Review of Synthesis and Mechanical Properties of Graphene Reinforced Magnesium Composites

[1]R.Vinoth, [2]A.Asharudeen, [3]E.Balachandar, [4]M.Dinesh Kumar, [5]S.Dinesh

[1]Assistant Professor, [2,3,4,5]B.E. Students
Mechanical Engineering Department
Nandha Engineering College, Erode, India.

***Abstract*: To fabricate the magnesium reinforced metal matrix composites by using graphene nanoplatelets (GNPs) in powder metallurgy processing, Its very excellent mechanical properties lead it to be used in nanocomposites for strength enhancement, In microstructural evaluation and mechanical behaviors of composite powders and extruded bulk materials were examined by X-ray diffraction(XRD), differential scanning calorimetry (DSC), scanning electron microscopy(SEM), equipped with energy-dispersive spectrometer and mechanical tests. The graphene nanoplatelets addition on the mechanical behavior of pure magnesium under both tension and hardness is investigated, to increase in a young's modulus, yield strength.**

***Keywords*: Magnesium, graphene nanoplatelets, metal matrix composites, powder metallurgy method, crystallographic texture, mechanical properties.**

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1. INTRODUCTION

Graphene is a single layer of graphite, To have attracted particular interest owing to its high electrical, thermal and mechanical properties, An attempt was made to synthesize the Al-graphene nanocomposite through hot isostatic pressing and extrusion techniques, In experimental result is that Al-graphene nanocomposite showed decreased strength and hardness, The thermal and tensile properties of Al- graphene nanocomposites through friction stir processing, The friction stir processing and graphene reinforcement both improve the ductility of the fabricated component, The tensile strength of graphene nanoflakes-aluminium nanocomposites, Its result is increase in filling content of graphene nanoflakes, and poor ductile. To synthesize the magnesium metal matrix composite reinforced by graphene nanoplatelets due to poor wettability between Mg –graphene platelets, To prepare the magnesium-graphene nanocomposites to evaluate the micro hardness, Have increase in wettability of graphene-magnesium matrix composite to added in aluminium metal matrix, therefore small amount aluminium particles can be added matrix along with graphene nanoplatelets to enhance the wettability.

2. LITERATURE REVIEW:

1. The aim of this study is to fabricate magnesium reinforced metal matrix composites using graphene nanoplatelets (GNPs) via powder metallurgy processing in order to enhance room temperature mechanical properties. The uniform dispersion and large specific surface area per volume of GNPs embedded in magnesium matrix led to increment in micro hardness, tensile strength of composites.

2. Its excellent mechanical properties lead it to use in nanocomposites for enhancement of strength. The effect of graphene nanoplatelets addition on the mechanical behaviour of pure magnesium under tension and hardness is investigated.

3. The elastic properties and an intrinsic strength of monolayer graphene will be investigated. Graphene was the strongest material, that atomically nanoscale materials.

4. A Rapid growth of engineering communities to thermal properties of materials. Thermal And thermoelectric properties of carbon materials focusing for graphene, carbon nanotubes with degrees of disorder.

5. The thermal properties of graphene and graphite at room temperature are dominated by the acoustic phonons. Additional benefits of the graphene based composites which come at no additional are their expense low coefficient of thermal expansion and increased mechanical strength.

6. The synthesis and thermal properties of the electrically conductive thermal interface material with the hybrid graphene-metal particle filler. The strong enhancement of thermal properties are to the high intrinsic thermal conductivity of the graphene materials.

7. Carbonaceous materials attracted interest for engineering application due to fascinated electrical, thermal and mechanical properties. Pure Mg and Mg-composites are synthesized by semi-powder metallurgy with sintering process followed by hot extrusion.

8. Graphene reinforcement is applied in the form of a graphene oxide (GO) water colloid for safer and simpler processing. The result of Raman spectroscopy, the graphene reinforcement successfully mixed into the aluminium matrix by FSP (Friction stir processing).

