substance: Eu_3S_4
property: crystal structure, physical properties

crystal structure	cubic (Th_3P_4-type, $T_d^6 - I\bar{4}3d$)			
lattice parameters				
a	8.533(1) Å			67B
	8.534 (3) Å			77E
	8.527 (5) Å			78P
melting point				
T_m	1600...2500°C			77E
density				
d	6.27 g cm^{-3}			77E, 78P
phonon wavenumbers				
$(\nu/c)_{LO}$	300 cm^{-1}		Raman scattering	77V
$(\nu/c)_{TO}$	250 cm^{-1}			
energy gap				
E_g	1.7 eV		optical absorption edge	76V
activation energy				
E_A	0.22 (1) eV		from conductivity	67B
	0.32(1) eV	T < 186 K	from conductivity	83P
	0.160(5) eV	T > 186 K		
	0.21(1) eV	T < 175 K	from conductivity; endothermic DTA	70H
	0.163(4) eV	T > 175 K	transition at 170 K	
resistivity				
ρ	100 Ω cm		E_A = 0.18 eV	76B

Figures and further references:

phase transition at 182 K [83P, 82W]

thermal expansion: Fig. 1

photoluminescence: Figs. 2, 3

resistivity, Seebeck coefficient: Figs. 4...7

Raman scattering: Figs. 8...10

heat capacity: Figs. 11, 12

mixed valence [80H, 80W, 80M, 81R]

References:

67B Berkooz, O., Malamud, M., Shtrikman, S.: Solid State Commun. 6 (1967) 185.
70H Henderson, J. R. Muramato, M., Gruber, J. B., Menzel, R.: J. Chem. Phys. 52 (1970) 2311.
76B Batlogg, B., Kaldis, E., Wachter, P.: J. Magn. Magn. Mater. 3 (1976) 96.
76M Massenet, O., Coey, J. M. D., Holtzberg, F.: J. Phys. (Paris) 37 Collq. (1976) C4297.
76V Vitins, J., Wachter, P.: Phys. Lett. 58A (1976) 275.
77E Eliseeu, A. A., Sadovskaya, O. A.: Izv. Akad. Nauk SSSR, Neorg. Mater. 13 (1977) 1394.
77V Vitins, J., Wachter, P.: Phys. Rev. B 15 (1977) 3225.
78P Palazzi, M., Jadmes, S.: Mater. Res. Bull. 13 (1978) 1153.
80H Holtzberg, F.: Phil. Mag. B 42 (1980) 491.
80M Morán-López, J. L., Schlottmann, P.: Phys. Rev. B 22 (1980) 1912.
80W Wachter, P.: Phil. Mag. B 42 (1980) 497.
81G Güntherodt, O., Wichelhaus, W.: Solid State Commun. 39 (1981) 1147.
81R Röhler, J., Kaindl, G.: Solid State Commun. 37 (1981) 737.
82W Wichelhaus, W., Simon, A., Stevens, K. W. H., Brown, P. J., Ziebeck, K. R. A.: Philos. Mag. B 46 (1982) 115.
83P Pott, R., Güntherodt, G., Wichelhaus, W., Ohl, M., Bach, H.: Phys. Rev. B 27 (1983) 359.

Fig. 1.

Eu_3S_4. Relative length change and thermal expansion coefficient vs. temperature [83P].

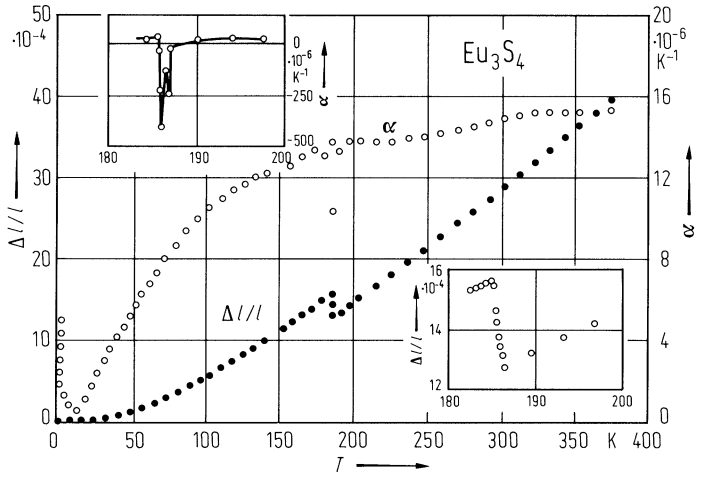

Fig. 2.

