Abstract

Copper based metal matrix composite with a negative thermal expansion material $Y_2W_3O_{12}$, as thermal expansion compensator has been synthesized and characterized for the potential applications as heat sinks, high precision optics, space structures, etc. $Y_2W_3O_{12,}$ with coefficient of thermal expansion (CTE) = -7.1 x 10^{-6} /°C in the temperature range 150-650 °C, has been synthesized by mixing stoichiometric ratios of Y_2O_3 and WO_3 powders through a Fritsch Pulverisitte-4 ball-milling machine at a disc revolution speed of 300 rpm for 10 h. The transmission-ratio(r) in the P4 ball-milling machine is optimized for the synthesis of $Y_2W_3O_{12}$ at an r value of -2.25.The volume fraction of $Y_2W_3O_{12}$ has been varied from 40 to 70% for the synthesis of Cu/ $Y_2W_3O_{12}$ composite. The synthesis technique is optimized for the 10 h milled powders followed by compaction at a pressure of 700 MPa and sintering at 1000 °C in order to achieve the densified composites.

The thermomechanical analysis and thermal conductivity measurement indicate that, controllable thermal expansion and thermal conductivity can be achieved by adjusting the volume fraction of $Y_2W_3O_{12}$ in Cu matrix. The CTE for Cu-70% $Y_2W_3O_{12}$ composite is found to be 4.32 ± 0.75 x 10^{-6} /°C and it matches with that of Si substrate. The hardness measurements, both by Vickers and nanoindentation, show that the hardness values of the composites are higher than that of Cu and it increases with the $Y_2W_3O_{12}$ content. The Young's modulus values obtained by ultrasonic and nanoindentation techniques are well in agreement with the Halpin-Tsai Model. The composites show compressive residual stress and it decreases with an increase in the $Y_2W_3O_{12}$ content. The surface roughness, measured by profilometry and AFM, shows that pure Cu has the lowest roughness and in the case of the composites the average roughness increases with the increase in the amount of reinforcement. The composites have better wear resistance than that of Cu and the wear resistance improves with the increase in the volume fraction of $Y_2W_3O_{12}$, except for the Cu30 composite. The corrosion resistance increases with the addition of $Y_2W_3O_{12}$ as compared to that of Cu. The electrical resistivity of the composite samples increases with the addition of $Y_2W_3O_{12.}$

Key Words: Negative thermal expansion (NTE), $Y_2W_3O_{12}$, Composites, Thermal expansion, Thermal conductivity.