EFFECT OF INTERFERENCE AND SHEET-LIKE FAULT SCATTERINGS IN MEASURING CONDUCTIVITY OF $YBa_2Cu_3O_7$ SUPERCONDUCTORS

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ABSTACT

Due to the wide range of applications of superconducting systems in the areas of communication, memory devices etc., thermal conduction estimation has been a great interest of the researchers. The present paper is an attempt to measure the conductivity aiming to observe the effect of different scattering strengths involve during the conduction. The thermal conductivity of $YBa_2Cu_3O_7$ superconductors has been evaluated in the temperature range of 10K to 240K, using computer-based simulation approach considering various scattering strengths due to boundary scattering, point defect scattering, sheet like fault, electron-phonon scattering, interference scattering between point defect and three phonon processes and three phonon U-scattering respectively. These scattering strengths are symbolically referred as A, α, β, γ, δ and ϵ respectively. With the applications of simulation, in the present paper the effect of scattering strengths of disloction and sheet-like fault in measuring the conductivity of $YBa_2Cu_3O_7$ superconductors is observed. Some interesting results have been observed which dipicts the behaviour of these scattering strenths at different temeratures. For example when interference scattering (δ) and sheet like fault (β) are changed, conductivity values varies from significantly.

Keywords: Scattering, Thermal Conductivity, $YBa_2Cu_3O_7$ Superconductors

I. INTRODUCTION

Research investigations in the field of high temperature superconductors have been carried by several workers due to its peculiar and inherent properties. This has led to its wide theoretical and experimental investigations for the industrial applications[1]. For high temperature superconductors, transport properties have been reviewed by Jezowski and Klamut[2]. Some years back, Ravindran et. al.[3] have theoretically interpreted their measurements in terms of Tewordth and Wolkhausan theory[4], neglecting the dislocation scattering which has been taken into account by considering various scattering strengths viz. dislocation scattering, sheet-like faults, interference scattering between point-defects and three-phonon processes and three-phonon U-scattering combined. This shows the good impact on the conductivity calculations considering these scattering strengths; which has been further analyzed by and R. M. Bhatt et. Al.[5]. In the present analysis, conductivity has been estimated in the temperature range from 10 to 240 K in examining the effect of some scattering strengths. In the

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following sections, analysis, behavior modeling, results, and discussion have been described. Lastly, a conclusion has been drawn.

II. ANALYSIS

For the estimation of the scattering strengths, the thermal conductivity model of Callaway's[6] is given by [2,4,7] has been taken as follows :

$$K = A\, t^3 \int x4\, e^x / [(e^x - 1)^2 . F(t, x)]\, dx \qquad (1)$$

Where F(t,x) is -

$$F(t,x)=[1+\alpha x^4 t^4+\beta x^2 t^2+ \gamma t x g(x,y)+ \delta x^3 t^4+ \in x^2 t^5] \qquad (2)$$

Parameters A, α, β, γ, δ and $\in$ used in the above equations are referred as the scattering strengths due to boundary scattering, point defect scattering, sheet like fault, electron-phonon scattering, interference scattering between point defect and three phonon processes and three phonon U-scattering respectively. x (= ħ/KT) is the reduced energy, T (= T/T_c) is the reduced temperature and g(x,y) is the BRT function, defined by Bardeen et.al.[8].

In the present analysis, some interesting results have been observed which depicts the behavior of these scattering strengths at different temperatures. Following section discussed the result so obtained.

III. RESULT

The thermal conductivity of $Yba_2Cu_3O_7$ superconductors has been evaluated using Eq.-1 and Eq.-2 in the temperature range of 10K to 150K, using computer-based simulation approach for A, α, β, γ, δ and $\in$ the scattering strengths. Keeping the above mentioned approach for the behavior modeling, thermal conductivity has been measured in the temperature range from 10K to 150K by assigning different values to the scattering parameters. These estimated results are compared with the experimental results and found a good match with the experimental results of Ravindran et. al.[3]. The various parameters used in the present analyses are mentioned in the Table-I and graphical presentation is in the Fig.-1.

