substance: VO_2
property: resistivity, conductivity, photoconductivity

resistivity

The first order phase transition at 340 K is accompanied by a discontinuity in ρ of ca. $10^4...10^5$ Ω cm [69L]. High quality crystals show a transition in σ from ca. $10^{-1}\ \Omega^{-1}\ cm^{-1}$ to $10^4\ \Omega^{-1}\ cm^{-1}$ at 339(1) K over about a 0.1 K interval with hysteresis of 0.1...1 K [69L].

$d \ln \rho/dX$	$-4\cdot10^{-5}\ bar^{-1}$	$\rho \parallel c$	temperature region just below T_{tr}	69L
$d \ln \rho/dp$	$-1.5\cdot10^{-5}\ bar^{-1}$	$\rho \parallel c$, RT		

The conductivity is slightly anisotropic (Fig. 1) with $\rho_{\perp}/\rho_{\parallel} \approx 0.5$ on both sides of the transition [65B]. Effects of stoichiometry: Figs. 2, 3, pressure effects in both phases: Figs. 4, 5.

No clear activation energy found in the semiconducting phase [74S, 75B1] but $T^{-1/4}$ plot found to be linear (Fig. 6). Alternatively the band gap may show marked temperature dependence [80K]. Additional evidence for this comes from photoconductivity measurements [74S, 70P, 80K]. With 18.7 at% ^{18}O substitution, T_{tr} increases by + 0.6 K [80R].

ac conductivity

follows a power law for $T < T_{tr}$ [78M]: $\sigma(\omega) \propto \omega^s$ ($0.7 \le s \le 1$). Variation with temperature: Fig. 7. Some workers report only a slight dispersion at 300 K save at very high frequencies [67K] though dispersion does not increase at lower temperatures [72K]. Dispersion can be accounted for by invoking a distribution of relaxation times [78M]. Detailed investigation of transport measurements suggest at low temperatures, conductivity is essentially due to impurity states in the bandgap [76R] which might arise from so-called "phasons" and that just below T_{tr} intrinsic excitation across the bandgap has become significant, giving rise to band-type conduction. These impurity states may also be extrinsic, and are a strong function of stoichiometry. Their concentration has been estimated at $10^{18}...10^{20}\ cm^{-3}$ [76R, 69B1, 74S].

photoconductivity

Response broadens considerably at high temperature (Fig. 8). Variation with energy at 150 K: Fig. 9. Onset ≈ 0.5 eV corresponds to band gap transition $d_{x2-y2} \to d_{xz}$ [80K, 75S]. Peak at 0.72 eV, $d_{x2-y2} \to d_{yz}$ and peak at 0.92 eV transition across Mott-Hubbard gap [75S].

References:

65B Bongers, P. F.: Solid State Commun. 3 (1965) 275.
67K Kabashima, S., Tshuchiya, Y., Kawakuba, T.: J. Phys. Soc. Jpn. 22 (1967) 932.
69B1 Berglund, C. N., Guggenheim, H. J.: Phys. Rev. 185 (1969) 1022.
69B2 Berglund, C. N., Jayaraman, A.: Phys. Rev. 185 (1969) 1034.
69L Ladd, L. A., Paul, W.: Solid State Commun. 7 (1969) 425.
70P Paul, W.: Mater. Res. Bull. 5 (1970) 691.
72K Kabashima, S., Goto, T., Nishimura, K., Kanwakubo, T.: J. Phys. Soc. Jpn. 32 (1972) 158.
74K Kimizuka, N., Ishii, M., Kawada, I., Saeki, M., Nakahira, M.: J. Solid State Chem. 9 (1974) 69.
74P Palmier, J. F., Bellini, Y., Merenda, P.: Solid State Commun. 14 (1974) 575.
74S von Schulthess, G., Wachter, P.: Solid State Commun. 15 (1974) 645.
75B1 Blaauw, C., Leenhouts, F., van der Woude, F., Sawatzky, G. A.: J. Phys. C8 (1975) 459.
75B2 Brückner, W., Moldenhauer, W., Wich, H., Wolf, E., Oppermann, H., Gerlach, U., Reichelt, W.: Phys. Status Solidi (a) 29 (1975) 63.
75S Sommers, C., de Groot, R., Kaplan, D., Zylberstejn, A.: J. Phys. (Paris) Lett. 36 (1975) L157.
76R Reyes, J. M., Sayer, M., Mansingh, A., Chen, R.: Can. J. Phys. 54 (1976) 413.
78M Mansingh, A., Singh, R., Sayer, M.: Phys. Status Solidi (a) 49 (1978) 773.
80K Kaminskii, V. V., Terukov, E. I., Shelykh, A. I.: Fiz. Tverd. Tela 22 (1980) 1686.
80R Reichelt, W., Oppermann, H., Wagner, H., Terukov, E. I., Wolf, E.: Z. Anorg. Allg. Chem. 463 (1980) 193.

