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An Investigation of Aluminium & Magnesium Alloy with Interlayer Using Diffusion Bonding

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Abstract--- *This work is conducted to obtain better understanding and characterization of the diffusion bonding of similar and dissimilar metals. It also aimed to obtain optimum parameters for diffusion bonding of aluminium coating over magnesium alloy with Aluminium alloy. This work aims at developing a simple method to obtain diffusion bonding joints at relatively not low cost. On one hand, the research is intended to establish a method. It is not much easy to perform fusion welding of dissimilar metals of entirely two different metal species and getting a sound joint. Therefore, an alternate method is essential, for this solid state welding is the right method, among several such processes diffusion bonding is one of the solid state welding process suitable for joining aluminium coating over magnesium alloy with Aluminium alloy. On the other hand, the method is to serve as the basis for further research for production of application oriented components and parts. These two metals are jointed inside the die after finishing surface treatment. Then the die is kept inside the diffusion bonding machine by varying the time, temperature, pressure by means of load. Hot press diffusion bonding equipment is fabricated and verified with experiments so that it is capable of rendering accurate diffusion bonding joints with facilities to measure parameters and to investigate the super plastic diffusion bonding joints with interlayer. This method is devised to study the physical phenomena that have significant influence on diffusion bonding such as time, temperature, pressure on joints and metallurgical characteristics. Tensile and shear tests are to be conducted.*

Keywords--- *Investigation of Aluminium, Magnesium Alloy, Diffusion Bonding.*

I. INTRODUCTION

Magnesium alloys are promising materials in the automotive industry where their lightweight can be used to great advantage and contribute to energy savings and reduced environmental impact However, the use of magnesium alloys is limited by their low corrosion and wear resistance Thus, the corrosion protection of magnesium alloys has evoked great interest during recent year .Several surface treatments such as anodising, chemical conversion, gas-phase deposition processes and electroplating can be used for tailoring the surface properties of magnesium alloys Among gas-phase deposition processes, thermal spraying (TS) technology offers a variety of techniques that allow the deposition of a wide range of functional coatings designed for specific environments. For instance, TS processing is widely used in the automotive industry to produce coatings on transmission and engine parts such as synchronizing rings, shift forks and large volume of piston rings.

Recent studies have also shown that thermal spraying has a high potential for surface modification of magnesium alloys. Regarding Al-coatings, they can be deposited on magnesium alloys using several routes. For instance, Al-

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rich coatings can be obtained by painting and further heating at _400 8C. Even though the coatings were not very uniform, the formation of the Mg17Al12 Applied Surface Science 255 (2009) 6968–6977 ABSTRACT phase improved the hardness and corrosion resistance of the magnesium alloy. This approach is in line with the fact that aluminium produces a significant improvement of the corrosion resistance of Mg/Al systems by formation of aluminium rich oxides as well as networks of b-phase (Mg17Al). In the present study, the corrosion behaviour of Al-TS coatings deposited on three commercial magnesium/aluminium alloys— AZ31, AZ80 and AZ91D—was evaluated in 3.5 wt.% NaCl. The effect of a cold-pressing post-treatment on the morphology and corrosion performance of the coatings was also investigated. Mg and Al are used in a wide variety of aerospace structural applications due to some unique performance such as low density, high specific strength and good ductility. For example, they are considered as advanced materials applied to parts in the automotive and aerospace industries, where lightweight metals are needed to minimize weight or to reduce stress at high accelerations (Munitzet al., 2000). The refractory oxide film of Mg and Al forms inclusions in the heat-affected zone. And since the Mg has obvious thermal brittleness, the welding of Mg/Al dissimilar materials is difficult by the fusion welding. Tests indicate that distortion and crack in the heat affected zone of Mg can be produced (Weisheit et al., 1998; Su et al., 2002). The vacuum diffusion bonding has made increasingly progress with the development of computer and vacuum techniques, and it is used in joining brittle and dissimilar materials. The crack, distortion and segregation produced using fusion welding can be avoided. The dissimilar materials of Ti/Al and Al/18-8 stainless steel were bonded successfully by means of vacuum diffusion bonding, and the microstructure of the bonded joint was analysed (Ren et al., 2002; Liuet al., 2003). At present, the diffusion bonding of Mg/Al active metal has been not reported. So it is necessary for a study of the diffusion bonding and microstructure of Mg/Al dissimilar materials. In this paper, vacuum diffusion bonded joint of Mg/Al dissimilar materials are analysed. The microstructure, fracture morphology and phase constituent near the interface of Mg/Al diffusion bonding are analysed by scanning electron microscope (SEM) and X-ray diffraction (XRD). The relationship of technological parameters, microstructure and joint performance was obtained by observing the microstructure and analysing the new phase constituent.

II. LITERATURE REVIEW

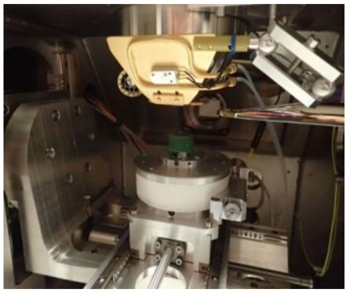
Magnesium alloys are promising materials in the automotive industry where their lightweight can be used to great advantage and contribute to energy savings and reduced environmental impact. However, the use of magnesium alloys is limited by their low corrosion and wear resistance.

