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PHOTOINDUCED SUPERCONDUCTIVITY IN $YBa_2Cu_3O_{6.4}$ FILMS

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Photoinduced superconductivity has been investigated in YBa2Cu3O6.4 films near to the semiconductor-metal transition. Light induced changes in the resistance and growth of a diamagnetic moment were observed. The data revealed a dependence between photoinduced reduction of normal state resistance and the increase of the onset temperature of superconductivity in the films. Prolonged irradiation leaded to a seemingly complete loss of resistivity below 5 K. These phenomena were attributed to photo generation of additional mobile holes in CuO2 layers resulting to superconductivity.

Films of $YBa_2Cu_3O_{6.4}$ are near to the border line of oxygen contents above which the transition to the superconducting state is observed. We have recently shown that prolonged exposure of $YBa_2Cu_3O_{6.4}$ films to visible light leads to appearance of persistent photoconductivity[1]. Measurements of the resistivity and the increase of the diamagnetic moment in the irradiated samples reveal an enhancement of their superconducting properties (*photoinduced superconductivity*). We attribute this effect to an increase of the free carrier (hole) concentration resulting from persistent photoconductivity[1,2].

Our experiments were made with c-axis oriented $YBa_2Cu_3O_7$ films (68 nm) grown by the laser ablation technique on $SrTiO_3$. Supplied $YBa_2Cu_3O_7$ films had T_c=89-91K. To reduce the oxygen content to value x=0.4 the films were vacuum annealed. The $YBa_2Cu_3O_{6.4}$ films were irradiated by an Ar ion laser (514.5nm, power up to 300mW). Fig.1 shows the temperature dependence of the resistance for the film before (the upmost curve 1) and after cumulative doses of illumination (2-5). In the low temperature region the resis-

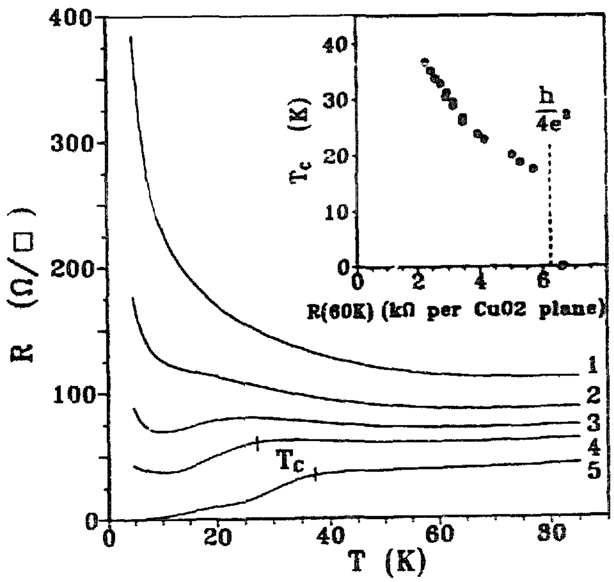

FIGURE 1

Temperature dependence of the film resistance after illumination with cumulative doses Q at λ=514.5 nm. Curve (1) - Q=0, (2) - $4.8\cdot10^{21}$; (3) - $1.4\cdot10^{22}$; (4) - $1.8\cdot10^{22}$; (5) - $5\cdot10^{23}$ photons/cm^2. In insert: the dependence of the onset temperature Tc of superconductivity vs. the sheet resistance R(60K) calculated per one CuO2 layer.

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tance of the unirradiated film rises without any sign of the superconducting inclusions. When $YBa_2Cu_3O_{6.4}$ film was exposed to laser light for several hours at 77 K (photon flux $2.4 \cdot 10^{18}$ ph/s·cm^2) its resistance was found to reduce down to 40%. After interrupting the irradiation no change of the resistance could be found with time (the phenomenon of persistent photoconductivity[1]). As the film is irradiated the localization increase of resistance is reduced (Fig.1). At $Q=1.4 \cdot 10^{22}$ ph/cm^2 the descending part on the R(T) curve appears below 20K. With prolonged exposure the drop of R(T) becomes more pronounced and indicates transition-like behavior which moves to higher temperatures when Q grows (see insert in Fig.1). Finally the resistance drops below a measurable level at 5 K (curve 5). At the same time the voltage-current characteristic becomes nonlinear.

To investigate the growth dynamics of the photoinduced superconducting phase absolute values of the diamagnetic moment were determined (using SQUID magnetometer) as a function of the photon dose, Q, at T=4.3K in a magnetic field of 4.5 Oe perpendicular to the film (Fig.2). For low irradiation doses M(Q) remains approximately constant. At higher doses it begins to grow almost linearly until a saturation value $\Delta M=-3.3 \cdot 10^{-8}$ Am^2 (corresponding to 1% of diamagnetic moment of the $YBa_2Cu_3O_7$ film) is reached.

We propose the following *scenario* of the superconducting phase growth under light irradiation. Before irradiation the films exhibit semiconductor like behavior. Resulting from photo generation of additional mobile holes in CuO_2 layers the conductivity increases and the semi-

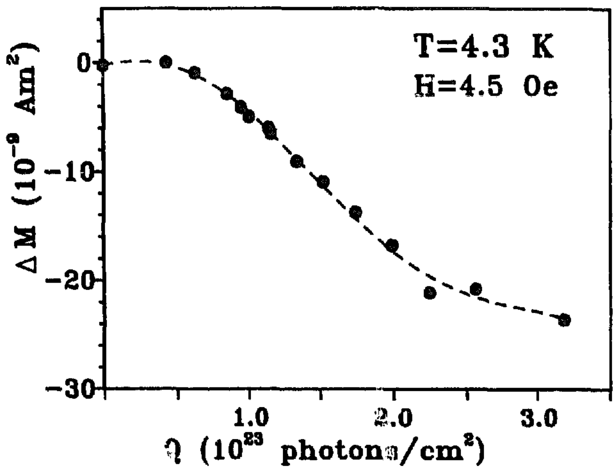

FIGURE 2

Photoinduced diamagnetic moment of film vs. cumulative photon dose.

conductor like behavior progressively changes to that of a metal. At this stage the superconducting domains do not grow and the diamagnetic moment stays constant. At higher doses the free carrier concentration reaches the limit at which the superconducting phase begins to grow. As a result a descending part in the R(T) curve appears and the induced diamagnetic moment tends to increase with irradiation time. Further there took place the size growth of photoinduced superconducting domains and the temperature increase of the superconducting transition (insert in Fig.1). Finally the growth of the superconducting phase size approaches the percolation limit and the resistance goes to zero below 5 K.

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2. V.I.Kudinov et.al., Phys.Lett.151A (1990) 358