respectively comparing with the pure Cu sample. Increasing SiC volume fraction to 25 and 30%vol, the average lattice strain and the crystallite size increased but still lower than pure Cu. this behavior could be attributed to nonuniform dispersion of SiC within the matrix.

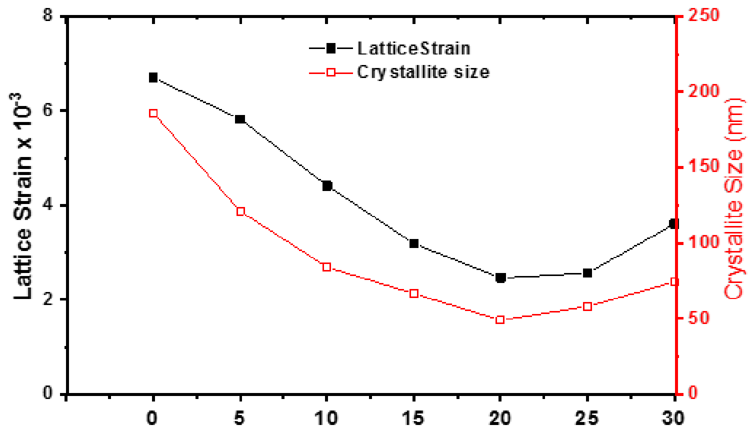

Figure 7. Effect Of SiC Volume Fractions On The Crystallite Size And Lattice Strain

3.4. Mechanical properties

3.4.1. Hardness

Hardness is an important mechanical characteristic for understanding composites' overall mechanical behaviour. The hardness of composites can be evaluated by several parameters, such as particles volume fraction, size of particle, distribution, density of reinforcement, and production method [15]. Fig. 8 (a-g) represents the color- contour maps of the hardness on the Cu pure and Cu/SiC composite with different mass fraction of SiC particles. Variation in hardness magnitudes observed in all samples compared with pure Cu sample. The variations in hardness seem to be very low when the SiC mass fraction was 0%. Hardness difference between the maximum value and minimum value was 67,149,151,154,156,141HVin the case of the Cu, Cu/5 vol%SiC, Cu/10 vol%SiC, Cu-15 vol%SiC, 20 vol%SiC, Cu-25 vol%SiC and Cu-30 vol%SiC respectively. The variations in hardness seem to be more significant when the SiC mass fraction was between 25 to 30%. Also, fig 9(a-g) shown that, the hardness value decreased from center to outside of sample. The variation in the value of hardness is due to the variation in the SiC particles distribution in the matrix or the difference in internal strain from the sample's core to the outer surface [16,17]. Fig. 9 presented the results of the hardness for the investigated samples. The outcomes revealed that the microcomposites hardness values were higher than the pure Cu specimen. The values became higher as the SiC volume fraction increased, and the hardness increased as well, reaching 231 HV for the composite sample with 20% SiC particles. The hardness was increased from 75% for Cu 20% SiC composite compared with unrienforced Cu. This increase in hardness was caused by the existence of hard SiC particles in the Cu matrix. In comparison to pure Cu, it has been hypothesized that the addition of reinforcements in Cu composites may increase grain refinement even more [18,19]. On the other hand, the hardness results revealed significant decrease with the addition of 25 and 30%-SiC particles. The average hardness values of microcomposite which contain 25 and 30% SiC (217and 181HV) as shown in Fig. 9 were obviously lower than that of the Cu/20%SiC (231 HV), indicating an inhomogeneous distribution of SiC reinforcement with the Cu matrix. Further, Fig. 4 shows the non-uniform arrangement of reinforcement particles and clusters of SiCp at higher volume fraction.