Thus, the corrosion protection of magnesium alloys has evoked great interest during recent years. Several surface treatments such as anodising, chemical conversion,Gas phase deposition processes and electroplating can be used for tailoring the surface properties of magnesium alloys. Among gas-phase deposition processes, thermal spraying (TS) technology offers a variety of techniques that allow the deposition of a wide range of functional coatings designed for specific environments. For instance, TS processing is widely used in the automotive industry to produce coatings on transmission and engine parts such as synchronizing rings, shift forks and large volume of piston rings. Recent studies have also shown thermal spraying has a high potential for surface modification ofmagnesium alloys [12–20]. Regarding Al-coatings, they can be deposited on magnesium alloys using several routes [21,22]. For instance, Al-rich coatings can be obtained by painting and further heating at _400 8C [23,24]. This approach is in line with the fact that aluminium produces a significant improvement of the corrosion resistance of Mg/Al systems by formation of aluminium rich oxides as well as networks of-phase (Mg17Al) [25,26]. In the case of aluminium-based thermal sprayed coatings12 applied to magnesium alloys [12,16,18–20] and the assessment of their corrosion behaviour [16,18,19] the number of studies is relatively scarce. In general, the coatings produced by TS process are quite uniform in thickness and they do not exhibit phase transformations with respect to the original powder, which is advantageous for achievement of certain control over desirable properties, i.e. corrosion resistance. Although the Al-TS coatings may present interfacial reactions with the magnesium surface during the process, the composition of the coating can be controlled by heat post-treatments [19,20]. And in the case of high levels of porosity the coatings can be consolidated by several post-treatment methods [16]. In the present study, the corrosion behaviour of Al-TS coatings deposited on three commercial magnesium/aluminium alloys—AZ31, AZ80 and AZ91D—was evaluated in 3.5 wt.% Na Cl. The effect of a cold-pressing post-treatment on the morphology and corrosion performance of the coatings was also investigated.

III. EXPERIMENTAL ANALYSIS

The erosion behaviors of aluminum alloy have been evaluated practically at different test conditions under ambient temperature. Irregular silica sand (SiO_2) is used as an erodent within the range of 300–600 µm. The impact velocity within 30–50 m/s, impact angle 15–90°, and stand-off distance 15–25 mm considered as related parameters. The maximum level of erosion is obtained at impact angle 15° which indicates the ductile manner of the tested alloy. The higher the impact velocity, the higher the erosion rate as almost linear fashion is observed. Mass loss of aluminum alloy reduces with the increase of stand-off distance. A dimensional analysis, erosion efficiency (η) and relationship between friction and erosion indicate the prominent correlation. The test results are designated using Taguchi's concept to ensure the minimization of observations for clarification of results in alternative process.

ANOVA data analysis is considered to signify the interaction of tested parameters as well as identifying most influencing operating parameter. S/N ratio indicates that there are 2.92% deviations estimated between predicted and experimental results. To elaborately analyze the results, GMDH method is mentioned. After erosion process of the tested composite, the damage propagation on the surfaces is examined using SEM for confirming wear mechanisms. The elemental composition of eroded test samples at varying percentage of aluminum is analyzed by energy dispersive X-ray spectroscopy analysis.



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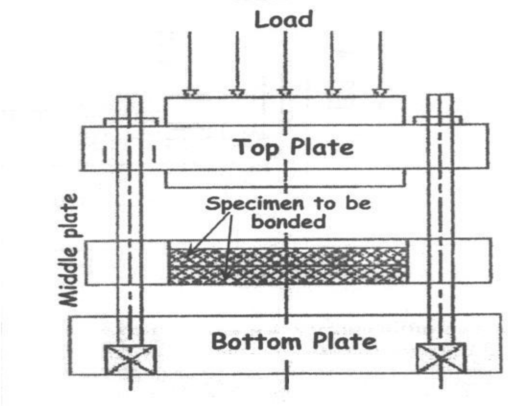


The present work aims at studying the combined effect of tangential bending and stretching stress (quite common in the stamping process, e.g. in the pinch or die shoulder regions) on thin magnesium (Mg) sheets when working at elevated temperature. An experimental/numerical approach was adopted using specific equipment able to heat the sheet only in the bending region and to stretch the sheet after the wiping process. Stretch-bending tests were aimed at understanding the process parameters really affecting the stretch-bending process at elevated temperature using the design of experiment (DOE) technique. In particular, the temperature, the punch speed, the bending radius and the rolling direction were considered in the screening analysis.

IV. RESULTS & DISCUSSION

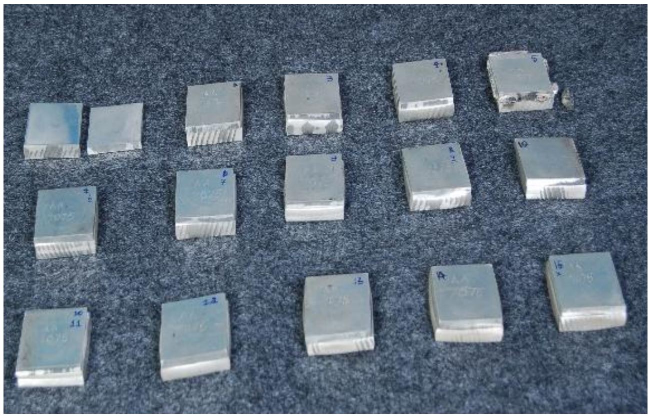
Intertie optical microscopy labs are staffed with microscopy scientists with years of experience in research and production problem-solving for problems, materials and clients.

