

**UNIVERSITI TEKNOLOGI MARA**

**EFFECT OF  $\text{Al}^{3+}$  SUBSTITUTIONS AT  
Cu-SITE AND  $\text{Al}_2\text{O}_3$  ADDITION ON  
ULTRASONIC VELOCITIES AND ELASTIC  
ANOMALIES OF  $\text{EuBa}_2\text{Cu}_3\text{O}_{7-\delta}$   
SUPERCONDUCTOR**

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of the requirements for the degree of  
**Master of Science**

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## AUTHOR'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 acknowledge as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

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## ABSTRACT

The ultrasonic longitudinal and shear velocities were measured in  $\text{EuBa}_2\text{Cu}_3\text{O}_{7-\delta}$  ( $\delta = 0.1$  and  $0.7$ ),  $\text{EuBa}_2\text{Cu}_{3-x}\text{Al}_x\text{O}_{7-\delta}$  ( $x=0.06$  and  $0.1$ ) and  $\text{EuBa}_2\text{Cu}_3\text{O}_{7-\delta} + y\text{Al}_2\text{O}_3$  ( $y= 0.2$  and  $0.4$  wt%) superconductors in temperature ranges of  $80\text{-}280\text{K}$  and  $80\text{-}220\text{K}$ , respectively. For  $\text{EuBa}_2\text{Cu}_3\text{O}_{7-\delta}$  ( $\delta = 0.1$  and  $0.7$ ) samples, the absolute velocity (at  $80\text{K}$ ) showed to decrease when the oxygen content was reduced from  $\text{O}_{6.9}$  to  $\text{O}_{6.3}$ . However, for  $\text{EuBa}_2\text{Cu}_{3-x}\text{Al}_x\text{O}_{7-\delta}$  ( $x=0.06$  and  $0.1$ ) samples, although both samples have same oxygen content ( $\text{O}_{6.8}$ ), the absolute velocity also showed to decrease when the amount of  $\text{Al}^{3+}$  increased. In contrast, the absolute velocity for  $\text{EuBa}_2\text{Cu}_3\text{O}_{7-\delta} + y\text{Al}_2\text{O}_3$  ( $y= 0.2$  and  $0.4$  wt%) samples showed to increase when the amount of nano-size  $\text{Al}_2\text{O}_3$  increased, even though both samples have same oxygen content ( $\text{O}_{6.8}$ ). Besides, a step-like elastic anomaly indicating sudden lattice stiffening was observed for  $\text{EuBa}_2\text{Cu}_3\text{O}_{6.9}$  around  $260\text{K}$  but suppressed for  $\text{EuBa}_2\text{Cu}_3\text{O}_{6.3}$ . This step-like elastic anomaly was suggested to be due to some kind of oxygen ordering process taking place in Cu-O chains of  $\text{EuBa}_2\text{Cu}_3\text{O}_{7-\delta}$ . Moreover, partial substitution of  $\text{Al}^{3+}$  in  $\text{EuBa}_2\text{Cu}_{3-x}\text{Al}_x\text{O}_{7-\delta}$  (where  $x=0.06$  and  $0.1$ ) affected the step-like elastic anomaly to suppress and display a monotonous velocity change with temperature. The suppression of the step-like anomaly is due to the substitution of  $\text{Al}^{3+}$  which enters and disturbs Cu-O chains and interferes with oxygen ordering. In addition, the maximum  $T_C$  was observed at sample  $x = 0.06$  and this related with enhanced value of the computed BCS electron-phonon coupling constant. Moreover, the addition of nano-size  $\text{Al}_2\text{O}_3$  on  $\text{EuBa}_2\text{Cu}_3\text{O}_{7-\delta}$ , showed the step-like elastic anomaly was slightly shifted from higher temperature ( $210\text{K}$ ) to lower temperature ( $200\text{K}$ ) when the amount of  $\text{Al}_2\text{O}_3$  increased. The addition of nano-size  $\text{Al}_2\text{O}_3$  is not expected to substitute directly into the  $\text{EuBa}_2\text{Cu}_3\text{O}_{7-\delta}$  unit cell; therefore it does not suppress the step-like elastic anomaly but only shifted it slightly to a lower temperature. In addition, observation of enhancement of electron-phonon coupling constant,  $\lambda$  together with suppression of the step-like anomaly for  $x=0.06$  sample, indicates that the anomaly may not be a precursor for high-temperature superconductivity.

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