Fig. 1.

VO_2. Resistivity vs. reciprocal temperature showing anisotropy [65B].

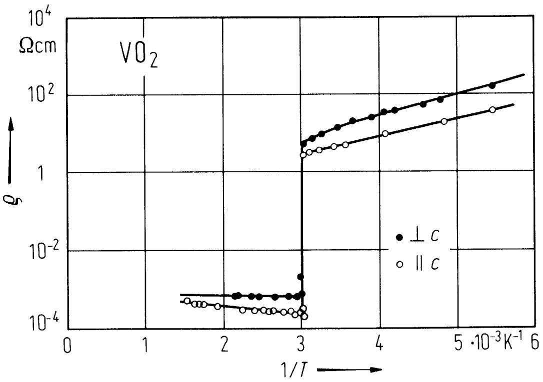

Fig. 2.

$VO_{2+\delta}$. Conductance vs. reciprocal temperature for various stoichiometries (a) $VO_{2.00}$, (b) $VO_{2.03}$, (c) $VO_{2.05}$, (d) $VO_{2.07}$. Numbers 1, 2,3 refer to successive measurement cycles [74K].

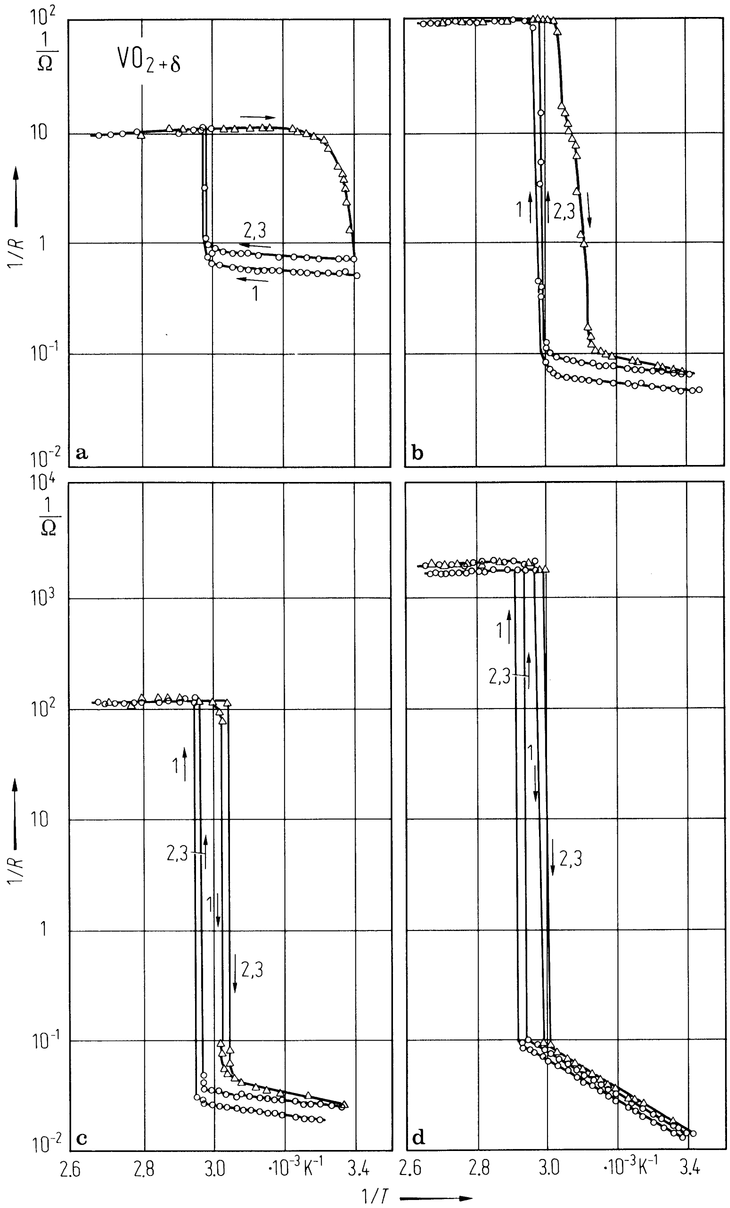

Fig. 3.