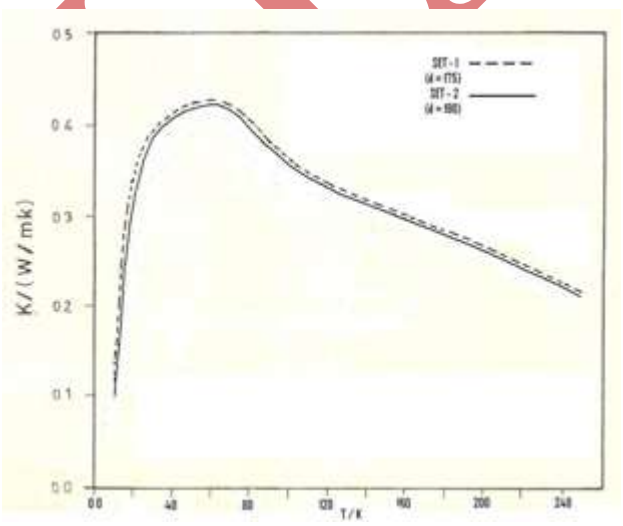

Fig.1. Conductivity of $Yba_2Cu_3O_7$ for SET-1 and SET-2

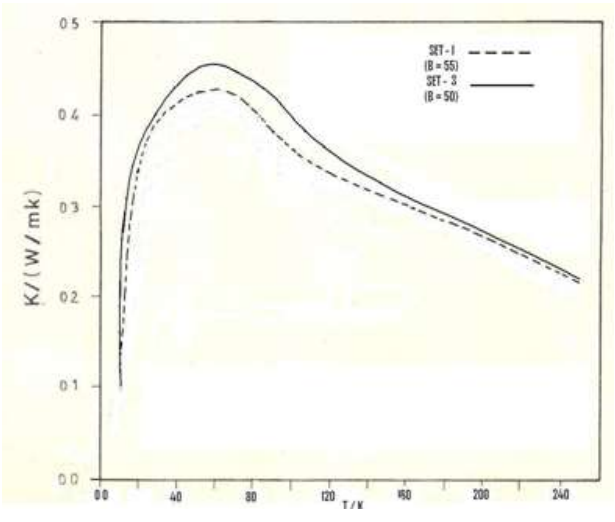

Fig.2. Conductivity of $Yba_2Cu_3O_7$ for SET-1 and SET-3

Further, after validating the conductivity up to 150K with the help of experimental results, the model is simulated over different parameters to examine and predicting the behavior at different levels of temperature. Following Table-1 contains four results viz. Reading-A, B, C, and D corresponding to different values of the scattering strengths. Maximum conductivity so obtained is also shown with the conductivity values in the temperature range of 80K to 240K. Simulation approach[9,10] has been applied in generating different responses for three sets of parameters shown in Table 1and their corresponding conductivity values have been tabulated in the Table -2.

Table-1: Parameters of Scattering Processes

Sr. No.	Parameters					
	A	γ	α	β	∈	δ
Set -1	4.0	25	10	55	.20	175
Set -2	4.0	25	10	55	.20	190
Set -3	4.0	25	10	50	.20	175

Table-2: Conductivity of YBCO Superconductor

Temp/ K	Conductivity (W $cm^{-1}K^{-1}$)		
	SET-1	SET-2	SET-3
10	1.3878	1.3785	1.4758
20	2.8622	2.8111	3.0286
30	3.6971	3.5980	3.8799
40	4.1194	3.9818	4.2935
50	4.3121	4.1471	4.4711
60	4.3759	4.1923	4.5200
70	4.3630	4.1667	4.4940
80	4.3015	4.0968	4.4208
90	4.2083	3.9982	4.3168
100	4.0946	3.8814	4.1930
110	3.9685	3.7540	4.0572
120	3.8358	3.6215	3.9154
130	3.7006	3.4877	3.7780
140	3.5661	3.3556	3.6299
150	3.4344	3.2269	3.4912
160	3.3067	3.1029	3.3574
170	3.1839	2.9842	3.2292
180	3.0666	2.8713	3.1070
190	2.9550	2.7641	2.9911
200	2.8489	2.6627	2.8813
210	2.7485	2.5668	2.7775
220	2.6534	2.4763	2.6795
230	2.5634	2.3909	2.5870
240	2.4784	2.3103	2.4996

In examining the effect of interference and sheet-like fault, the above results have been discussed below.

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IV. EFFECT OF INTERFERENCE AND SHEET-LIKE FAULT SCATTERINGS

With the applications of simulation, in the present paper the effect of scattering strengths of disloction and sheet-like fault in measuring the conductivity of $YBa_2Cu_3O_7$ superconductors. Some interesting results have been observed which dipicts the behaviour of these scattering strenths at different temeratures e.q. when interference scattering (δ) is 175 then the value of conductivity starts from 0.13785 at 10K and ends with 2.31030 at 240K; further, when interference scattering is increased to 190 then the value of conductivity starts from 0. 13878 at 10K and ends with 2.4784 at 240K. This shows that increase in the interference scattering increases the conductivity. In contrary to this behaviour, when the value of sheet like fault (β) is decreased from 55 to 50, conductivity values varies from 0.13878 to 0.14758 at 10K and from 2.4784 to 2.4996. Shifting of the gradient of the temperatur between 20 to 60K towards left-side can also be observed through its graphically reprented figure.

V. CONCLUSION

Some interesting results have been observed to infer the effect of scattering strengths of interference (δ) and sheet-like fault (β) in measuring the conductivity of $YBa_2Cu_3O_7$ superconductors to dipict the behaviour of these scattering strenths at different temeratures. Further, it can be concluded that this kind of pre-experimental test helps in saving the resources involved.

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