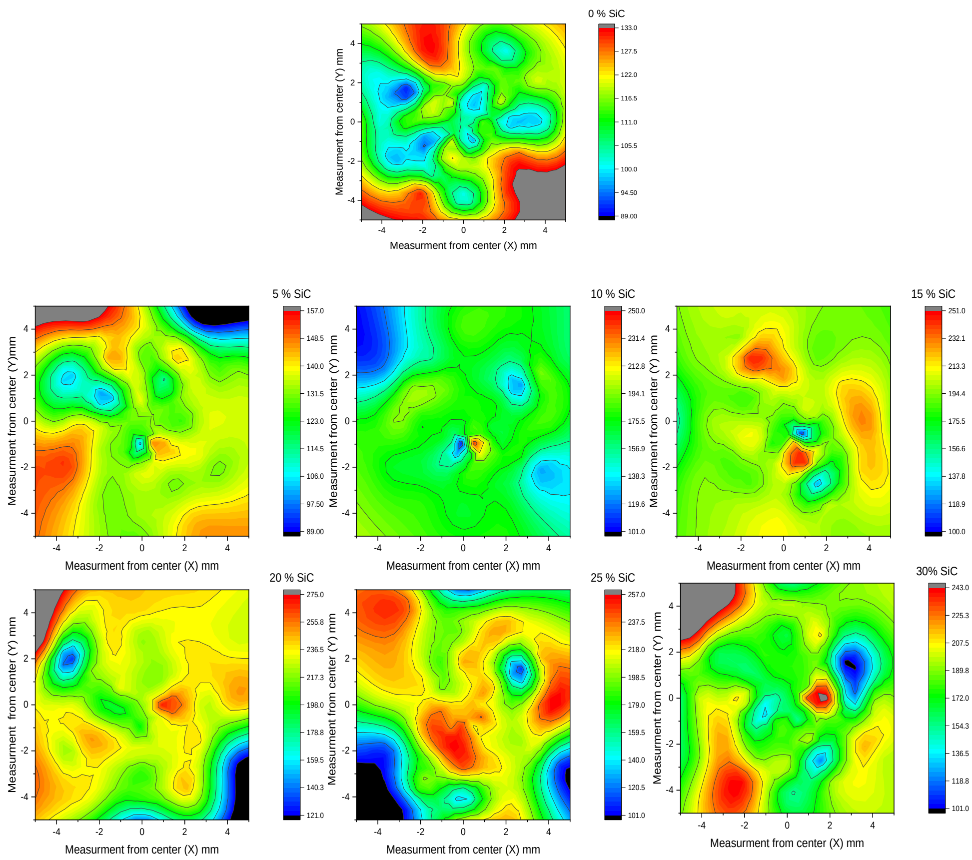

Figure 8. Show The Contour Map For Hardness Values Of Cu/SiC Composites With Different SiC Contents (0,5,10,15,20,25,30%) Resulted From Hardness Testing With Indentation Distance Of 1mm.

3.4.2. Compressive strength

Fig. 10 illustrated the compression stress-strain graphs for unrienforced Cu and Cu/SiC microcomposites with various volume fractions of SiC reinforcement. Whereas ultimate compressive strength and compressive yield strength which extracted from fig 10 were showed in Fig 11. The results revealed that, the micrcomposites had greater yield and ultimate strength than the unreinforced Cu, as shown in Figs 10 & 11. The ultimate compressive and yield compressive strength were increased from ~26.1% for unreinforced Cu to ~57% for the Cu /20 vol% SiC microcomposite, respectively. as demonstrated in Fig. 11, increasing the SiC reinforcement inside the Cu matrix to 25 and 30 percent did not result in substantial gains in yield and ultimate composite strength when compared to the Cu/20vol % SiC composite. The decrease in yield and ultimate compressive strength of the Cu reinforced with 25 and 30 % SiC composites comparing to 20vol%SiC can be attributed to the presence of certain clusters and nonuniform homogeneity of SiC particles inside the Cu matrix, as indicated in microstructure. This behavior caused a weak interfacial bonding. It is known that, the interface between the hard SiC reinforcement and the Cu matrix plays an important role in the mechanical properties of composites [20,21].

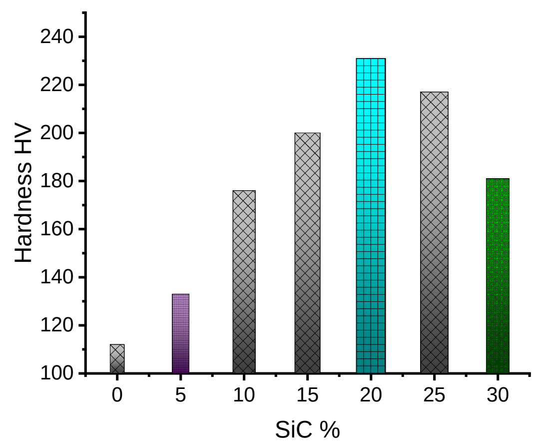

Figure 9 Hardness Of Cu / SiC Microcomposite With Various SiC Content.