Digital images of client samples are quickly forwarded from the surface science laboratory to the client. Optical microscopy is often the starting point for successful materials related problem-solving, and helps clients fully understand microstructure and product property relationships.

- Fixing, Staining and Embedding of Difficult-to-Image Materials
- Expert Microtommy for Thin-section preparation
- Research Microscopy of Surfaces and internal Micro-structures
- Polarized Light Microscopy for identification of Contaminants
- Confocal Microscopy using Molecular Probes and 3D Reconstruction
- Hot-Stage Optical Microscopy Laboratory
- Cold and Shear Stages for altering Sample Micro-environments
- Dynamic Time-lapse Imaging for Fast and Slow events
- Digital Imaging from Macro to Ultra-Micro Magnifications
- Fixing, Staining and Embedding of Difficult-to-Image Materials
- Optical Profilometry
- Non-Contact Evaluation of Encapsulated or Multi-Component Systems
- Optimization of Time Dependent variables such as Crystallization

- Root Cause determination of Product Fracture or Product Failure
- Identification and Measurement of Product Contamination Problems

Intertek operates a global network of laboratories which are recognized centres of excellence in forensic microscopy and supply chain contamination analysis.



Microscopy analysis is essential to understanding the microstructure or nanostructure of materials, chemicals or products. Data from microscopy analysis is important to progressing your research and product development programs conducting failure analysis where your product or material has failed or resolving contamination issues in manufacturing or other parts of the supply chain.

Effective digital microscopy analysis requires precise preparation equipment, advanced microscopy instrumentation, specialist cameras and image analysis software. The results and images captured must be assessed by qualified and experienced microscopy experts to gain the valuable insight that you will need to solve problems or extend understanding of your materials.

Sem Analysing

Scanning Electron Microscopy (SEM), also known as SEM analysis or SEM microscopy, is used very effectively in microanalysis and failure analysis of solid inorganic materials. Scanning electron microscopy is performed at high magnifications, generates high-resolution images and precisely measures very small features and objects.

Sem Analysis Applications

The signals generated during SEM analysis produce a two-dimensional image and reveal information about the sample including:

- External morphology (texture)
- Chemical composition (when used with EDS)
- Orientation of materials making up the sample

The EDS component of the system is applied in conjunction with SEM analysis to:

- Determine elements in or on the surface of the sample for qualitative information
- Measure elemental composition for semi-quantitative results
- Identify foreign substances that are not organic in nature and coatings on metal

Capabilities

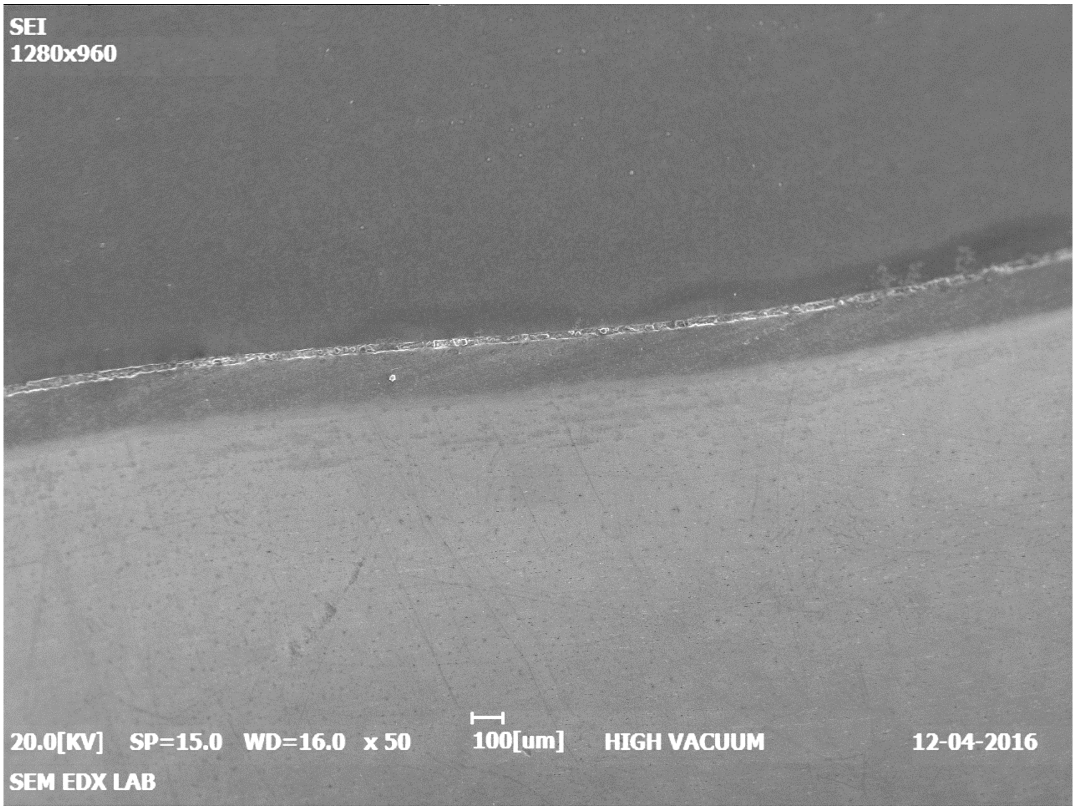
- SEM Analysis with EDS – qualitative and semi-quantitative results
- Magnification – from 5x to 300,000x
- Sample Size – up to 200 mm (7.87 in.) in diameter and 80 mm (3.14 in.) in height
- Materials Analysed – solid inorganic materials including metals and polymers

The Sem Analysis Process

Scanning Electron Microscopy uses a focused beam of high-energy electrons to generate a variety of signals at the surface of solid specimens. In most SEM microscopy applications, data is collected over a selected area of the surface of the sample and a two-dimensional image is generated that displays spatial variations in properties including chemical characterization, texture and orientation of materials. The SEM is also capable of performing analyses of selected point locations on the sample.

