

SURFACE MODIFICATION OF RESORBABLE MAGNESIUM ALLOY

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Automobile

By

AKASH SUNDARAESWAR (Reg No.39860004)



**DEPARTMENT OF AUTOMOBILE ENGINEERING
SCHOOL OF MECHANICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

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SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)



Accredited with “A” grade by NAAC | 12B Status by UGC | Approved by AICTE

Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai - 600 119

www.sathyabama.ac.in

DEPARTMENT OF AUTOMOBILE

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of K.AKASH SUNDARAESWAR who have done the Project work as a team, who carried out the project entitled “**SURFACE MODIFICATION OF RESORBABLE MAGNESIUM ALLOY**” under my / our supervision from August 2022 to November 2023

Bupesh Raja
24/4/23

Internal Guide

(Dr. V. K. BUPESH RAJA, M.E., Ph.D.,)

Bupesh Raja
24/4/23

Head of the Department

(Dr. V. K. BUPESH RAJA, M.E., Ph.D.,)

Submitted for Viva voce Examination held on 26-04-2023

Dr. V. K. Bupesh Raja
26.04.23

Internal Examiner

Dr. V. K. Bupesh Raja

External Examiner

DECLARATION

I **K.AKASH SUNDAREASWAR (39860004)** hereby declare that the Project Report entitled **“SURFACE MODIFICATION OF RESORBABLE MAGNESIUM ALLOY”** done by us under the guidance of **Dr.V.K.Bupesh Raja M.E., Ph.D.**, at **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Automobile.

DATE: 26-04-2023



(K.AKASH SUNDAREASWAR)

PLACE: CHENNAI

SIGNATURE OF THE CANDIDATE

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ABSTRACT

Magnesium alloy have recently attracted significant attention for fabrication of biodegradable orthopedic implants and cardiovascular stents. Mg Zn alloy is treated under water (O) and without water (W) via laser etching process. We present a surface modification strategy to tailor the degradation rate of Mg alloy under physiological condition. SEM (Scanning Electron Microscope) is used to identify the Mg alloy's microstructure, grain size hardness and edax (element composition). After treating the Mg alloy, Melt zone (Mz) Heat affected zone(HAZ) and Parent material is viewed.

KEYWORDS

Mg Zn Alloy, grain size, melt zone,

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LIST OF ABBREVIATIONS

SCC	Stress Corrosion
GMAW	Gas Metal Arc Welding Cracking
LSP	Laser Shock Peening
MMC	Metal Matrix Composite
HAZ	Heat Affected Zone
DMD	Disintegrated Melt Deposition
PM	Parent Metal
SEM	Scanning Electron Microscopy
AFM	Atomic Force Microscopy
F	Focal position(mm)

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DESIGNING A MAGNESIUM ALLOY
WITH STRENGTH AND HIGH
FORMABILITY

LASER PROCESSING OF METALS
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LASER PROCESSING OF
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CHAPTER 1

INTRODUCTION

This chapter is about magnesium material that has the potential to replace aluminum alloys, steel, and plastic-based materials. It is achievable for an design engineer as the specific stiffness and strength of magnesium that exceeds most of commonly used metals and plastic-based materials.

MAGNESIUM

Magnesium is the third most widely used structural steel, steel and aluminum. Magnesium is the 12th atomic chemical chain, and magnesium is the brightest gray of the alkaline earth series. Magnesium-based materials in metal materials provide high strength in a variety of engineering applications. Two-thirds of the four-volume density of aluminum and steel. Due to the low density and high mechanical properties, magnesium-based materials are strongly involved in the company with significant weight applications. Magnesium has been used as another building material in applications such as automotive, sports, electronics and the universe. Depending on the environmental impact of the products, the products are used in permanent light alloys. Magnesium is a very low melting point (923 K (1,202 ° F)) and a low boiling point at 1363 K (1994 ° F) of all metals from the alkaline environment. Magnesium reacts with water at room temperature, although it reacts more slowly than calcium. When exposed to air, it is slightly reduced, although with a different alkaline iron, but it retains a oxygen-free environment, because magnesium is protected by a soft layer, this is waterproof and difficult to eliminate oxides. When immersed in water, when locked up, hydrogen bubbles are slowly formed in the metal surface, and the reaction is rapid. Reactions occur faster with better temperatures. It burns a lot, especially if it is blossomed or shaved into thin strands, though it is difficult to burn in bulk or in bulk. Temperatures of magnesium alloy and magnesium flames can reach 5,610 ° F (3,100 ° C). After combustion, such a fire is difficult to extinguish, as it burns in nitrogen (to form Mg_3N_2), CO_2 (to form MgO and C), and water (to form MgO and H). Magnesium produces a bright white light, when it burns in the air containing strong ultraviolet waves.