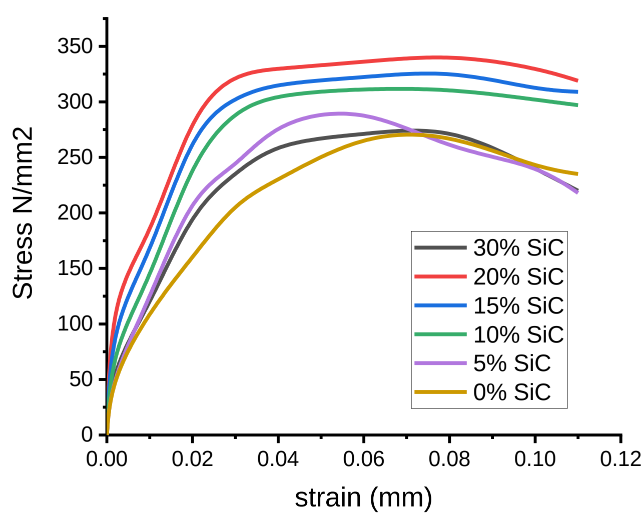

Figure 10. Compressive Stress–Strain Curves For The Cu/SiC Microcomposites.

3.4.3. Dislocation density measurements

The following equation was used to determine the effect of SiC volume fraction on the dislocation density (ρ) of α-Cu using an XRD pattern. [22].

$$\rho = \frac{7.75 \text{ x } \eta}{\text{b x t}} \qquad (3)$$

Where (η) characterizes lattice strain, (b = 0.154nm) represents burger vector of Cu and (t) signifies crystallize size.

The obtained results can be presented in Fig.. 12. It is obvious that increasing SiC content to 20 (vol. %) increases the dislocation density according to increasing the lattice strain. When the tungsten was 15 vol%, Arsenault and Shi [64] found that the lowest dislocation density within the matrix was 7×10^{11} (m^{-2}), while at the Cu-W interface, the dislocation density was 4 $\times10^{12}$ (m^{-2}). It was concluded that the variation in coefficient of thermal expansion (about 4:1) between copper and tungsten was shown to be the cause of the increasing dislocations. In our case the difference in the coefficient of thermal expansion between copper and SiC is 8:1 more than twice as great as in the Cu-W system. On the other hand, Fig. 12 reveals that after 20 %SiC, the dislocation density decreased, which can be related to the existence of SiC reinforcement agglomeration in the composites with 25 and 30% SiC, as demonstrated in the microstructure images previously. The dislocation density increased from 12×10^{14} (m^{-2}) for pure copper to 37×10^{14} (m^{-2}) by increasing SiC content to 20 (vol. %). However, the results observed that the dislocation density reduced to 32 $\times10^{14}$ and 30 ×1014 (m^{-2}) when SiC content increased to 25 and 30 (vol. %) respectively.

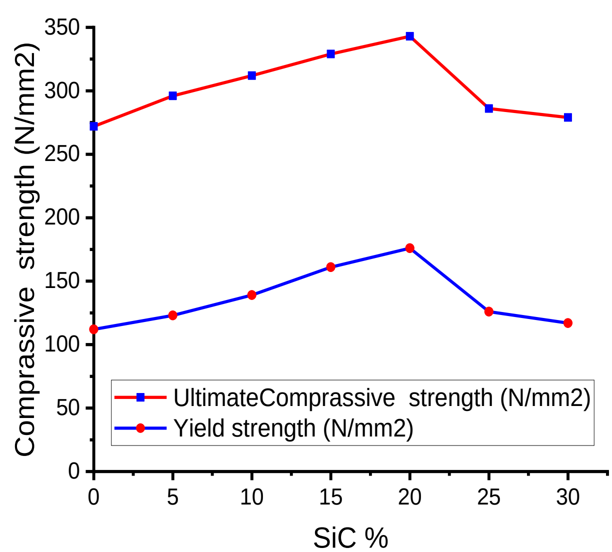

Figure 11. Effect Of The SiC Content On The Yield And Ultimate Compressive Strength Of Cu/SiC Micrcomposites.

