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RESISTIVITY OF THE METALLIC PHASE OF EPITAXIAL VO_2 FILMS

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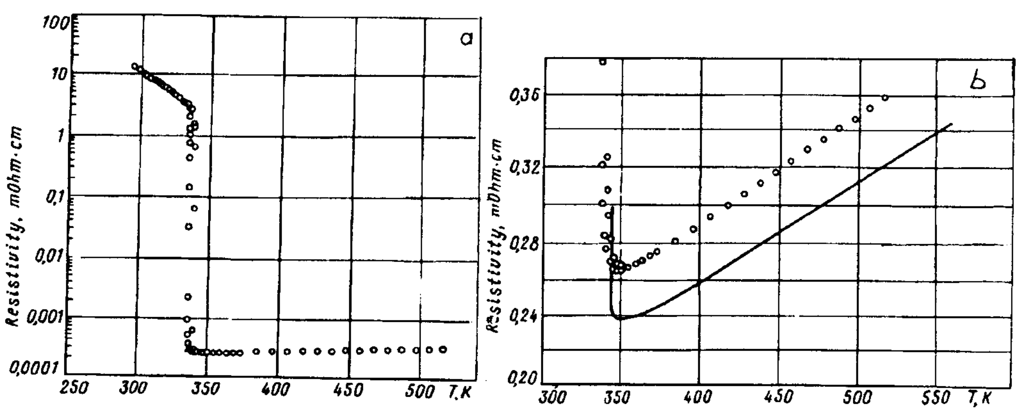
Temperature dependence of resistivity of thin epitaxial films of VO_2 was studied. The films as distinguished from single crystals are not destroyed at metal-insulator phase transition. It was arrived at a conclusion that the metallic phase of VO_2 might not be conventional Fermi liquid.

Pure vanadium dioxide undergoes a striking first order metal-insulator phase transition at temperature $T_c \simeq 340$ K marked by jump of electrical distinguished up to five order magnitude and by the crystalline phase change involves an atomic displacement and small volume increase from low-temperature ($T < 340$ K) monoclinic to the high-temperature ($T > 340$ K) tetragonal structure [1]. The metallic phase of VO_2 ($T > 340$ K) has been the subject of considerable experimental and theoretical investigation motivated by a desire to understand the nature of the metal-insulator transition and unusual metallic properties of this compound.

Recently P.Allen et.al. [2] studied the resistivity of the high temperature metallic phase of VO_2 single crystals and found that in "common with the normal state of copper oxide superconductors metallic VO_2 may not be a conventional Fermi liquid". They also noted that there might be the "trivial" interpretation of unusual parameters of metallic VO_2 obtained in the work; e.g. the very short electron mean free path (3.3 Å) can results from cracks of VO_2 single crystal when passing phase transition and one possible way to avoid this problem is to study thin films [2].



Temperature dependence of resistivity of VO_2 thin films. (a) dielectric and metallic phases, (b) metallic phase. Triangles – thin films. Solid line – single crystals from [2]

The VO_2 films were deposited by two-beams lazer ablation technique using vanadium metal target and YAG-pulse lazer [3]. The thickness of the films varies from 150 to 200 nm. To achieve a high epitaxial and structural quality, VO_2 films were grown on polished TiO_2-single crystal substrates. The structure of VO_2 at the deposition temperature of 600 °C is also rutile and the lattice constants nearly match with those of TiO_2. The X-ray and Rutherford backscattering measurements showed high degree of epitaxial VO_2-films. The very sharp and large ($> 10^4$) resistivity jump at T_c shown in Fig.1a also indicates the high epitaxy of VO_2-films. The DC conductivity was measured using four probe method.

The thin VO_2-films are free of the failure when passing phase transition. So it is interesting to compare the temperature dependence of resistivity in metallic phase of VO_2-films with that of single crystals. The result of comparison (see Fig.*a*) shows that resistivity of thin film and single crystal agrees to within the experimental error of film thickness measurements. It must be emphasized that the temperature dependence of resistivity of thin film shown in Fig.*b* dosn't changed when cycling more than 20 times through phase transition.

So, the "trivial" reason when resistivity data influenced by cracks resulting when sample heated through T_c, has to be ruled out and following Allen et al. [2] we can suggest that the metallic phase of VO_2 might not be conventional Fermi liquid.

The fact that very broad Raman scattering background of the metallic phase of VO_2 [4] is similar with those normal state in copper oxide superconductors [5] and in K_3C_{60} [6] is an added reason for suggest that metallic VO_2 is not strictly a Fermi liquid and may be described using Varma et al. [7] marginal Fermi liquid theory.

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