A Study on Microstructure and Mechanical Behavior of Cu-Al2O3 Composites: an Explanation by Deformation Theory

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Introduction

✓The unification of metal as matrix and ceramic as reinforcement leads to the development of excellent candidate material for advanced engineering system arising from the high ductility of the matrix material.

✓Performance and microstructural characteristics of a particle reinforced MMCs depends on the size, shape, volume fraction, spatial distribution of the reinforcement and nature of the interfacial bonding.

✓The driving phenomena to generate the dislocation in MMCs are misfit strain, thermal misfit, allotropic misfit, lattice parameter misfit and elastic inhomogenity misfit .

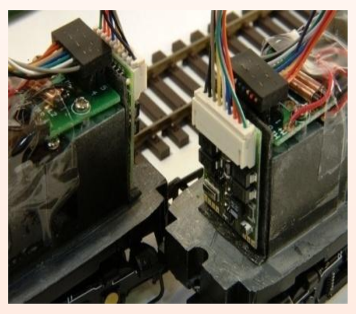
✓The interfacial pinning of dislocation can be explained on the basis of Orowan mechanisms.

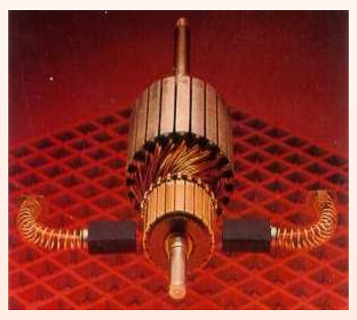
✓Different forms of damage in particle reinforced MMCs are particulate fracture, de-bonding or cracking in the interfaces, failure in the matrix via micro-void coalescence, shear fracture of the matrix.

✓Typically fracture nucleates at the clustered regions and crack propagate by linking the damage contained in the clustered regions. Fracture toughness increases with increase in reinforcement content and size because of bifurcation of crack by large ceramic particle.


Relay blades


Electrodes for lead wires


Electrical contact support


Commutators

Applications

Experimental

Copper powder (average size- 11.09µm)

Alumina powder (average size- 6µm, 10µm)

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Blending and compaction

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Conventional sintering at different temperatures

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Characterization [XRD, SEM, TEM, AFM]

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Mechanical assesment

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Fractography

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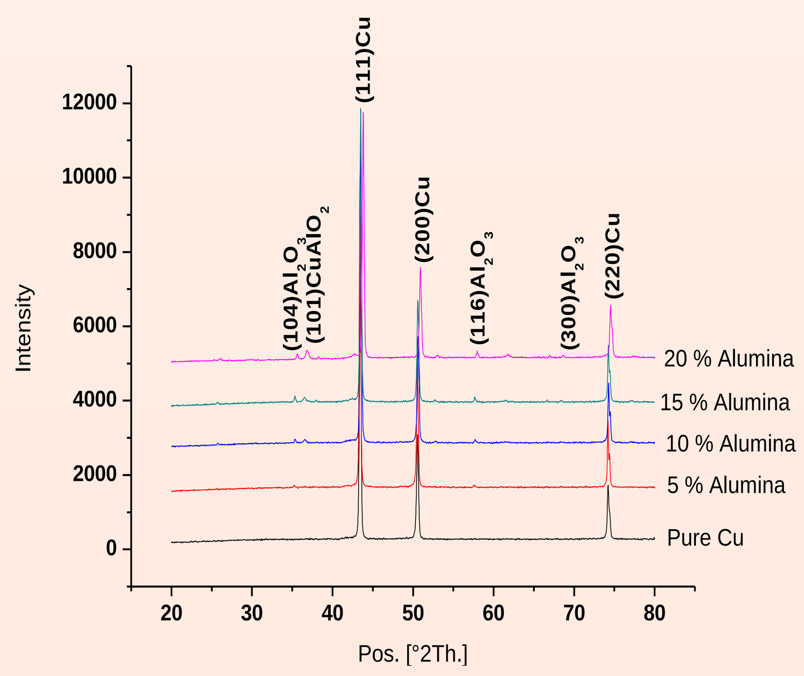
Numerical simulation