9. The electronic structure of graphene is captured in Raman spectrum that clearly evolves with the number of layers. The unambiguous, high-throughput, non-destructive identification of graphene layers are allowed. This layer is critically lacking in this emerging research area. Various forms of graphite, nanotubes, bucky balls, and other can all be derivatives of graphene and not surprisingly, this basic materials has been investigated.

10. Carbon nanotubes reinforced magnesium nanocomposites are synthesised using powder metallurgy followed by hot extrusion. The thermo mechanical property results increase in thermal stability with increasing amount of CNTs and Mg nanocomposites.

11. There have been several investigations of the elastic stresses and strains generated about an inclusion, which has a coefficient of thermal expansion different from that of the matrix, as a result of heating or cooling. There have been a few investigations of the magnitude of the plastic strain and the plastic zone under the above conditions wherein the plastic deformation induced by the difference between the thermal expansion coefficients was treated in a continuum manner. An in situ transmission electron microscopy investigation was undertaken of dislocation generation at the inclusions due to the differential thermal contraction.

12.The strengthening behaviour of particle reinforced metal matrix composites is primarily attributed to the dislocation strengthening effect.to account for this two effect in a unified way , a new hybrid approach is developed in this paper by incorporating the geometrically necessary dislocation strengthening effect into the incremental micro mechanical scheme.

13. Magnesium is the lightest structural metal CNTs are light weight reinforced with exceptional mechanical properties. Nano-composites configuration exhibit different tensile and compressive response as function of CNT. Due to inherent nature of ball milling may get different Al-CNT particles in term of size and surface energy.

14. Modern technology in the areas aerospace and automotive industry had led to development of metal matrix composites. MMCs are in light in weight, economically viable, amenable for production. Mg has some limitations such as low elastic module, rapid loss of strength with increase of temperature.

15. There are two main approaches to interpreting the mechanical properties of materials In the continuum approach it is assumed that the material's properties can be described by global parameters. In the micro-mechanistic approach the understanding is built-up from a knowledge of the deformation processes at the atomic level. The effect of the particle parameters on the mechanical properties and to assess the relative importance of the various strengthening models, MMCs based on pure aluminium were manufactured using a powder metallurgy route. Billets were made using -45 micron aluminium (1050) powder and black Sic of various grades. The billets contained from 5 to 30 % reinforcement.

16. The Al-Cu particulate hybrids were incorporated into the Mg through into the powder metallurgy. Powder metallurgy and hot extrusion method proved to be effective in synthesizing the Mg based alloys. The mechanical properties of the synthesized alloys were superior when compared to the composites reinforced.

17. Graphene nanoplatelets (GNPs) are novel reinforcing fillers due to their fascinating mechanical properties. However, their unique mechanical properties rapidly devolve as the sheets aggregate due to strong van der Waals forces. Therefore limiting their applications in metal matrix composites. The rapid aggregation of two-dimensional GNPs was inhibited by intercalating one-dimensional multi-walled carbon nanotubes (MW-CNTs).

18**.** The cohesive law for interfaces between a carbon nanotube (CNT) and polymer that are not well bonded and are characterized by the van der Waals force. The cohesive strength and energy are given by a terms of the area density of carbon nanotube and volume density of polymer. CNT in infinite polymer, the shear cohesive stress vanishes, and the tensile cohesive stress depends on the opening displacement. CNT in a finite polymer matrix, the tensile cohesive stress remains same.

19. The graphene was achieved by a combination of electron beam lithography and etching. The specimen cleaned in situ by employing current-induced heating. Then, directly resulting in a significant improvement of electrical transport.With large mobility enhancement, widths of the characteristic Dirac peaks are reduced by a factor of 10 compared to traditional, non-suspended devices.

20. The graphene-MLG nanocomposites were prepared by ultrasonication of natural graphite in aqueous solution of sodium. The solution was left for ~1 hr to settle followed by removal of thick graphite flakes.