This approach is especially useful in qualitatively or semi-quantitatively determining chemical compositions, crystalline structure and crystal orientations.

The EDS detector separates the characteristic X-rays of different elements into an energy spectrum and EDS system software is used to analyse the energy spectrum in order to determine the abundance of specific elements. A typical EDS spectrum is portrayed as a plot of X-ray counts vs. energy (in KEV). Energy peaks correspond to the various elements in the sample. Energy Dispersive X-ray Spectroscopy can be used to find the chemical composition of materials down to a spot size of a few microns and to create element composition maps over a much broader raster area. Together, these capabilities provide fundamental compositional information for a wide variety of materials, including polymers and metals.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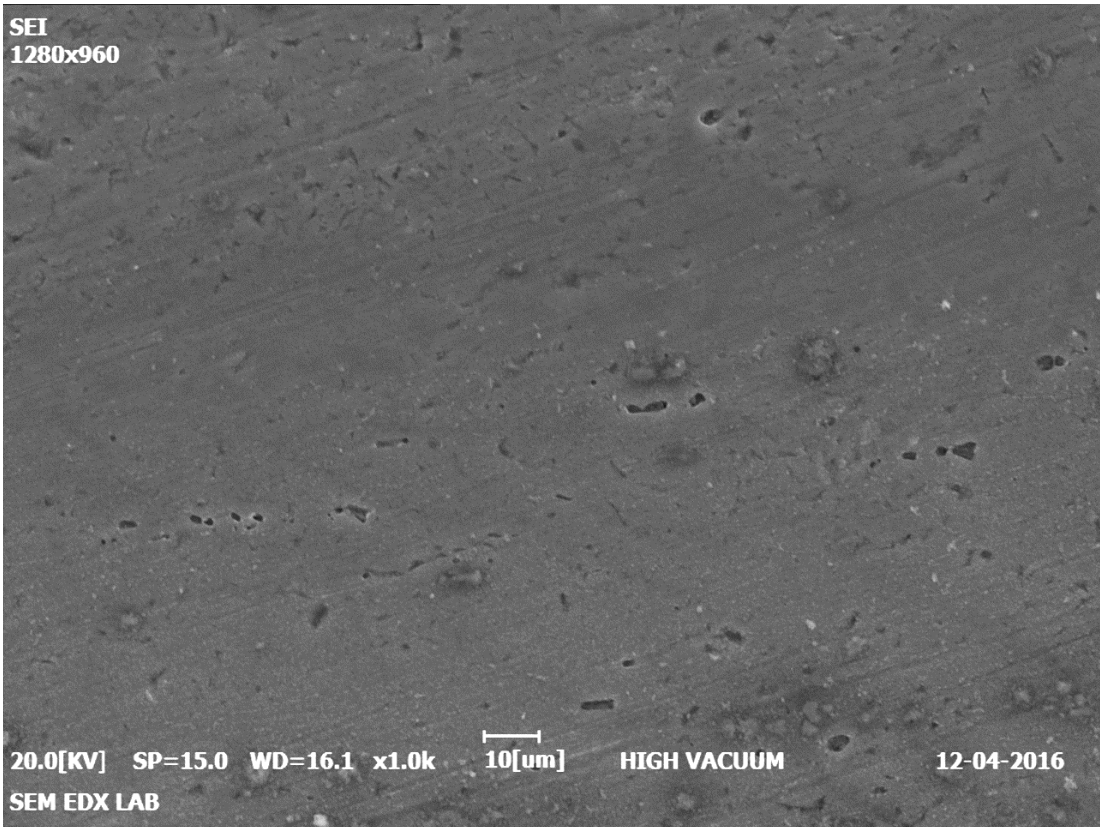
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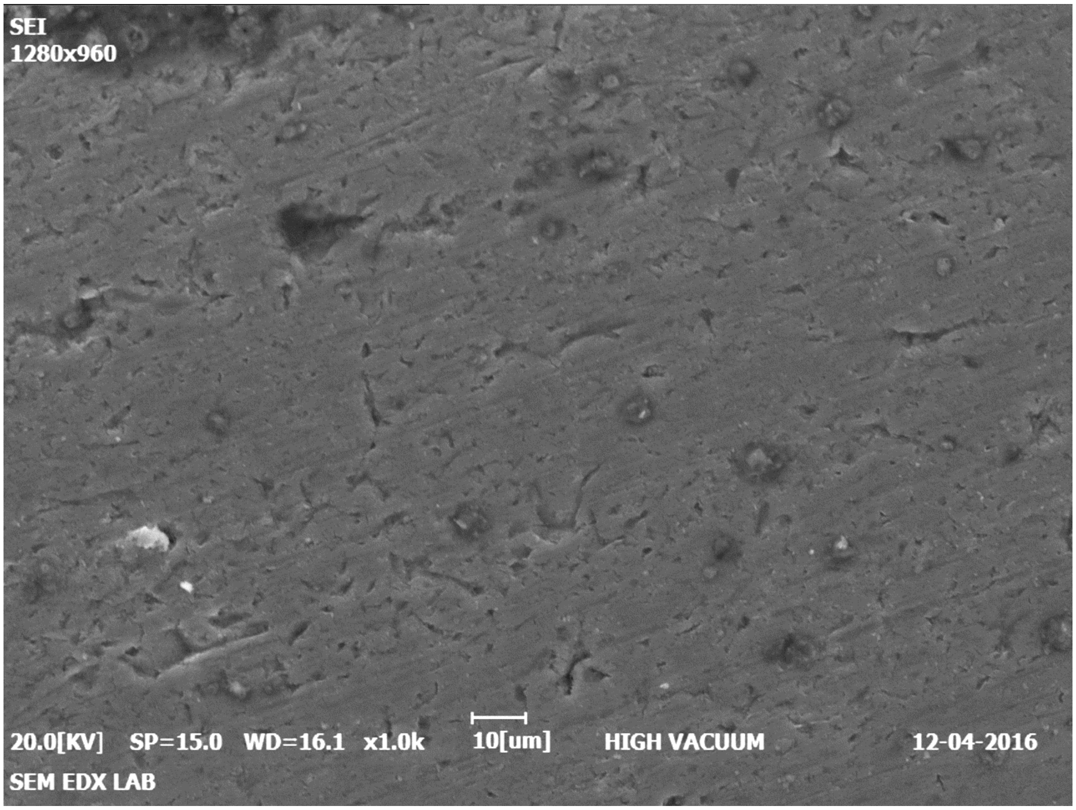
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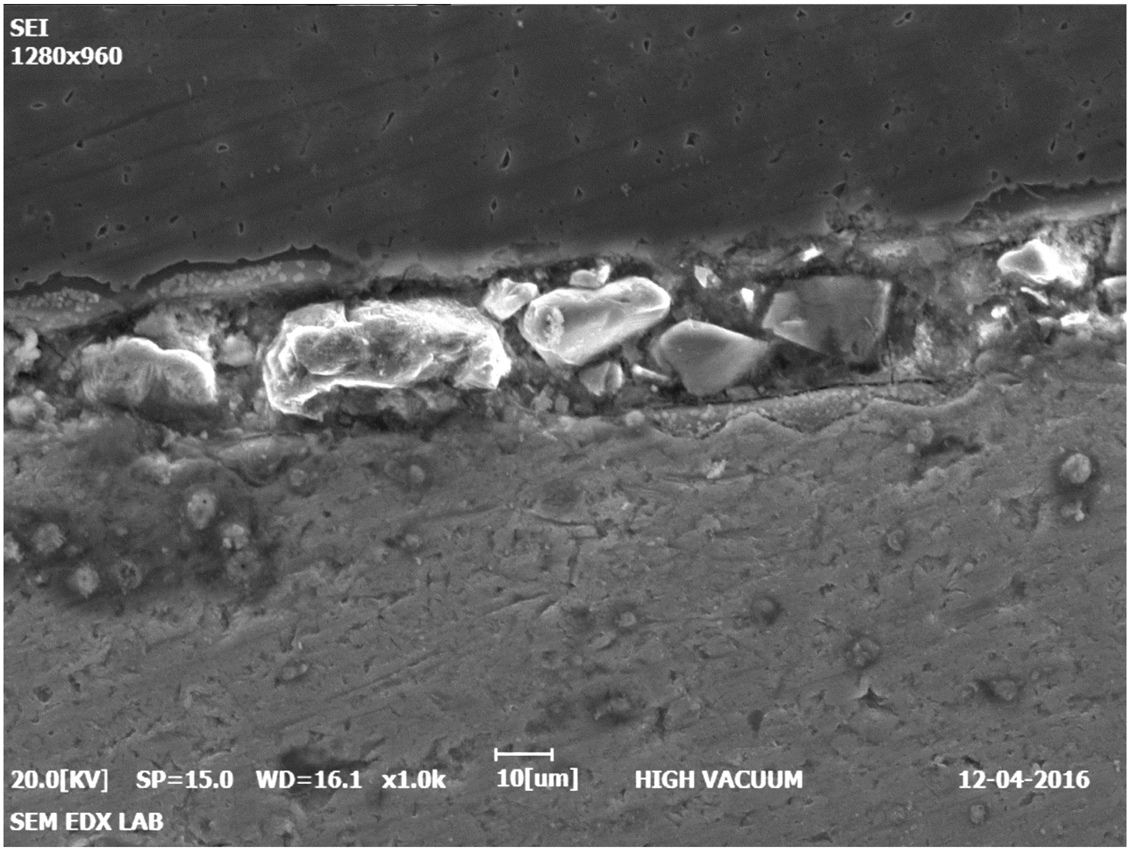
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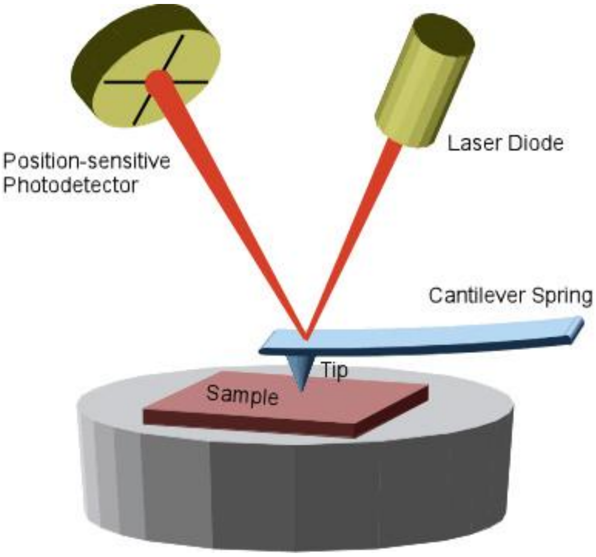
AFM Analysis

