Scopus

Documents

Parveez, B.[a] , Jamal, N.A.[a] , Nazurah, N.I.[a] , Aabid, A.[b] , Baig, M.[b]

Effects of Diamond Content on the Morphology and Compressive Properties of Porous Aluminum Composites
(2024) *ACS Omega*, .

DOI: 10.1021/acsomega.4c05354

[a] Department of Manufacturing and Materials Engineering, Kulliyyah of Engineering, International Islamic University Malaysia, Kuala Lumpur, 53100, Malaysia
[b] Department of Engineering Management, College of Engineering, Prince Sultan University, Riyadh, 11586, Saudi Arabia

Abstract
Porous aluminum (Al) is popular due to its lightweight properties and impact energy absorption. However, it often has a lower mechanical strength than solid Al. To improve the performance, diamond reinforcement was introduced into the matrix. Further, addressing the challenge of interfacial bonding between Al and diamond, coated diamond with varying contents of 5, 10, 15, and 20 wt % was added to the porous Al alloy matrix via the powder metallurgy technique. The porosities were formed by using poly(methyl methacrylate) (30 wt %) as a space holder. The densities of the resultant porous composites ranged from 2.20 to 2.37 g/cm3 and porosities ranged from 33 to 38% for 5-20 wt % diamond contents. Furthermore, the yield strength and plateau stress increased from 21.47 to 29.46 MPa and 14 to 20 MPa, respectively, up to 10 wt % diamond content but declined upon further addition. Similarly, the energy absorption capacity increased from 2.15 to 2.95 MJ/m3 up to 10 wt % diamond content and thereafter decreased. Thus, the addition of coated diamond and alloying elements in Al strengthened the porous Al composites, making it suitable for applications requiring good compressive strength and energy absorption capacity. © 2024 The Authors. Published by American Chemical Society.

References

- Fleck, N.
(2016) *Metal Foams: A Design Guide*, 3069, p. 264.
Elsevier

- Goel, M.D., Matsagar, V.A., Marburg, S., Gupta, A.K.
Comparative Performance of Stiffened Sandwich Foam Panels under Impulsive Loading
(2013) *J. Perform. Constr. Facil.*, 27 (5), pp. 540-549.

- Atturan, U.A., Nandam, S.H., Murty, B.S., Sankaran, S.
Processing and Characterization of In-Situ TiB2 Stabilized Closed Cell Aluminium Alloy Composite Foams
(2016) *Mater. Des.*, 101, pp. 245-253.

- Zhiqiang, G., Donghui, M., Xiaoguang, Y., Xue, D.
Effect of Mg Addition on the Foaming Behaviour of AlSi7 Based Alloy Prepared by Powder Metallurgy Method
(2016) *Xiyou Jinshu Cailiao Yu Gongcheng/Rare Met. Mater. Eng.*, 45 (12), pp. 3068-3073.

- Das, S., Rajak, D.K., Khanna, S., Mondal, D.P.
Energy Absorption Behavior of Al-SiC-Graphene Composite Foam under a High Strain Rate
(2020) *Materials*, 13 (3), p. 783.

- Maiorano, L.P., Castillo, R., Molina, J.M.
Al/Gf Composite Foams with SiC-Engineered Interfaces for the next Generation of Active Heat Dissipation Materials
(2023) *Compos. Part A Appl. Sci. Manuf.*, 166, p. 107367.

- Parveez, B., Jamal, N.A., Aabid, A., Baig, M.
  Microstructure and Strengthening Effect of Coated Diamond Particles on the Porous Aluminum Composites
  (2023) *Materials (Basel).*, 16 (8), pp. 3240-3312.

- Ukhina, A.V., Bokhonov, B.B., Dudina, D.V.
  Selective Deposition of Mo2C-Containing Coatings on {100} Facets of Synthetic Diamond Crystals
  (2022) *Int. J. Mol. Sci.*, 23 (15), p. 8511.

- Damanik, F.S., Damanik, M.S.F., Lange, P.G.
  Effect of Nickel Coated of Carbon Fiber on Distribution of Carbon Fiber Reinforced Aluminium (AlSi7) Foam Composite by Powder Metallurgy
  (2019) *Int. Conf. Innov. Technol.*, 1381, pp. 9-13.