$VO_{2-\delta}$. Resistivity vs. temperature for two samples of different stoichiometry in the tetragonal *a* direction [75B2].

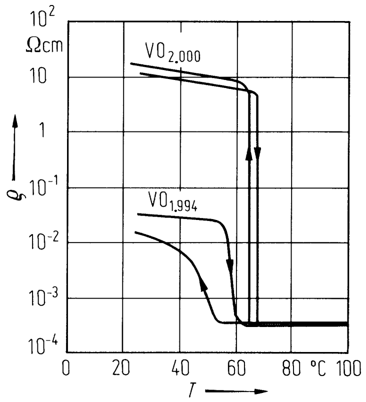

Fig. 4.

VO_2. Conductivity vs. hydrostatic pressure for $T > T_{tr}$. The two curves are two different samples, measurement along c_R axis [69B2].

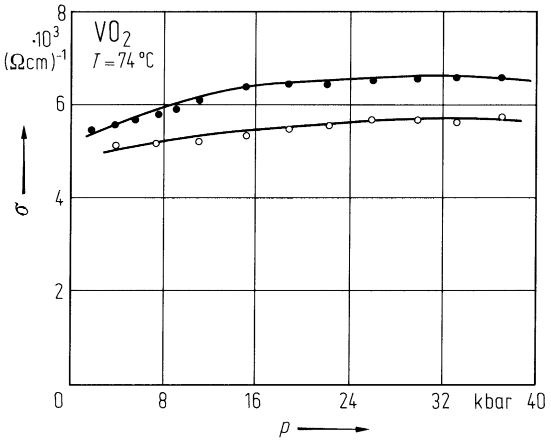

Fig. 5.

VO_2. Conductivity vs. reciprocal temperature for three different pressures, $T < T_{tr}$ along c_R axis [69B2].

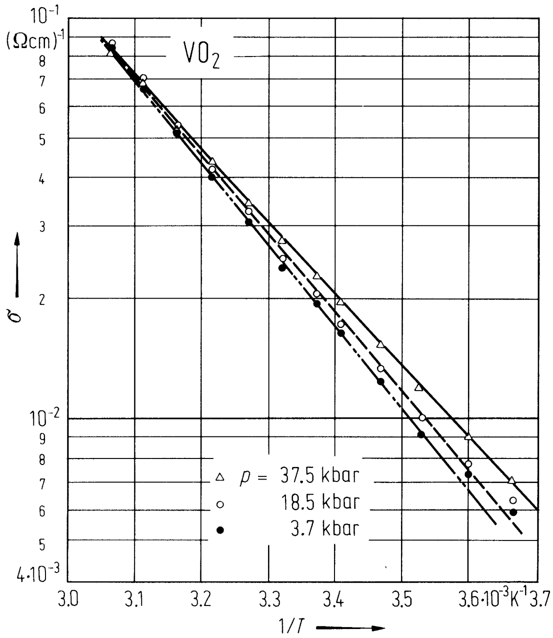

Fig. 6.

VO_2. Conductivity vs. $T^{-1/4}$; inset: conductivity vs. reciprocal temperature [74S]. Orientation σ not given.

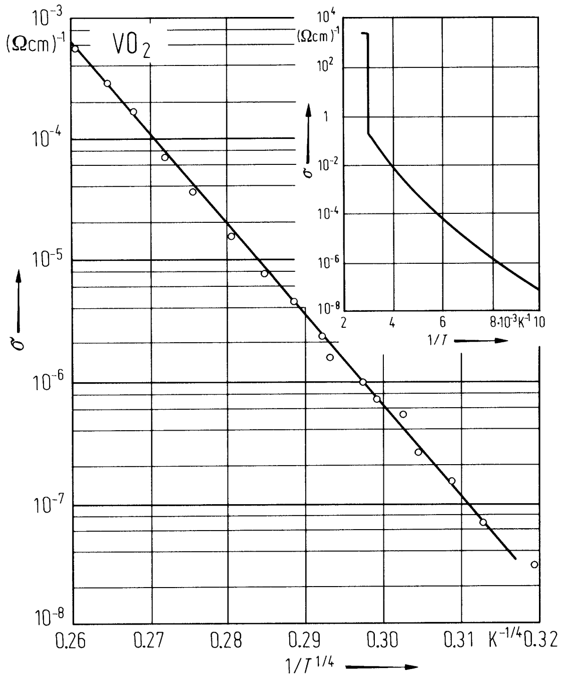

Fig. 7.