Eu_3S_4.(a) 5d–4f interband photoluminescence spectra (relative intensity vs. photon energy) at different temperatures. All curves are normalized at 1.18 eV and have had the spectral sensitivity of the detector corrected. Fig. (b) shows the energies on the high energy side of the spectra (chosen at an arbitrary level marked by an arrow in Fig. (a)) vs. temperature [76V].

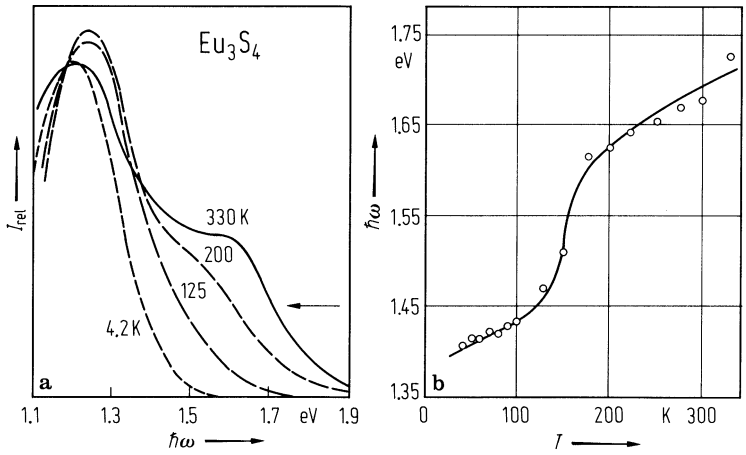

Fig. 3.

Eu_3S_4. Intra-4f photoluminescence spectrum (relative intensity vs. photon energy) at 4.2 K resulting from the $^5D_0$–^7F_J transitions of Eu^{3+}. The optical excitation (465.8 nm) was into the $^5D_2$ multiplet level of Eu^{3+} [76V].

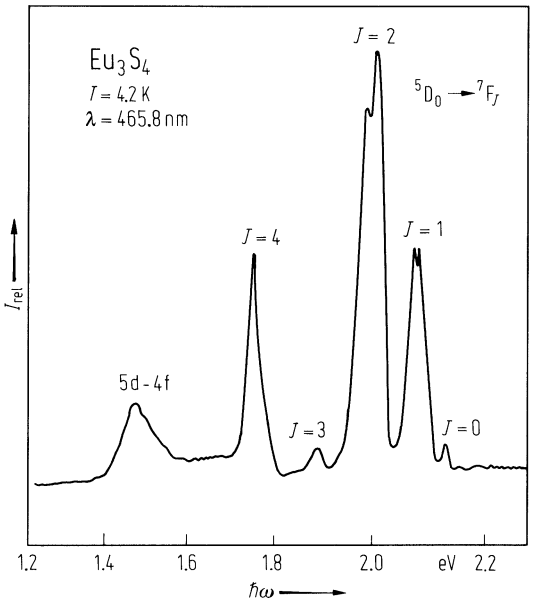

Fig. 4.

Eu_3S_4. Resistivity and absolute Seebeck coefficient vs. (reciprocal) temperature [70H].