Atomic force microscopy (AFM) is a technique for analyzing the surface of a rigid material all the way down to the level of the atom. AFM uses a mechanical probe to magnify surface features up to 100,000,000 times, and it produces 3-D images of the surface.

History and background of AFM;

- Basic component of an AFM;
- Tip-Sample interactions and feedback mechanism;
- Atomic force and different scanning modes;
- AFM tips and resolution.



Atomic force microscopy (AFM) was developed when people tried to extend STM technique to investigate the electrically non-conductive materials, like proteins.

V. CONCLUSION

Diffusion bonding is an advanced material process for joining materials. Thin platelets of various metals can be diffusion bonded to produce cooling devices with extremely small and complicated flow channels for liquid rocket combustion chambers and missile sensor windows. Platelet diffusion bonding was also used to fabricate arrays of corrugated horns for mile meter wave frequencies in antenna systems. This fabrication technique has been proven as a simple and accurate process to produce low-cost and high performance engineering devices, which is a basic requirement for manufacturing technologies in the 21st century.

The optimization of bonding parameters for diffusion bonding magnesium AZ80 alloy and aluminiumAA7075 alloy are to be diffused in a diffusion bonding machine and the die is kept inside the diffusion bonding machine by varying the time, temperature, pressure by means of load. Before making diffusion bonding equipment, experiments are conducted with high expensive and simple fixture which is kept inside an induction furnace in clamping position to get diffusion bonded joints. Hot press diffusion bonding equipment is fabricated and verified with experiments so that it is capable of rendering accurate diffusion bonding joints with facilities to measure parameters and to investigate the super plastic diffusion bonding joints. This method is devised to study the physical phenomena that have significant influence on diffusion bonding such as time, temperature, pressure on joints and metallurgical characteristics. Tensile and shear tests are to be conducted and optical Microscope and micro hardness test are also conducted.

For the diffusion bonding of Az80 Magnesium alloy and AA7075 Aluminum alloy, the maximum shear strength was obtained for the specimen bonded at 400^{o}C ,10 MPa and 15 minutes. The tensile shear strength of the bonded specimens was found to be increased with increasing temperature until a maximum value is reached beyond which it decreased. The width of the inter metallic are smaller at a lower diffusion bonding temperature and their widths increase with the increase in the joining temperature due to increasing the inter-diffusion of chemical species

REFERENCES

[1] Thooyamani, K.P., Khanaa, V., & Udayakumar, R. (2014). Virtual instrumentation based process of agriculture by automation. *Middle-East Journal of Scientific Research*, *20*(12): 2604-2612.

[2] Udayakumar, R., Kaliyamurthie, K.P., & Khanaa, T.K. (2014). Data mining a boon: Predictive system for university topper women in academia. *World Applied Sciences Journal*, *29*(14): 86-90.

[3] Anbuselvi, S., Rebecca, L.J., Kumar, M.S., & Senthilvelan, T. (2012). GC-MS study of phytochemicals in black gram using two different organic manures. *J Chem Pharm Res*., *4*, 1246-1250.

[4] Subramanian, A.P., Jaganathan, S.K., Manikandan, A., Pandiaraj, K.N., Gomathi, N., & Supriyanto, E. (2016). Recent trends in nano-based drug delivery systems for efficient delivery of phytochemicals in chemotherapy. *RSC Advances*, *6*(54), 48294-48314.

[5] Thooyamani, K.P., Khanaa, V., & Udayakumar, R. (2014). Partial encryption and partial inference control based disclosure in effective cost cloud. *Middle-East Journal of Scientific Research*, 20(12), 2456-2459.

[6] Lingeswaran, K., Prasad Karamcheti, S.S., Gopikrishnan, M., & Ramu, G. (2014). Preparation and characterization of chemical bath deposited cds thin film for solar cell. *Middle-East Journal of Scientific Research*, *20*(7), 812-814.

[7] Maruthamani, D., Vadivel, S., Kumaravel, M., Saravanakumar, B., Paul, B., Dhar, S.S., Manikandan, A., & Ramadoss, G. (2017). Fine cutting edge shaped Bi2O3rods/reduced graphene oxide (RGO) composite for supercapacitor and visible-light photocatalytic applications. *Journal of colloid and interface science*, *498*, 449-459.

[8] Gopalakrishnan, K., Sundeep Aanand, J., & Udayakumar, R. (2014). Electrical properties of doped azopolyester. *Middle-East Journal of Scientific Research*, *20*(11). 1402-1412.