- Chen, M., Liu, B., Ji, Z., Jia, C., Wu, Q., Liu, Z.
  Mechanical Properties and Damping Properties of Carbon Nanotube-Reinforced Foam Aluminum with Small Aperture
  (2020) *J. Mater. Res.*, 35 (19), pp. 2567-2574.

- Zhang, C., Wang, R., Cai, Z., Peng, C., Wang, N.
  Low-Temperature Densification of Diamond/Cu Composite Prepared from Dual-Layer Coated Diamond Particles
  (2015) *J. Mater. Sci. Mater. Electron.*, 26 (1), pp. 185-190.

- Che, Z., Wang, Q., Wang, L., Li, J., Zhang, H., Zhang, Y., Wang, X., Kim, M.J.
  Interfacial Structure Evolution of Ti-Coated Diamond Particle Reinforced Al Matrix Composite Produced by Gas Pressure Infiltration
  (2017) *Compos. Part B Eng.*, 113, pp. 285-290.

- Yang, W., Peng, K., Zhu, J., Li, D., Zhou, L.
  Enhanced Thermal Conductivity and Stability of Diamond/Aluminum Composite by Introduction of Carbide Interface Layer
  (2014) *Diam. Relat. Mater.*, 46, pp. 35-41.

- B.Novak, K., Tschope, A.P.R.
  Fundamentals of Aluminium Carbide Formation
  (2012) *Light Met.*, (2), pp. 1-1407.

- Jiao, Z., Kang, H., Zhou, B., Kang, A., Wang, X., Li, H., Yu, Z., Wei, Q.
  Research Progress of Diamond/Aluminum Composite Interface Design
  (2022) *Funct. Diam.*, 2 (1), pp. 25-39.

- Parveez, B., Jamal, N.A., Raeez, M.
  Investigation of Morphology and Compressive Properties of Diamond Reinforced Porous Aluminium Composites
  (2023) *Asian J. Fundam. Appl. Sci.*, 4 (1), pp. 12-17.

- Parveez, B., Jamal, N.A., Anuar, H., Ahmad, Y., Aabid, A., Baig, M.
  Microstructure and Mechanical Properties of Metal Foams Fabricated via Melt Foaming and Powder Metallurgy Technique: A Review
  (2022) *Materials*, 15, p. 5302.

- Yang, X., Hu, Q., Li, W., Song, H., Zou, T., Zong, R., Sha, J., Zhao, N.
  Compression-Compression Fatigue Performance of Aluminium Matrix Composite Foams Reinforced by Carbon Nanotubes
  (2020) *Fatigue Fract. Eng. Mater. Struct.*, 43 (4), pp. 744-756.

- Duarte, I., Ventura, E., Olhero, S., Ferreira, J.M.F.
  A Novel Approach to Prepare Aluminium-Alloy Foams Reinforced by Carbon-

Nanotubes
(2015) *Mater. Lett.*, 160, pp. 162-166.

- Jiang, B., Wang, Z., Zhao, N.
Effect of Pore Size and Relative Density on the Mechanical Properties of Open Cell Aluminum Foams
(2007) *Scr. Mater.*, 56 (2), pp. 169-172.

- Mohd Razali, R.N., Abdullah, B., Muhammad Hussain, I., Ahmad, U.K., Idham, M.F., Ramli, A.
Mechanical Properties of Aluminium Foam by Conventional Casting Combined with NaCL Space Holder
(2013) *Appl. Mech. Mater.*, 393, pp. 156-160.

- Yang, X., Hu, Q., Du, J., Song, H., Zou, T., Sha, J., He, C., Zhao, N.
Compression Fatigue Properties of Open-Cell Aluminum Foams Fabricated by Space-Holder Method
(2019) *Int. J. Fatigue*, 121, pp. 272-280.

- Yang, K., Yang, X., He, C., Liu, E., Shi, C., Ma, L., Li, Q., Zhao, N.
Damping Characteristics of Al Matrix Composite Foams Reinforced by In-Situ Grown Carbon Nanotubes
(2017) *Mater. Lett.*, 209, pp. 68-70.