21. These paper establish graphene as the strongest material ever measured, and show that automatically perfect nanoscale materials can be mechanically tested to deformations well beyond the linear regime.

22. A special attention is given to the unusual size dependence of heat conduction in two dimensional crystal and specifically in graphene

23.That the demonstrated enhancement of TIM's thermal conductivity by a factor of 10-20 compared to that of the matrix materials may lead to revolutionary increase in device and system performance not only in electronic but also in open electronics and renewable energy generation.

24. The unusually strong enhancement of thermal properties were attributed to the high intrinsic thermal conductivity of graphene, strong graphene coupling to matrix material. The obtained results are important for thermal management of advanced electronic and open electronics

25. We found that the optimized mixture of graphene and multilayer graphene, produced by the high-yield inexpensive liquid-phase-exfoliation technique, can lead to an extremely strong enhancement of the cross-plane thermal conductivity *K* of the composite

26. This article presents the preparation and characterization of wood flour/polypropylene (PP) composites filled with graphene nanoplatelets (GNPs). The effects of GNPs act as reinforcing agent, on the mechanical and physical properties were investigated. The order to increase the interphase adhesion, the maleic anhydride grafted polypropylene (MAPP) was added as the coupling agent to all the composites were studied.

27.The roles of interfaces and matrix grain size in the deformation and failure of polycrystalline Cu–graphene nanolayered (PCuGNL) composites under shear loading are explored with molecular dynamics simulations for the different layer spacings (λ), Cu grain sizes (*D*) and graphene chiralities.

28. Graphene/Al MMC is fabricated by FSP in order to take advantage of the extremely high thermal conductivity of graphene while maintaining a light Weight aluminium matrix.

29. The hybrid MW-CNT'S intercalated GNP's reinforced Mg matrix composites revealed significant improvement in mechanical strength.

30. Its excellent mechanical properties lead it to be used in nanocomposites for strength enhancement. In present work, a new magnesium-graphene nanoplatelets composite is fabricated for the first time using semi-powder metallurgy method.

31**.** The hybrid MW-CNT'S intercalated GNP's reinforced Mg matrix composites revealed significant improvement in mechanical strength.

32. Graphene's electronic structure is uniquely captured in Raman spectrum that clearly evolves with number of layers.

33. This method can be an alternative of ball milling and has great potential for fabrication of Mg-based nanocomposites, for engineering applications.

34. Room temperature tensile results showed that the addition of Ti þ GNPs to monolithic Mg lead to increase in 0.2% yield strength (0.2% YS), ultimate tensile strength (UTS), and failure strain.

35. The aim of this study is to fabricate magnesium reinforced metal matrix composites using graphene nanoplatelets (GNPs) via powder metallurgy processing in order to enhance room temperature mechanical properties

36. We found that an optimized mixture of graphene and multilayer graphene – produced by the high-yield inexpensive liquid-phase-exfoliation technique – can lead to an extremely strong enhancement of the cross-plane thermal conductivity K of the composite.

37. The modification of grapheme/graphene oxide and the utilization of these materials in the fabrication of nanocomposite with different polymer matrix have been explored.

38. Graphene has been attracted considerable attention in the last several years because of properties such as high mechanical strength and modulus, electrical and thermal conductivity and optical transmittance.

39. The thermal conductivity enhancement due to the presence of graphene in the composites has been observed for a range of matrix materials used by industry. The hybrid composites of the graphene is utilized together with metallic micro and nanoparticles allow to tune both the thermal and electrical conductivity of these materials.

40. The strengthening behavior of particle-reinforced metal–matrix composites (MMCp) is primarily attributed to the dislocation strengthening effect and the load-transfer effect. The new hybrid approach was developed by incorporating the geometrically necessary dislocation strengthening effect into the incremental micromechanical scheme.