[9] Subhashree, A.R., Parameaswari, P.J., Shanthi, B., Revathy, C., & Parijatham, B.O. (2012). The reference intervals for the haematological parameters in healthy adult population of chennai, southern India. *Journal of Clinical and Diagnostic Research: JCDR*, *6*(10), 1675-1680.

[10] Niranjan, U., Subramanyam, R.B.V., & Khanaa, V. (2010, September). Developing a web recommendation system based on closed sequential patterns. In *International Conference on Advances in Information and Communication Technologies*, *101*, 171-179. Springer, Berlin, Heidelberg.

[11] Slimani, Y., Baykal, A., & Manikandan, A. (2018). Effect of Cr3+ substitution on AC susceptibility of Ba hexaferrite nanoparticles. *Journal of Magnetism and Magnetic Materials*, *458*, 204-212.

[12] Premkumar, S., Ramu, G., Gunasekaran, S., & Baskar, D. (2014). Solar industrial process heating associated with thermal energy storage for feed water heating. *Middle East Journal of Scientific Research*, *20*(11), 1686-1688.

[13] Kumar, S.S., Karrunakaran, C.M., Rao, M.R.K., & Balasubramanian, M.P. (2011). Inhibitory effects of Indigofera aspalathoides on 20-methylcholanthrene-induced chemical carcinogenesis in rats. *Journal of carcinogenesis*, *10*.

[14] Beula Devamalar, P.M., Thulasi Bai, V., & Srivatsa, S.K. (2009). Design and architecture of real time web-centric tele health diabetes diagnosis expert system. *International Journal of Medical Engineering and Informatics*, *1*(3), 307-317.

[15] Ravichandran, A.T., Srinivas, J., Karthick, R., Manikandan, A., & Baykal, A. (2018). Facile combustion synthesis, structural, morphological, optical and antibacterial studies of Bi1− xAlxFeO3 (0.0≤ x≤ 0.15) nanoparticles. *Ceramics International*, *44*(11), 13247-13252.

[16] Thovhogi, N., Park, E., Manikandan, E., Maaza, M., & Gurib-Fakim, A. (2016). Physical properties of CdO nanoparticles synthesized by green chemistry via Hibiscus Sabdariffa flower extract. *Journal of Alloys and Compounds*, *655*, 314-320.

[17] Thooyamani, K.P., Khanaa, V., & Udayakumar, R. (2014). Wide area wireless networks-IETF. *Middle-East Journal of Scientific Research*, *20*(12), 2042-2046.

[18] Sundar Raj, M., Saravanan, T., & Srinivasan, V. (2014). Design of silicon-carbide based cascaded multilevel inverter. *Middle-East Journal of Scientific Research*, *20*(12), 1785- 1791.

[19] Achudhan, M., Jayakumar M.P. (2014). Mathematical modeling and control of an electrically-heated catalyst. *International Journal of Applied Engineering Research, 9*(23), 23013.

[20] Thooyamani, K.P., Khanaa, V., & Udayakumar, R. (2013). Application of pattern recognition for farsi license plate recognition. *Middle-East Journal of Scientific Research*, *18*(12), 1768-1774.

[21] Jebaraj, S., Iniyan S. (2006). Renewable energy programmes in India. *International Journal of Global Energy Issues*, *26*(43528), 232-257.

[22] Sharmila, S., & Jeyanthi Rebecca, L. (2013). Md Saduzzaman., Biodegradation of domestic effluent using different solvent extracts of Murraya koenigii. *J Chem and Pharm Res*, *5*(2), 279-282.

[23] Asiri, S., Sertkol, M., Guner, S., Gungunes, H., Batoo, K.M., Saleh, T.A., Manikandan A., & Baykal, A. (2018). Hydrothermal synthesis of CoyZnyMn1-2yFe2O4 nanoferrites: magneto-optical investigation. *Ceramics International*, *44*(5), 5751-5759.

[24] Rani, A.J., & Mythili, S.V. (2014). Study on total antioxidant status in relation to oxidative stress in type 2 diabetes mellitus. *Journal of clinical and diagnostic research: JCDR*, *8*(3), 108-110.

[25] Karthik, B. (2014). Arulselvi, Noise removal using mixtures of projected gaussian scale mixtures. *Middle-East Journal of Scientific Research*, *20*(12), 2335-2340.

[26] Karthik, B., Arulselvi, & Selvaraj, A. (2014). Test data compression architecture for low power VLSI testing. *Middle - East Journal of Scientific Research*, *20*(12), 2331-2334.

[27] Vijayaragavan, S.P., Karthik, B., & Kiran Kumar, T.V.U. (2014). Privacy conscious screening framework for frequently moving objects. *Middle-East Journal of Scientific Research*, *20*(8), 1000-1005.

[28] Kaliyamurthie, K.P., Parameswari, D., & Udayakumar, R. (2013). QOS aware privacy preserving location monitoring in wireless sensor network. *Indian Journal of Science and Technology, 6*(5), 4648-4652.

[29] Silambarasu, A., Manikandan, A., & Balakrishnan, K. (2017). Room-temperature superparamagnetism and enhanced photocatalytic activity of magnetically reusable spinel ZnFe 2 O 4 nanocatalysts. *Journal of Superconductivity and Novel Magnetism, 30*(9), 2631-2640.

