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# Semiconducting $YBa_2Cu_3O_6$ Films: A New Material

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Comprehensive studies of the optical properties of thin $YBa_2Cu_3O_{7-x}$ films are presented with a strong focus on the semiconducting mode. The results recommend this multinary compound material for adaptable hybrid applications, as light detectors and emitters.

Cuprates (Cu oxides) have induced a worldwide outburst of excitement in the solid state research community, because of the superconducting phase-transition $T_c$ above the technological barrier of the liquid-nitrogen boiling point ($77K$). $YBa_2Cu_3O_7$ is one of these materials with $T_c = 93K$. Our initially superconducting samples were prepared by single target magnetron sputtering on sapphire. The crucial point is that the physical properties of this material are tunable between superconductors with various $T_c's \leq 93K$ and nonmetallic, i.e. semiconducting, phases by the variation of the oxygen concentration. In particular, our superconducting samples were converted to the nonmetallic state by vacuum annealing at $770K$. In this work the hybrid (optoelectronic) features of thin ($\approx 1\mu m$) $YBa_2Cu_3O_6$ films were investigated. Photocurrent spectra (Fig.1) were measured at $300K$ and $77K$. From those we determined the free-carrier lifetime ($\tau_{300K} = 3.7ms$ and $\tau_{77K} = 11.1ms$) and the photoconductor responsivity ($\leq 1mA/W$). In this context it is demonstrated that the classical semiconductor theory holds for this kind of material.[1] Furthermore, high electric field ($\approx 5 \times 10^3 V/cm$) effects like photon assisted tunneling (Franz-Keldysh effect) were established in photocurrent and luminescence.

A highly remarkable feature was observed in the luminescence of $YBa_2Cu_3O_6$: The spectral response strongly depends on the laser line ($458nm/351nm$) used for the excitation as shown in Fig.2. We want to point out that this effect is reported here for the first time and does not occur in classical compound semiconductors as e.g. CdS. This new effect can be explained by a depth dependent gap (oxygen concentration gradient) in thin $YBa_2Cu_3O_6$ films. On the basis of the presented data, semiconducting Y-Ba-Cu-O compounds are very promising materials for innovative hybrid concepts as detectors and (tunable) light emitting devices in the technically interesting range of $2.2 - 3.1eV$.

References

1) B. Ullrich, I. Kulaç, H. Pint, G. Leising and H. Kahlert, Jap.J.Appl.Phys.31 (1992) L856

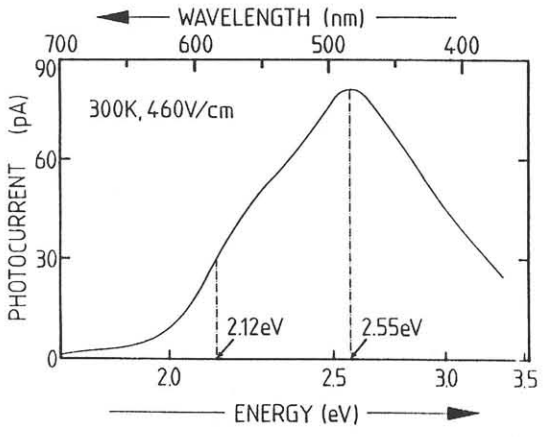


Fig.1 Photocurrent spectrum of a thin $YBa_2Cu_3O_6$ film at $300K$. The applied electric field was $460V/cm$. The energy values marked by arrows are correlated with those in Fig.2.

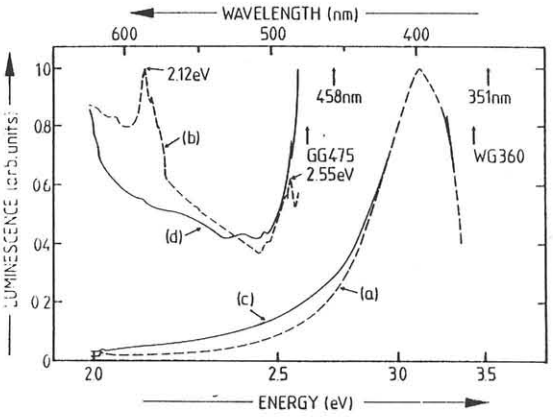


Fig.2 Luminescence spectra: (a), (c) were excited with the $351nm$ laser line and (b), (d) with the $458nm$ one. The solid lines are the measurements at $77K$ and the broken ones at $300K$. The optical filters used were GG475 and WG360 (Schott). Obviously, a large dependence of the luminescence response on the exciting laser line is observed. It is remarkable that a fairly good coincidence between the photocurrent and luminescence transitions are found only with the $458nm$ line. This can be interpreted by the different sample regions which are involved in the luminescence process, namely the surface ($351nm$) and the bulk ($458nm$).