- Parveez, B., Jamal, N.A., Maleque, M.A., Rozhan, A.N., Aabid, A., Baig, M.
Optimizing the Compressive Properties of Porous Aluminum Composites by Varying Diamond Content, Space Holder Size and Content
(2023) *Materials*, 16 (3), p. 921.

- Jamal, N.A., Tan, A.W., Yusof, F., Katsuyoshi, K., Hisashi, I., Singh, S., Anuar, H.
Fabrication and Compressive Properties of Low to Medium Porosity Closed-Cell Porous Aluminum Using PMMA Space Holder Technique
(2016) *Materials*, 9 (4), p. 254.

- Tan, P.P., Mohamad, H., Anasyida, A.S.
Properties of Porous Magnesium Using Polymethyl Methacrylate (PMMA) as a Space Holder
(2018) *J. Phys. Conf. Ser.*, 1082 (1), pp. 12063-12066.

- Shahzeydi, M.H., Parvanian, A.M., Panjepour, M.
The Distribution and Mechanism of Pore Formation in Copper Foams Fabricated by Lost Carbonate Sintering Method
(2016) *Mater. Charact.*, 111, pp. 21-30.

- Wang, H., Su, M., Hao, H.
Compressive Properties and Energy Absorption Behavior of Mg17Al12/Al Ordered Structure Composites
(2021) *Compos. Part B Eng.*, 210 (2), p. 108688.

- Showaiter, N., Youseffi, M.
Compaction, Sintering and Mechanical Properties of Elemental 6061 Al Powder with and without Sintering Aids
(2008) *Mater. Des.*, 29 (4), pp. 752-762.

- Jamal, N., Tan, A., Yusof, F., Katsuyoshi, K., Hisashi, I., Singh, S., Anuar, H.
Fabrication and Compressive Properties of Low to Medium Porosity Closed-Cell Porous Aluminum Using PMMA Space Holder Technique
(2016) *Materials*, 9, p. 254.

- Awad, M., Hassan, N.M., Kannan, S.
Mechanical Properties of Melt Infiltration and Powder Metallurgy Fabricated

Aluminum Metal Matrix Composite
(2021) *Proc. Inst. Mech. Eng. Part B J. Eng. Manuf.*, 235 (13), pp. 2093-2107.

- Lee, B., Lee, T., Lee, Y., Lee, D.J., Jeong, J., Yuh, J., Oh, S.H., Lee, C.S.
Space-Holder Effect on Designing Pore Structure and Determining Mechanical Properties in Porous Titanium
(2014) *Mater. Des.*, 57, pp. 712-718.

- Michailidis, N., Tsouknidas, A., Lefebvre, L.P., Hipke, T., Kanetake, N.
Production, Characterization, and Applications of Porous Materials
(2014) *Adv. Mater. Sci. Eng.*, 2014, pp. 1-2.

- Khamsuk, S., Choosakull, K., Wanwong, P.
Effect of Space Holder Size on the Porous High Purity Aluminum Property
(2020) *Key Eng. Mater.*, 846, pp. 93-98.

- Bekoz, N., Oktay, E.
Effects of Carbamide Shape and Content on Processing and Properties of Steel Foams
(2012) *J. Mater. Process. Technol.*, 212 (10), pp. 2109-2116.

- Liang, X., Jia, C., Chu, K., Chen, H., Nie, J., Gao, W.
Thermal Conductivity and Microstructure of Al/Diamond Composites with Ti-Coated Diamond Particles Consolidated by Spark Plasma Sintering
(2012) *J. Compos. Mater.*, 46 (9), pp. 1127-1136.

- Bo, Y.A., Yu, J.K., Chuang, C.H.
Microstructure and Thermal Expansion of Ti Coated Diamond/Al Composites
(2009) *Trans. Nonferrous Met. Soc. China*, 19 (5), pp. 1167-1173.

- Zhang, Y., Wang, X., Jiang, S., Wu, J.
Thermo-Physical Properties of Ti-Coated Diamond/Al Composites Prepared by Pressure Infiltration
(2010) *Mater. Sci. Forum*, 654-656, pp. 2572-2575.