[30] Jasmin, M., Vigneshwaran, T., & Beulah Hemalatha, S. (2015). Design of power aware on chip embedded memory based FSM encoding in FPGA. *International Journal of Applied Engineering Research*, *10*(2), 4487-4496.

[31] Philomina, S., & Karthik, B. (2014). Wi-Fi energy meter implementation using embedded linux in ARM 9. *Middle-East Journal of Scientific Research*, *20*, 2434-2438.

[32] Vijayaragavan, S.P., Karthik, B., & Kiran Kumar, T.V.U. (2014). A DFIG based wind generation system with unbalanced stator and grid condition. *Middle-East Journal of Scientific Research*, *20*(8), 913-917.

[33] Rajakumari, S.B., & Nalini, C. (2014). An efficient data mining dataset preparation using aggregation in relational database. *Indian Journal of Science and Technology*, *7*, 44-46.

[34] Karthik, B., Kiran Kumar, T.V.U., Vijayaragavan, P., & Bharath Kumaran, E. (2013). Design of a digital PLL using 0.35 Î¼m CMOS technology. *Middle-East Journal of Scientific Research*, *18*(12), 1803-1806.

[35] Sudhakara, P., Jagadeesh, D., Wang, Y., Prasad, C.V., Devi, A.K., Balakrishnan, G., Kim B.S., & Song, J.I. (2013). Fabrication of Borassus fruit lignocellulose fiber/PP composites and comparison with jute, sisal and coir fibers. *Carbohydrate polymers*, *98*(1), 1002-1010.

[36] Kanniga, E., & Sundararajan, M. (2011). Modelling and characterization of DCO using pass transistors. In *Future Intelligent Information Systems,* 86(1), 451-457. Springer, Berlin, Heidelberg.

[37] Sachithanandam, P., Meikandaan, T.P., & Srividya, T. Steel framed multi storey residential building analysis and design. *International Journal of Applied Engineering Research*, *9*(22), 5527-5529.

[38] Kaliyamurthie, K.P., Udayakumar, R., Parameswari, D., & Mugunthan, S.N. (2013). Highly secured online voting system over network. *Indian Journal of Science and Technology*, *6*(S6), 4831-4836.

[39] Sathyaseelan, B., Manikandan, E., Lakshmanan, V., Baskaran, I., Sivakumar, K., Ladchumananandasivam, R., Kennedy, J., & Maaza, M. (2016). Structural, optical and morphological properties of post-growth calcined TiO2 nanopowder for opto-electronic device application: Ex-situ studies. *Journal of Alloys and Compounds*, *671*, 486-492.

[40] Saravanan, T., Sundar Raj M., & Gopalakrishnan K. (2014). SMES technology, SMES and facts system, applications, advantages and technical limitations. *Middle - East Journal of Scientific Research, 20*(11), 1353-1358.

[41] Usman, A.M., & Souley, B. (2014). Online Antenatal Consultation System based on UML and Web Engineering Approach. *The SIJ Transactions on Advances in Space Research & Earth Exploration*, *2*(3), 25-34.

[42] Fred, M.O., Sigey, J.K., Okello, J.A., Okwoyo, J.M., & Kang'ethe, G.J. (2014). Critical Anthropometric Variables for Character Graphic Design. *The SIJ Transactions on Advances in Space Research & Earth Exploration*, *2*(4), 47-53.

[43] Dr. Kalaiselvi, C., & Aruna Senbagam, G. (2018).A Survey on Dual Authentication and Key Management Techniques for Secure Data Transmission in Vehicular Ad Hoc Network. *The SIJ Transactions on Computer Networks & Communication Engineering (CNCE)*, *6*(2), 10-14.

[44] Ashok Kumar, R., & Ponsekar, P. (2018).EABC-OLEEO: Enhanced Artificial Bee Colony Algorithm based Optimization of Lifetime and Energy Optimization under Reliability Constraint for Wireless Sensor Networks (WSNs).*The SIJ Transactions on Computer Networks & Communication Engineering (CNCE), 6*(3), 9-19.

[45] Shanmugapriya, I. (2018). Digital Certificate based Symmetric Key Anonymous Authentication for Secured Remote Health Monitoring in WBAN. *Journal of Computational Information Systems, 14*(6), 34 - 48.

[46] Jain, A. (2018). Security in Digital Images Using Visual Cryptography Scheme. *Journal of Computational Information Systems, 14*(6), 49 - 57.

[47] Silambarasan, K. (2018). Healthcare Service in Cloud and IOT Using Cuckoo Search PSO & ABC Optimization Techniques. *Journal of Computational Information Systems, 14*(6), 70 - 76.

[48] Dr.Sharma, Y. (2018). Enhanced Technique for LSB based Security in Digital Color Images Using Visual Cryptography. *Journal of Computational Information Systems, 14*(6), 81 - 88.

[49] Athulya Lakshmi Gokul, & Kanagaraj, G. (2015). Analysis and Design of a Low Voltage Low-Power Double-Tail Comparator. *International Journal of Advances in Engineering and Emerging Technology, 7*(6), 404-413.

[50] Sasi Rekha, S., Anita, N., & Pradeepa, P. (2015). Reduction of DC Harmonics using SFC in Transformerless Three-phase Grid Connected Photovoltaic Inverters. *International Journal of Advances in Engineering and Emerging Technology, 7*(10), 640-650.