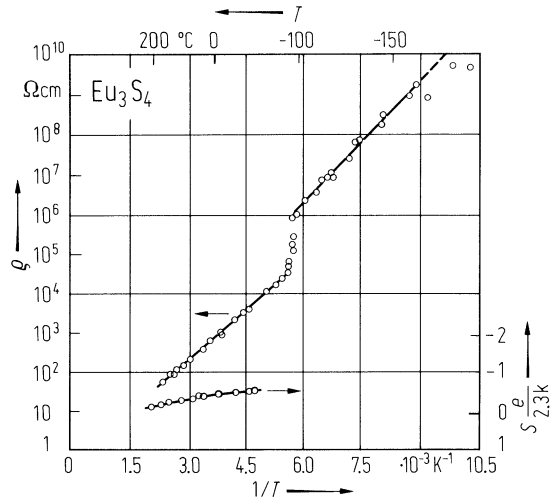

Fig. 5.

Eu_3S_4. High temperature resistivity vs. (reciprocal) temperature; the arrows indicate data taken while heating and cooling [70H].

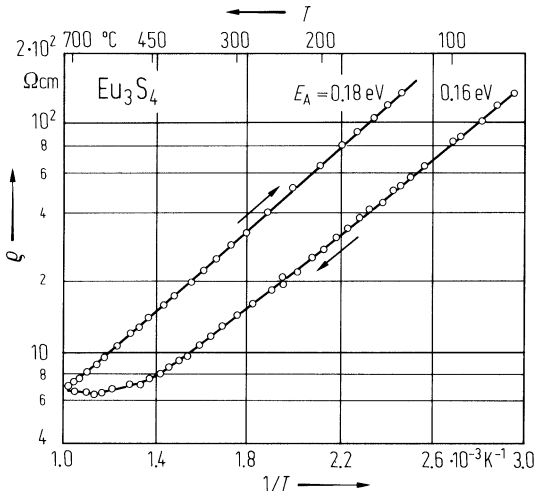

Fig. 6.

Eu_3S_4. Absolute Seebeck coefficient vs. (reciprocal) temperature; the phase transition temperature T_{tr} is indicated [70H]. The data scatter about T_{tr} due to hysteresis. The upper limit for the energy of free charge carrier formation is 0.035 eV.

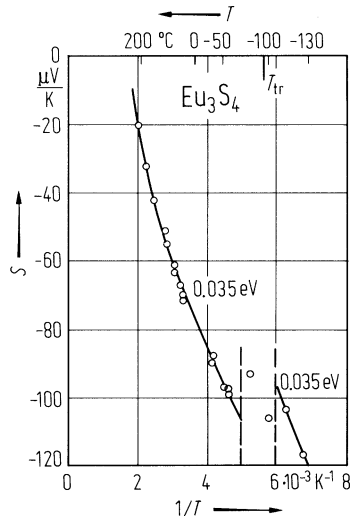

Fig. 7.

Eu_3S_4. Electrical resistivity as a function of (reciprocal) temperature for a single crystal [83P].

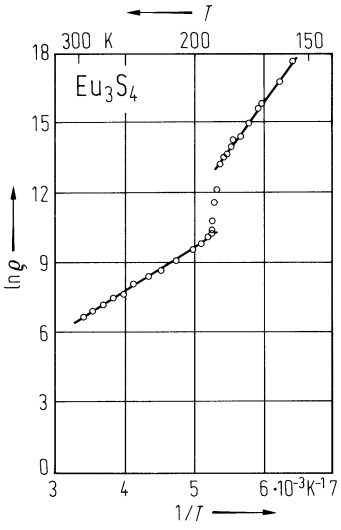

Fig. 8.

Eu_3S_4. Raman scattering (relative intensity vs. Raman shift) of a polycrystalline sample at 2 K using 514.5 nm laser excitation. Phonon modes are located at 300 cm^{-1} and 425 cm^{-1} [77V].

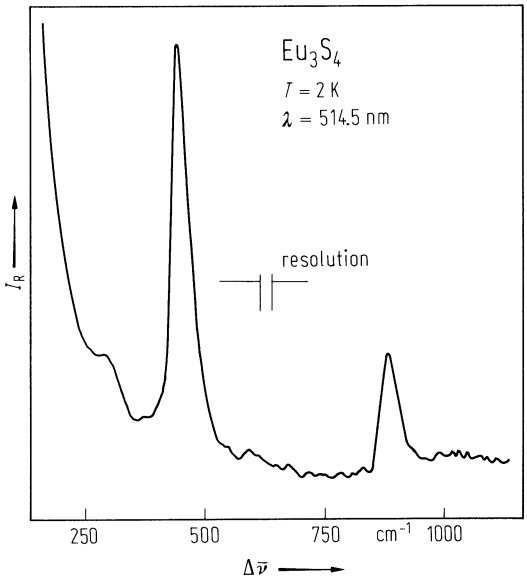

Fig. 9.