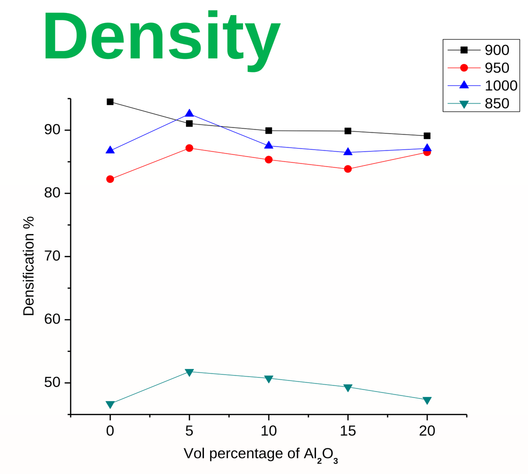
Results & Discussions

XRD



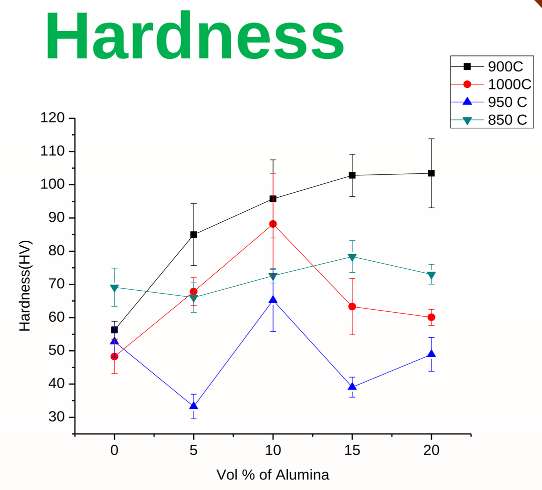
XRD spectra of different vol % reinforcement of Copper– Alumina micro composite

Density



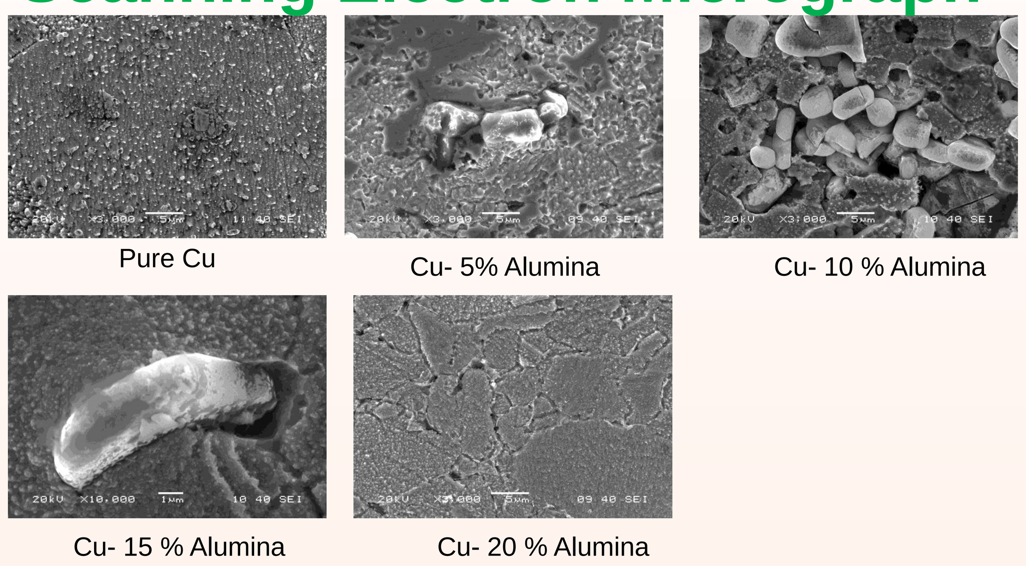
Variation of densification % with vol % of reinforcement at different sintering temperature