41. Carbon nanotubes (CNTs) reinforced magnesium nanocomposites were synthesized using the powder metallurgy technique

followed by hot extrusion. 0.3 wt. % of CNTs were added as reinforcements. Effects of carbon nanotubes on the physical and mechanical properties of Mg composites are investigated.

42. EM is operated in the vacuum and focuses the electron beam and magnifies images with the help of electromagnetic lenses. The electron microscope takes advantage of the much shorter wavelength of the electron, when compared to the wavelengths of visible light. The accelerating voltage is increased in EM, the wavelength and resolution are decreases. Scanning Electron Microscopy (SEM) is a powerful method to investigate the surface structures of molecules.

43.Graphene based papers attract particular interests recently owing to their outstanding properties, the key is the layer-by-layer hierarchical structures similar to biomaterials such as bone, teeth and nacre, combining interlayer strong bonds and interlayer crosslinks for efficient load transfer.

44. The synthesis and thermal properties of the electrically-conductive thermal interface materials with the hybrid graphene metal particle in fillers. The thermal conductivity of resulting composites was increased by 500% in a temperature range of 300 K to 400 K at a small graphene loading fraction.

45. Graphene is the two-dimensional building block for carbon allotropes of every other dimensionality. The electronic structure is captured in its Raman spectrum that clearly evolves with the number of layers. In the Raman spectrum, the peak second order changes in shape, width, and position for an increasing number of layers.

46. Friction stir processing (FSP) is a solid state surface modification technique, which uses the same approach as friction stir welding (FSW), and the solid-state joining technique developed. During FSP, a rotating tool was inserted into a material and mechanically stirs the material, which is softened by the frictional heat generated by the tool.

47. In the field of thermal interface materials (TIMs) graphene (thermal conductive nanomaterials) have been used as excellent fillers. The strong graphene coupling to the metal matrix particles caused an increase in the thermal conductivity of the resulting composite up to 2300%.

3. EXPERIMENTAL PROCEDURE

3.1. Raw materials:

The average thickness and diameter of graphene nanoplatelets were 5-15nm and 10-25µm respectively. The Mg powder of 70µm particle size.

3.2. Preparation of nanocomposites:

The magnesium and GNPs composites are fabricated using liquid based mixing in the ethanol. The Mg powder was mixed with required weight fractions of GNPs along with small amount of Al particles in ethanol amount of Al particles in ethanol solution using mechanical agitator and fabricated using powder metallurgy with sintering process by hot extrusion.

3.3. Material characterization:

The mechanical agitated composite powders were characterized by scanning electron microscopy, differential scanning calorimetry (DSC). Bulk samples were machined from extruded rods to evaluate the microstructural studies using TEM and SEM equipment. X-ray diffraction (XRD) is used for composite powders and extruded materials.

4. CONCLUSION:

From the literature survey, there is a significant increase in the strength of composites when compared to pure Mg the suspended graphene particles transfer the load applied more efficiently, there are improvements in the coefficient of thermal expansion and crystallographic texture of the composites when compared with pure Mg. The GNPs and CNTs have similar molecular structure but GNPs have high potential to enhance the strength of Mg composites compared to CNTs. This is because of high specific surface area per unit volume of GNPs.

REFERENCES

[1] C. Lee, X. Wei, J.W. Kysar, J. Hone, Science, 321 (2008) 385-388.

[2] A.A. Balandin, Nat Mater, 10 (2011) 569-581.

[3] K.M.F. Shahil, A.A. Balandin, Solid State Communications, 152 (2012) 1331-1340.

[4] V. Goyal, A.A. Balandin, Applied Physics Letters, 100 (2012) -.

[5] K.M.F. Shahil, A.A. Balandin, Nano Letters, 12 (2012) 861-867.

[6] T. Kuilla, S. Bhadra, D. Yao, N.H. Kim, S. Bose, J.H. Lee, Progress in Polymer Science, 35 (2010) 1350-1375.