Eu_3S_4. Raman spectrum (scattering intensity vs. Raman shift) of an unoriented single crystal at 300 K, measured at 20 mW (solid and long-dashed line) and 40 mW (short-dashed line) laser power. $E_{i(s)}$: electric field vector of incident (scattered) photon [81G].

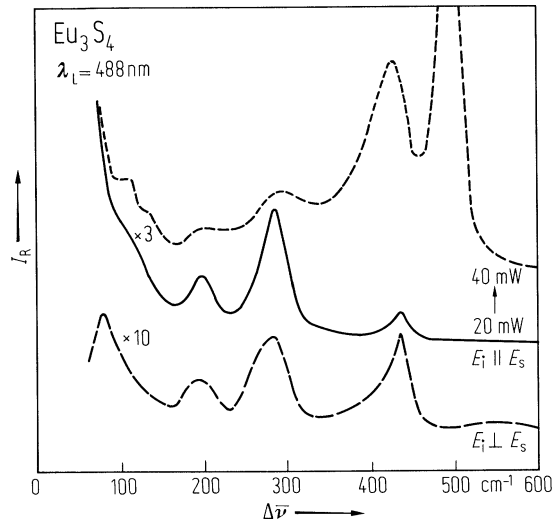

Fig. 10.

Eu_3S_4. Temperature dependence of the 280 cm^{-1} Raman peak [81G].

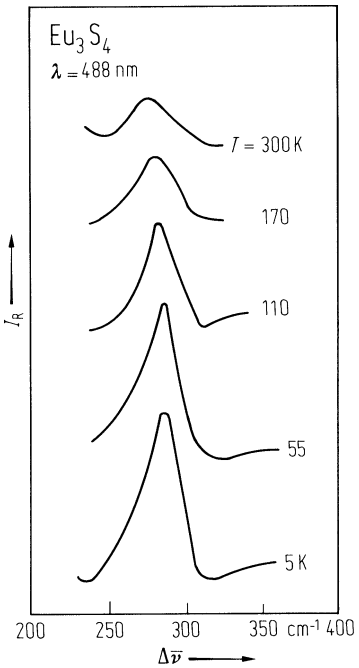

Fig. 11.

Eu_3S_4. Molar heat capacity vs. temperature. The peak, which is also shown in the insert, indicates a change in the charge ordering of Eu^{2+} and Eu^{3+} ions [76M].

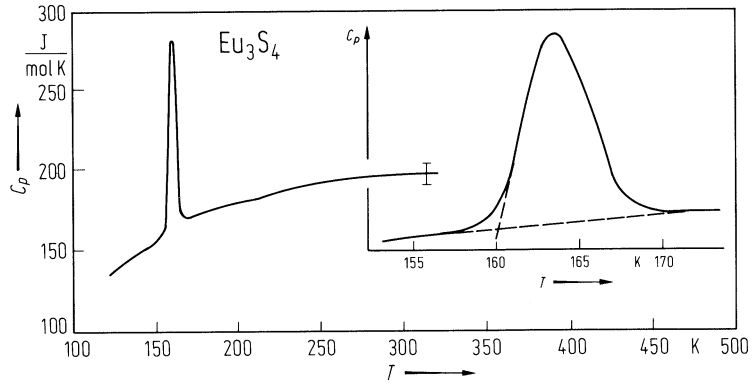

Fig. 12.

Eu_3S_4. Molar heat capacity vs. temperature at full (a) and expanded scale (b). The dashed line in (b) is a Debye fit extrapolated for $T > 186$ K [83P].