VO_2. ac conductivity vs. reciprocal temperature [74P]. Orientation not given.

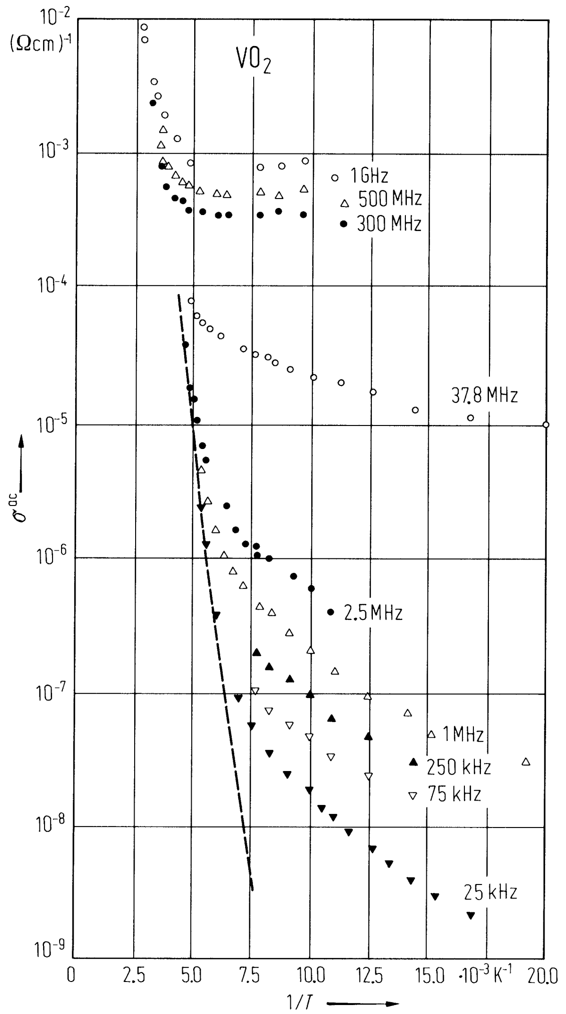

Fig. 8.

VO_2. (a) Photoconductivity vs. photon energy at different temperatures. (b) shows photoconductivity for a fixed photon energy of 1.4 eV vs. reciprocal temperature [74S].

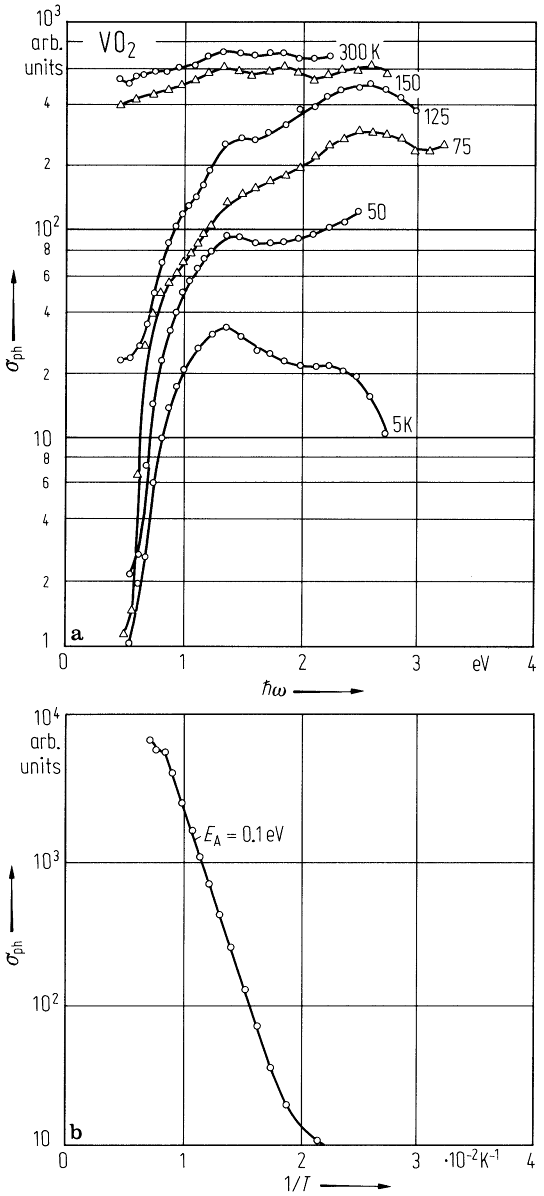

Fig. 9.

VO_2. Photoconductivity vs. photon energy for a single crystal at 150 K [80K].