[7] S.F. Bartolucci, J. Paras, M.A. Rafiee, J. Rafiee, S. Lee, D. Kapoor, N. Koratkar, Materials Science and Engineering: A, 528 (2011) 7933-7937.

[8] R. Pérez-Bustamante, D. Bolaños-Morales, J. Bonilla-Martínez, I. Estrada-Guel, R. Martínez-Sánchez, Journal of Alloys and Compounds, 615, Supplement 1 (2014) S578- S582.

[9] C.-H. Jeon, Y.-H. Jeong, J.-J. Seo, H. Tien, S.-T. Hong, Y.-J. Yum, S.-H. Hur, K.-J. Lee, Int. J. Precis. Eng. Manuf., 15 (2014) 1235-1239.

[10] S.J. Yan, S.L. Dai, X.Y. Zhang, C. Yang, Q.H. Hong, J.Z. Chen, Z.M. Lin, Materials Science and Engineering: A, 612 (2014) 440-444.

[11] M. Bastwros, G.-Y. Kim, C. Zhu, K. Zhang, S. Wang, X. Tang, X. Wang, Composites Part B: Engineering, 60 (2014) 111-118.

[12] L.-Y. Chen, H. Konishi, A. Fehrenbacher, C. Ma, J.-Q. Xu, H. Choi, H.-F. Xu, F.E. Pfefferkorn, X.-C. Li, Scripta Materialia, 67 (2012) 29-32.

[13] M. Rashad, F. Pan, A. Tang, M. Asif, J. She, J. Gou, J. Mao, H. Hu, Journal of Composite Materials, 49 (2015) 285-293.

[14] M.J. Ferrari AC, Scardaci V, Casiraghi C, Lazzeri M, Mauri F, Piscanec S, Jiang D, Novoselov KS, Roth S, Geim AK., physical Review Letters, 97 (2006) 187401-187404.

[15] N. Stanford, D. Atwell, A. Beer, C. Davies, M.R. Barnett, Scripta Materialia, 59 (2008) 772-775.

[16] Shahil KMF and Balandin AA. Thermal properties of the graphene and multilayer graphene, Applications in ther- mal interface materials. Solid State Common 2012; 152: 1331–1340.

[17] Shahil KMF and Balandin AA. The Graphene multilayer graphene nanocomposites as highly efficient thermal interface materials. Nano Lett 2012; 12: 861–867.

[18] Rashad M, Pan FS, Tang A. The Effect of graphene nanoplatelets, addition in strength and ductility of magnesium titanium alloys. J Magnesium Alloy 2013; 1: 242–248.

[19] Goh CS, Wei J, Lee LC. The development of novel carbon nanotube reinforced magnesium nano composites using a powder metallurgy technique. Nanotechnology 2006; 17: 7–12.

[20] Carren˜ o-Morelli E, Yang J, Couteau E, et al. Carbon nanotube/magnesium composites. Phys Stat Sol 2004; 201: R53–R55.

[21] Magnesium matrix composites reinforced with graphene nanoplatelets, Muhammad Rashad, Fusheng Pan, Huanhuan Hu, Muhammad Asif, Shahid Hussain, Jia She

[22] M. Rashad, F. Pan, A. Tang, M. Asif, J. She, J. Gou, J. Mao, H. Hu, Journal of Composite materials, 49 (2015) 285-293.

[23] C. Lee, X. Wei, J.W. Kysar, J. Hone, Science, 321 (2008) 385-388.

[24] A.A. Balandin, Nat Mater, 10 (2011) 569-581.

[25] K.M.F. Shahil, A.A. Balandin, Solid State Communications, 152 (2012) 1331-1340.

[26] V. Goyal, A.A. Balandin, Applied Physics Letters, 100 (2012)

[27] M. Bastwros, G.-Y. Kim, C. Zhu, K. Zhang, S. Wang, X. Tang, X. Wang, Composites Part B: Engineering, 60 (2014) 111-118.