Hardness

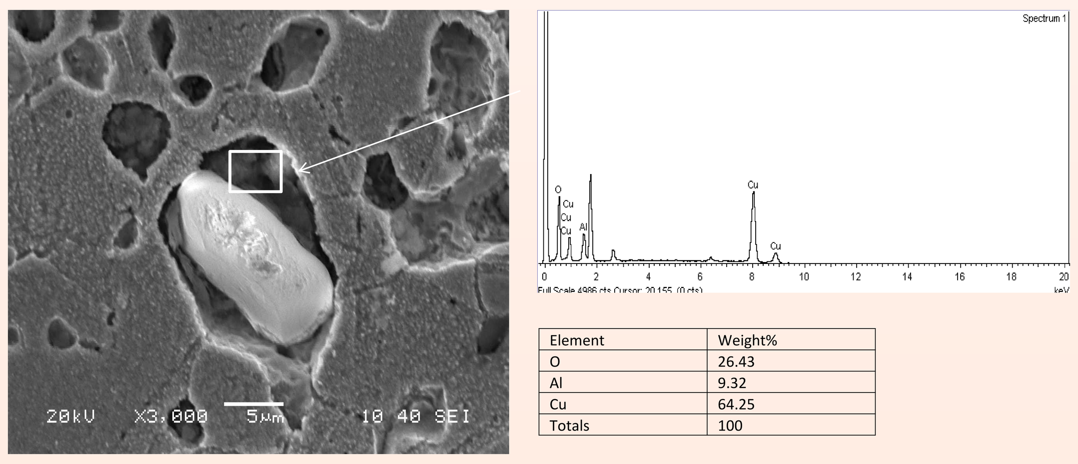


Variation of Microharness (HV) with vol % of reinforcement at different sintering temperature

Scanning Electron Micrograph



SEM micrograph of copper – alumina composite at a sintering temperature of 900 C . Matrix reinforcement interface interaxction are shown.

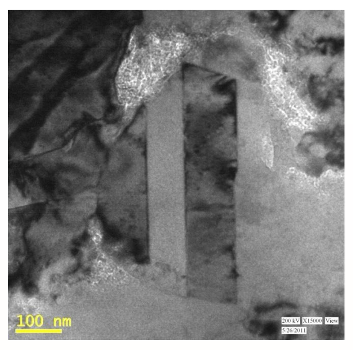


Element	Weight%
O	26.43
Al	9.32
Cu	64.25
Totals	100

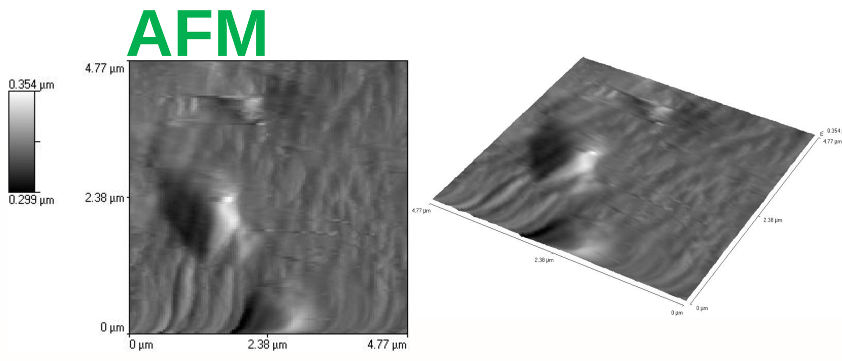
SEM micrograph & EDS spectra of Cu- 10% Alumina composite; elemental composition is also shown in the table

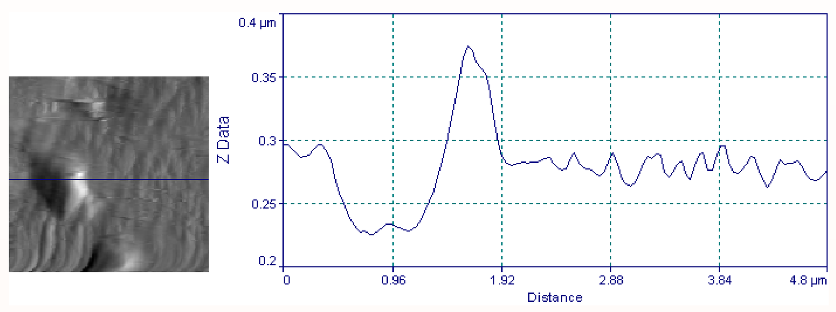
✓The inadequate ratio of the surface area of matrix particles to the reinforcement particles has lead to the formation of cluster in high vol. % of the reinforcement.
✓The homogeneous distribution of reinforcement, if ratio of the particle size of the particulate to the particle size of the matrix is close to one.