- Sun, Y., Zhang, C., He, L., Meng, Q., Liu, B.C., Gao, K., Wu, J.
Enhanced Bending Strength and Thermal Conductivity in Diamond/Al Composites with B4C Coating
(2018) *Sci. Rep.*, 8 (1), pp. 11104-11112.

- Chung, C.Y., Chu, C.H., Lee, M.T., Lin, C.M., Lin, S.J.
Effect of Titanium Addition on the Thermal Properties of Diamond/Cu-Ti Composites Fabricated by Pressureless Liquid-Phase Sintering Technique
(2014) *Sci. World J.*, 2014, pp. 1-7.

- Sahu, S., Goel, M.D., Mondal, D.P., Das, S.
High Temperature Compressive Deformation Behavior of ZA27-SiC Foam
(2014) *Mater. Sci. Eng., A*, 607, pp. 162-172.

- Aly, M.S.
Behavior of Closed Cell Aluminium Foams upon Compressive Testing at Elevated Temperatures: Experimental Results
(2007) *Mater. Lett.*, 61 (14-15), pp. 3138-3141.

- Mondal, D.P., Goel, M.D., Das, S.
Effect of Strain Rate and Relative Density on Compressive Deformation Behaviour of Closed Cell Aluminum-Fly Ash Composite Foam
(2009) *Mater. Des.*, 30 (4), pp. 1268-1274.

- Hakamada, M., Nomura, T., Yamada, Y., Chino, Y., Hosokawa, H., Nakajima, T., Chen, Y., Mabuchi, M.

Compressive Properties at Elevated Temperatures of Porous Aluminum Processed by the Spacer Method
(2005) *J. Mater. Res.*, 20 (12), pp. 3385-3390.

- Yang, K., Yang, X., Liu, E., Shi, C., Ma, L., He, C., Li, Q., Zhao, N.
Elevated Temperature Compressive Properties and Energy Absorption Response of In-Situ Grown CNT-Reinforced Al Composite Foams
(2017) *Mater. Sci. Eng., A*, 690, pp. 294-302.

- Guo, C., Zou, T., Shi, C., Yang, X., Zhao, N., Liu, E., He, C.
Compressive Properties and Energy Absorption of Aluminum Composite Foams Reinforced by In-Situ Generated MgAl2O4 Whiskers
(2015) *Mater. Sci. Eng., A*, 645, pp. 1-7.

- Ravi Kumar, N.V., Ramachandra Rao, N., Gokhale, A.A.
Effect of SiC Particle Content on Foaming and Mechanical Properties of Remelted and Diluted A356/SiC Composite
(2014) *Mater. Sci. Eng., A*, 598, pp. 343-349.

- Luo, Y., Yu, S., Liu, J., Zhu, X., Luo, Y.
Compressive Property and Energy Absorption Characteristic of Open-Cell SiCp/AlSi9Mg Composite Foams
(2010) *J. Alloys Compd.*, 499 (2), pp. 227-230.

- Parveez, B., Jamal, N.A., Raeez, M.
Effect of Uncoated and Coated Diamond on the Compressive Properties of Porous Aluminium Composites: Auswirkung von Unbeschichtetem Und Beschichtetem Diamant Auf Die Druckeigenschaften von Porösen Aluminiumverbundwerkstoffen
(2023) *Materwiss. Werksttech.*, 54 (9), pp. 1114-1121.

- Lee, W.M., Zikry, M.A.
Modeling the Interfacial Plastic Strain Incompatibilities Associated with Dispersed Particles in High Strength Aluminum Alloys
(2012) *Acta Mater.*, 60 (4), pp. 1669-1679.

Correspondence Address
Jamal N.A.; Department of Manufacturing and Materials Engineering, Malaysia; email: ayuni_jamal@iium.edu.my

Publisher: American Chemical Society

ISSN: 24701343
Language of Original Document: English
Abbreviated Source Title: ACS Omega
2-s2.0-85201636247
Document Type: Article
Publication Stage: Article in Press
Source: Scopus