[28] C.-H. Jeon, Y.-H. Jeong, J.-J. Seo, H. Tien, S.-T. Hong, Y.-J. Yum, S.-H. Hur, K.-J. Lee, Int. J. Precis. Eng. Manuf., 15 (2014) 1235-1239.

[29] M.J. Ferrari AC, Scardaci V, Casiraghi C, Lazzeri M, Mauri F, Piscanec S, Jiang D, Novoselov KS, Roth S, Geim AK., physical Review Letters, 97 (2006) 187401-187404.

[30] C.S.Goh, J.Wei, L.C.Lee and M.Gupta, Development of noval carbon nanotubes reinforced magnesium nanocomposites using powder metallurgy technique.

[31] R.J. Arsenault, N. Shi, Materials Science and Engineering, 81 (1986) 175-187.

[32] L.H. Dai, Z. Ling, Y.L. Bai. Composites Science and Technology, 61 (2001) 1057- 1063.

[33] M.K. Habibi, A.M.S. Hamouda, M. Gupta, Composites Science and Technology, 72 (2012) 290-298.

[34] M.K. Habibi, A.S. Hamouda, M. Gupta, Materials & Design, 49 (2013) 627-637.

[35] W.S. Miller, F.J. Humphreys, Scripta Metallurgical et Materialia, 25 (1991) 33-38.

[36] M. Rashad, F. Pan, M. Asif, S. Hussain, M. Salem, Materials Characterization, 95 (2014) 140-147.

[37] S.U. Reddy, N. Srikanth, M. Gupta, S.K. Sinha, Advanced Engineering Materials, 6 (2004) 957-964.

[38] Jiang.L.Y, Haung.Y, Jiang.H.et al.A cohesive law for carbon nanotube polymer interfaces based on van der waals force. J Mech Phys solids 2006: 54:2436-2452.

[39] Bolotin.KI, Sikes KJ, Jiang Z, et al. Ultra high electron mobility in suspended graphene. Solid state commun 2008: 146: 351-355

[40] Shahil KML and Balandin AA. Graphene-multilayer graphene nano composites as highly efficient thermal interface materials. Nano Let 2012: 12:861-867.

[41] C. S. Goh, J. Wei, L. C. Lee and M. Gupta1, Development of novel carbon nanotubes reinforced magnesium nanocomposites using powder metallurgy technique

[42] C. T. K.-H. Stadtländer Scanning Electron Microscopy and Transmission Electron

[43] Yilun Liu 1,2 , Bo Xie 1,2 , Zhong Zhang 2,3 , Quanshui Zheng 1,2 and Zhiping Xu 1,2,* Mechanical Properties of Graphene Papers

[44] Vivek Goyal1,2 and Alexander A. Balandin1,* Thermal Properties of the Hybrid Graphene-Metal Nano-Micro-Composites: Applications in Thermal Interface Materials

[45] A.C. Ferrari,1,* J.C. Meyer,2 V. Scardaci,1 C. Casiraghi,1 M. Lazzeri,3 F. Mauri,3 S. Piscanec,1 D. Jiang,4 K.S. Novoselov,4 S. Roth,2 and A.K. Geim4, Raman Spectrum of Graphene and Graphene Layers

[46] Chi-Hoon Jeon1, Yong-Ha Jeong2, Jeong-Jin Seo3, Huynh Ngoc Tien4, Sung-Tae Hong2,#, Young-Jin Yum2, Seung-Hyun Hur4, and Kwang-Jin Lee5, Material Properties of Graphene/Aluminum Metal Matrix Composites Fabricated by Friction Stir Processing.

[47] Muhammad Rashad, fusheng pan, aitato, tang yun Lu, Muhammad asif, shahid Hussain, Jia she, Jun gou, jianjun moa, Effect of graphene nanoplatelets (GNPs) addition on strength and ductility of magnesium –titanium alloys.