TEM


TEM micrograph showing the dislocation and twin bands on composite

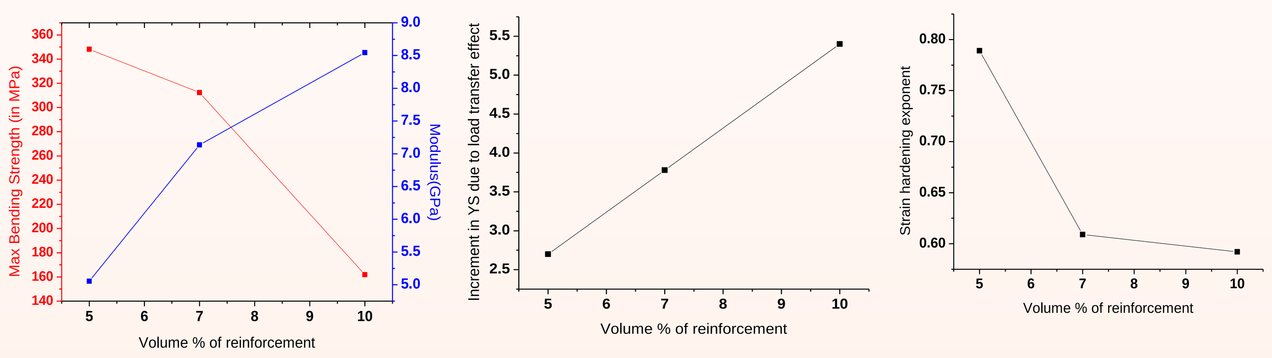
AFM


3 Dimensional surface profile of MMCs



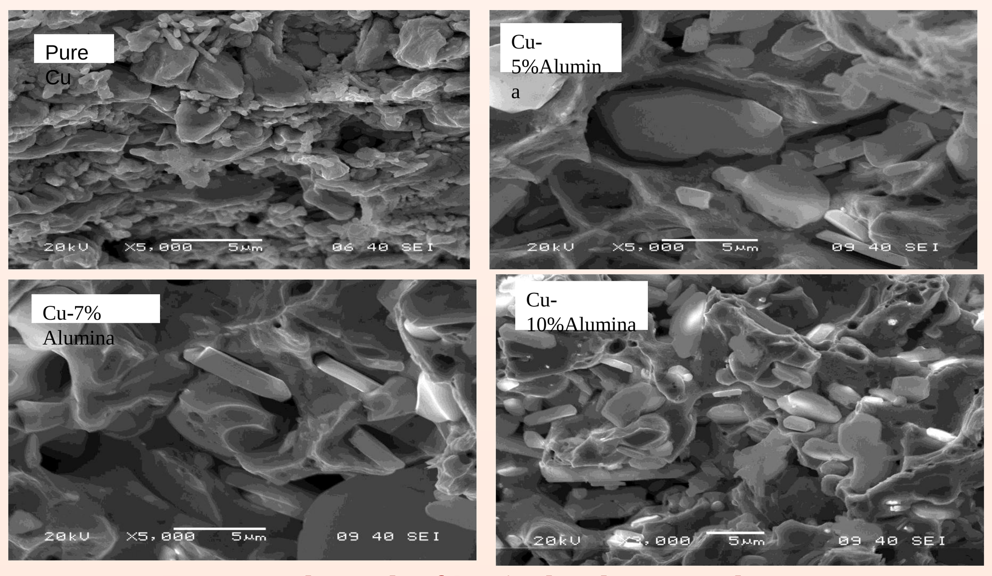
Line scan of Cu – 5 % alumina AFM micrograph

Mechanical Property



Effect of reinforcement content on mechanical properties of the composite

Fractography



Fractography study of 3 point bend test sample

Numerical Simulation

$$\sigma = K\epsilon^n$$

$$\sigma_{cy} = \sigma_{my}\ [\tfrac{1}{2}\times f(s+2) + (1-f)]$$

$$\sigma_{LT} = \sigma_{CY} - \sigma_{MY} \quad \sigma_y = \sigma_o + kd^{-\frac{1}{2}}$$

Conclusion

Due to the formation of CuAl2O4 makes the matrix softer as a result Hardness decreases at a high vol % of reinforcement.
Numerical simulation is a best tool to examine the performance of a composite.
Orowan strengthning mechanisms, Hall Pitch relation, Taylor work hardening equation are most useful relations to analysis the mechanical property of composite.

References

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