Cu/SiC micrcomposites have improved in hardness, compressive yield, and ultimate strength for many reasons. The first reason may be related to the Apparent strengthening efficiency (Ra). Ra refers to the ratio of yield strength increase of the composite to that of the matrix. The following equation can be used to calculate apparent strengthening efficiency [23].

$$\mathbf{Ra} = \frac{\boldsymbol{\sigma c - \sigma m}}{\boldsymbol{Vf\ \sigma m}} \qquad (4)$$

Where ((σm)) refer to the matrix yield; considering the difficulty to obtain an accurate value of the reference and ((V*f*)) is the volume fraction of the reinforcement particles, ((σc)) represents the composite yield strength,. Ra can characterizes the composite overall strength enhancement as a result of the reinforcement. According to the previous equation, the apparent strengthening efficiency (Ra) increases as the SiC volume fraction increases, accordingly, all mechanical properties will improve.
The second reason is rule of mixture. As a simplistic model, the rule of mixture can only be apply roughly to estimate the mechanical characteristics of composites, and it is frequently inconsistent with experimental data. The Rule of mixture [24], can be expressed as follows:

$$\boldsymbol{\sigma c = Vm\sigma m + Vf\sigma f} \qquad (5)$$

According to the rule of mixture, with increasing the SiC volume fraction the strength will be increase.
The third reason is the transfer of load from Cu matrix to SiC reinforcement and interface bonding between matrix and SiC particles which are important to the strengthening of Cu/SiC micrcomposites. When Cu matrix composite was loaded, the load was transferred from the Cu matrix to the SiC reinforcement particle, which increased the composite samples' resistance to plastic deformation due to the variation in thermal mismatch values of the matrix and reinforcement particles. This thermal mismatch caused increasing in dislocation density into the Cu matrix [25]. A higher dislocation density in the composite resulted in a higher degree of internal stress, which improved all of the composites mechanical properties.

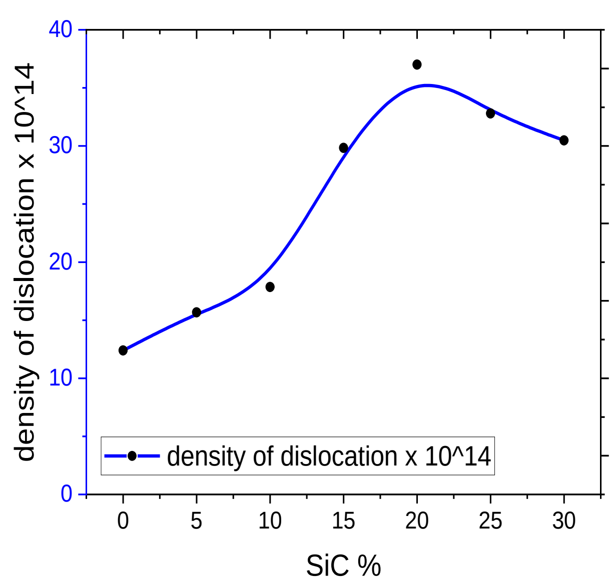

Figure 12. Effect of SiC Content on The Dislocation Density of Cu/SiC Micrcomposites.

4.Conclusion

In the current research, Cu matrix reinforced with different volume fraction of micro-SiC particles was fabricated. The crystallite size of copper matrix was decreased with increment of SiC contents to 20 (vol %) beyond this value, it was increased but still lower than the base matrix. SEM results showed a uniform distribution of SiC particles to 20 vol.%SiC .The dislocation density increased from 12×10^{14} (m^{-2}) for pure copper to 37×10^{14} (m^{-2}) by increasing SiC content to 20 (vol. %). However, the results showed that the dislocation density decreased to 32×10^{14} and 30×10^{14} (m^{-2}) when SiC content increased to 25 and 30 (vol. %) respectively. Further, sample of 20 (vol. %) SiC possesses the highest hardness, ultimate and yield compressive strength than that of the other six composites. The values of hardness, Ultimate and yield compressive strength increased to 231 HV,343 and 176 N/mm^2 , respectively for the composite sample containing 20% SiC particles with increasing percentage of 75%,26.6% and 57.2% respectively, compared with pure Cu.

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