

UNIVERSITI TEKNOLOGI MARA

**INFLUENCE OF DIVALENT Sr^{2+} , Zn^{2+} AND Ca^{2+}
SUBSTITUTIONS ON ULTRASONIC VELOCITY
AND ELASTIC PROPERTIES OF $\text{DyBa}_2\text{Cu}_3\text{O}_{7-\delta}$
HIGH TEMPERATURE SUPERCONDUCTORS**

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Thesis submitted in fulfilment of the requirements
for the degree of

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Candidate's Declaration

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my own work, unless otherwise indicated or acknowledged as referenced work. This topic has not been submitted to any other institution or non-academic institution for any other degree or qualification.

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ABSTRACT

Ultrasonic longitudinal velocity measurements between 80 K and 280 K and shear velocity measurements between 80 K and 220 K have been performed in polycrystalline superconducting $\text{DyBa}_{2-x}\text{Sr}_x\text{Cu}_3\text{O}_{7-\delta}$ ($x = 0, 0.3, 0.6$), $\text{DyBa}_2\text{Cu}_{3-x}\text{Zn}_x\text{O}_{7-\delta}$ ($x = 0.01$ and 0.03) and $\text{Dy}_{0.9}\text{Ca}_{0.1}\text{Ba}_2\text{Cu}_{3-x}\text{Zn}_x\text{O}_{7-\delta}$ ($x = 0.01$) samples utilizing the pulsed-echo-overlap technique. A step-like longitudinal anomaly characterized by a step-like slope change was observed at 240 K for $x = 0$ and $x = 0.3$ and at 260 K for $x = 0.6$ in $\text{DyBa}_{2-x}\text{Sr}_x\text{Cu}_3\text{O}_{7-\delta}$ samples. In addition, a longitudinal anomaly was also observed at around 240 K for $\text{DyBa}_2\text{Cu}_{3-x}\text{Zn}_{1-x}\text{O}_{7-\delta}$ ($x = 0$) and at 230 K for $x = 0.01$ and 0.03 . Substitution of Zn^{2+} which caused suppression of critical temperature, T_c however, did not suppress the step-like anomaly. On the other hand, substitution of Ca^{2+} in $\text{Dy}_{0.9}\text{Ca}_{0.1}\text{Ba}_2\text{Cu}_{3-y}\text{Zn}_{1-y}\text{O}_{7-\delta}$ ($y = 0.01$) caused the step-like anomaly to disappear. The step-like anomalies observed in samples were suggested due to oxygen ordering process in Cu-O chains during a phase transition process at low temperatures. For $\text{DyBa}_{2-x}\text{Sr}_x\text{Cu}_3\text{O}_{7-\delta}$ ($x = 0, 0.3, 0.6$), the reduction in the slope change of the step-like anomalies indicates some degree of weakening of oxygen ordering due to the Sr substitution. Substitution of Zn^{2+} ions in place of Cu in $\text{Dy}_{0.9}\text{Ca}_{0.1}\text{Ba}_2\text{Cu}_{3-x}\text{Zn}_x\text{O}_{7-\delta}$ ($x = 0.01$ and $x = 0.03$) was suggested to go into Cu-O planes and did not interfere with oxygen ordering in Cu-O chains and cause non-suppressed step-like anomalies in $\text{DyBa}_2\text{Cu}_{3-x}\text{Zn}_{1-x}\text{O}_{7-\delta}$ ($x = 0.01$ and 0.03) samples. But, disappearance of the step-like anomaly due to Ca^{2+} substitution in $\text{Dy}_{0.9}\text{Ca}_{0.1}\text{Ba}_2\text{Cu}_{3-x}\text{Zn}_x\text{O}_{7-\delta}$ ($x = 0.01$) is probably related to reduction in oxygen content which depletes at Cu-O chain sites. On the other hand, it was found that Sr substitution in $\text{DyBa}_{2-x}\text{Sr}_x\text{Cu}_3\text{O}_{7-\delta}$ ($x = 0, 0.3$ and 0.6), Zn substitution in $\text{DyBa}_2\text{Cu}_{3-x}\text{Zn}_{1-x}\text{O}_{7-\delta}$ ($x = 0.01$ and 0.03) and Ca^{2+} substitution in $\text{Dy}_{0.9}\text{Ca}_{0.1}\text{Ba}_2\text{Cu}_{3-y}\text{Zn}_{1-y}\text{O}_{7-\delta}$ ($y = 0.01$) has the effect of lowering the calculated Debye temperature and BCS electron-phonon coupling constant, signifying that the step-like anomaly may not be related to superconductivity. A comparison between experimental data and calculated lattice anharmonicity curve based on the model by Lakkad (1971) showed that the large deviation of the experimental velocity curves for $\text{DyBa}_{2-x}\text{Sr}_x\text{Cu}_3\text{O}_{7-\delta}$ ($x = 0, 0.3$) and $\text{DyBa}_2\text{Cu}_{3-x}\text{Zn}_{1-x}\text{O}_{7-\delta}$ ($x = 0, 0.01$ and 0.03) from the calculated curves is strongly influenced by the existence of the step-like longitudinal anomalies.

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