p = 4{,}81853 - 3{,}12708\,(T/100) + 0{,}182356\,(T/100)^2 + 0{,}484126\,(T/100)^3 - 0{,}905712\cdot 10^{-1}(T/100)^4, \qquad (2)$$

in which c_p is in kJ/(kg·K) and T is in K.

The standard deviations of the measurements from the equations were 0.14% for hexyl alcohol and 0.34% for 3-methyl-2-butanol. Equation (1) describes the input data with deviations not exceeding the errors of experiment.

Figure 1 shows c_p = f(T) from (1) together with the various measurements. Above 280 K, our values agree well with the c_p from [1, 3-11], while the divergence of the [3, 4, 8, 11] and [1, 5, 9] measurements from (1) does not exceed ±0.5 or ±1.8% correspondingly, while the [6, 7, 10] results are too low by up to 0.8%. The [1, 2] measurements may be compared with (1); the [1] c_p at 230-271 K are too low by 2.7-4.6%, while the [2] data for 229-301 K are too high by from 0.5 to 2.7%. Such discrepancies probably occur because of systematic

TABLE 2. Specific Heat c_p for Liquid Hexan-1-ol in kJ/(kg·K)

T, K	c_p	T, K	c_p
227,31	1,98	290,82	2,31
231,84	2,00	303,78	2,43
237,03	2,02	310,34	2,47
242,21	2,03	315,49	2,52
245,64	2,05	328,10	2,64
250,05	2,07	332,96	2,68
252,27	2,08	342,64	2,78
264,00	2,13	347,97	2,82
270,85	2,19	357,53	2,93
274,16	2,20	362,57	2,96

TABLE 3. Specific Heat c_p for Liquid 3-Methyl-2-Butanol in kJ/(kg·K)

T, K	c_p	T, K	c_p
218,38	1,86	286,49	2,66
224,68	1,91	294,41	2,77
234,21	1,99	300,22	2,84
238,27	2,03	304,97	2,90
241,53	2,05	311,54	2,96
242,61	2,07	317,66	3,02
244,84	2,09	327,92	3,11
245,90	2,11	332,36	3,15
249,08	2,14	342,04	3,20
253,66	2,20	346,37	3,23
257,76	2,26	353,03	3,27
261,79	2,33	357,31	3,28
267,67	2,37	364,44	3,31
271,55	2,44	370,68	3,33
281,42	2,59		

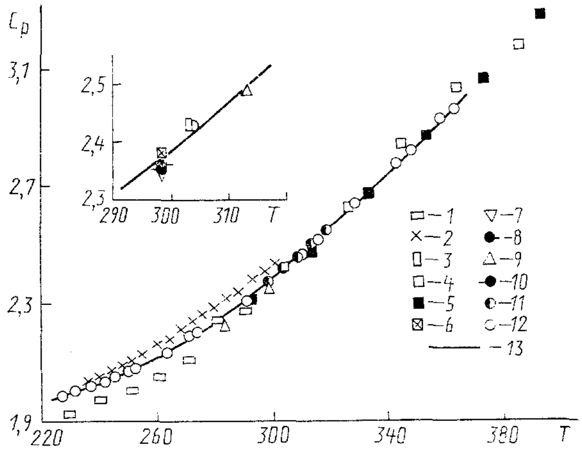

Fig. 1. Temperature dependence of the specific heat for liquid hexan-1-ol. Measurements: 1) [1]; 2) [2]; 3) [3]; 4) [4]; 5) [5]; 6) [6]; 7) [7]; 8) [8]; 9) [9]; 10) [10]; 11) [11]; 12) this study; 13) (1) approximation; c_p in kJ/(kg·K).

errors in measuring c_p in [1, 2]. For example, in [1, 15], the temperature measurements are estimated as having been made with an error of 0.05 K. It is found in [2] that the temperatures for the start and end of the heating steps at 229-273 K were determined from the temperature dependence of the resistance thermometer, while those above 273 K were derived by extrapolation. We consider that this is a cause of the discrepancy between our data and [1, 2].

The c_p measurements for 3-methyl-2-butanol can be compared only with calculations [16] for 293-453 K, where the error is estimated as not exceeding ±4%, which are based on calculated c_v from the method given by Sakiadis and Coates [17] together with measured bulk expansion coefficients and speeds of sound for the liquid. Above 293 K, the [16] values are lower than orus by 3-9.4%, and lower than the [5] values by 4.5-12.2% or the [6] ones by 2.6-13.4%. Those discrepancies are probably due to error in the [16] method for calculating c_v, since it is known [18] that the approach gives only approximate results.

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EFFECTIVE CONDUCTIVITY OF MATRIX COMPOSITES

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The effective-field method is generalized to the problem of the conductivity of microhomogeneous media having a random structure, with allowance for the binary interaction of inclusions. The calculations of the effective conductivity by various methods are compared with experiments on the electrical and moisture conductivity of composites.

Determining the relation between the macroscopic properties of a material and its microscopic structure is a very important problem of physics and mechanics. This pertains to the transport properties of microinhomogeneous media, corresponding to processes of heat and mass transfer, the electric conductivity and permeance, and filtration of a Newtonian liquid in undeformable cracked-porous media [1-4]. The equations describing the steady-state conditions of these processes are mathematically equivalent. If the linear scale of the field of the average motive force of the transfer process in a heterogeneous medium consisting of a homogeneous matrix with randomly distributed inclusions is substantially greater than the characteristic size of the inclusions, it is natural to describe the transfer process within the framework of the continuum approximation. It is then sufficient to use the effective conductivity coefficients (such as the coefficients of thermal conductivity and diffusion, electrical conductivity, dielectric constant, permeance, Darcy's constant, etc.) for the medium as a whole.

Four groups of methods for determining the effective coefficients are known. The first group is that of model treatments, replacing the real stochastic structure of composites by a regular structure [5] or some particular cases of random structures [6]; percolation models, in particular, belong to this group [7]. The perturbation method [3, 4] gives correct results when the differences in the conduction coefficients of the ocmponents of a composite are small. The variational method [8, 9] is invariant under randomly oriented inclusions and gives too wide a spread of estimates of the effective properties for highly inhomogeneous materials. The fourth group consists of methods based on expressing the solution of the steady-state transfer equation with random rapidly oscillating coefficients in terms of the Green's function of the analogous equation for a homogeneous medium. Depending

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