Uses of magnesium

Magnesium is slightly thicker than aluminum. It improves machinery, production and welding properties of aluminum when used as an alloyant. These alloys are beneficial in the production of aircraft and automobiles. Magnesium sulfate (MgSO_4) is used as a composite agent to prepare dyes. Magnesium hydroxide ($\text{Mg}(\text{OH})_2$) acts as a plastic flame retardant. Magnesium oxide (MgO) is mixed with bricks to withstand heat. Magnesium (Mg) is also used in other medicines. Other organic compounds of Mg are also important in the chemical industry. It is used as regnard reagents (organic chemical reactions) in other food and cultural products, as needed for biological development. Mg is extracted mainly from seawater containing calcium hydroxide ($\text{Ca}(\text{OH})_2$) and is present in minerals, such as magnesite, dolomite, talc, carnallite etc. Magnesium used in products is lightweight, for example luggage, car seats, cameras, laptops and electrical appliances. It is also supplied with molten metal and iron to remove sulfur.

ALLOYS AND COMPOSITES

The alloy and composite material are each made up of a combination of at the least two additives. Alloys and composites also are similar, in which they exhibit different properties and most belong properties associated with materials for making them. However, if you appearance a bit deeper, you will locate that alloys and composites are truely very special from one another. Take a closer look at the differences between the two alloys and composites.

Alloy

An alloy is a combination of at least elements with one of these elements being a metallic. The Alloy can be in the form solids and solutions. Alloy containing two elements called binary alloys, Those with 3 elements are called as ternary alloys. The amount of selected detail interior of an alloy is noramally measured in mass with percentage connected to it. Alloys are made from exceptional factors on the way to enhance the qualities commonly associated with them. When you blend two or more

elements together, you get an alloy that drags the quality of the element. Since the alloy always contains at least one metal aspect, it is generally a metal characteristic. However, one massive advantage of the use of alloys is that they don't have the same homes because the steel elements in them. For instance, you may locate that alloys don't have one set melting point. There are huge variety of melting points related to allots, depending upon which elements are inner of them.

Examples of Alloys

There are many examples of alloys. The most common is metal. Iron is usually composed of a mixture of carbon and iron, which is why iron is much stronger than iron. The metal can be produced in one way. In some cases, only carbon and iron are used to do so, but there are other elements such as chromium, tungsten, and magnesium, or they can be added. By changing the mixture, which you use when creating a metallic-like mixture, you can continuously alter the ductility and hardness in its areas. Another common example of an alloy is copper. Brass is a mixture of zinc and copper. Although zinc and copper are both prominent, copper has been proven to be more durable and better than zinc. That is why the alloy exists first. Many organizations have found that by using alloys, they can effectively control the appearance and feel of many different elements

Composite

Composite similar to an alloy, is a mixture of at least two or more additives. However, although the alloy always contains metals there, the compound is not included in the mixture. Combined additives also differ physically and chemically from each other. These materials are often called constituent material.

There are two different styles of composites that make up a combination. They are known as reinforcement and matrix materials. Matrix bonding materials are often used to carry reinforcing materials into a compound. This results in stronger compounds than their composite properties than the original components. However,

despite the interaction between these two components, they remain indistinguishable from the finished aggregate due to their chemical and physical variability..

Examples of Composites

Combinations can contain synthetic or natural ingredients. An example of a natural combination of wood. It consists of a mixture of cellulose lignin and fibers. Concrete is often referred to as a composite example as well. You can see the different elements contained within it by looking at those elements that do not come together to form a new object.

This indicates another major difference between compounds and alloys. Although the main difference between the two is apparently the lack of iron in the compounds, the composition of the compounds and alloys is also very different. Alloys can be heterogeneous or homogeneous mixtures, whereas compounds are heterogeneous and never form a homogeneous mixture.

As evidenced, composites and alloys have a few similarities, but for the most part, they are quite different. Alloy Eagles is focused on distributing alloys to companies in a variety of industries, including chemical, aviation and industrial.

MAGNESIUM ALLOYS

Magnesium alloys, the lightest structural alloys having a density approximately one-fourth that of steels, provide enormous capacity for improving strength performance of diverse transportation systems with cars. Numerous R&D efforts within the ultimate decade have brought the development of numerous sorts of magnesium alloys having properly combination of ductility and strength extraordinary corrosion resistance. Although there are many versions of magnesium alloys displaying big ductility, however, they typically show bad formability at room temperature, hindering their big applications in automobiles. Poor formability of Mg alloys arises from numerous elements; improvement of robust basal texture all through rolling (thermo mechanical treatment) and restrained variety of available deformation modes due to Mg having hexagonal close-packed (hcp) structure. Although Mg alloys are quite

formable at high or warm temperatures despite their bad formability at room temperature, forming at warm or excessive temperatures is pretty intensive and inefficient. Therefore, to make Magnesium alloys appealing for applications in automobiles, their formability at room temperature should be progressed. There is a lot of effort have to improve the chances of launching magnesium alloy, and it has shown that the formability of Magnesium alloys can be improved through a random structure of strong basic structure of conventional magnesium alloys, generally modifying the mechanical processing temperature and the elements of the rare earth. The randomized texture of REE-containing alloys is beneficial for formability, however also effects in low strength. Such inverse relationship among formability and energy is likewise applicable to different non-REE containing Magnesium alloys. It is plain that the conventional methods that enhance formability have unfavourable results on strength or vice versa. Consequently, new alloy layout and processing ideas have to be applied to develop excessive energy Mg alloys with excellent formability at room temperature. Mg is the lightest structural metal. Mg alloys have a hexagona structure of the lattice, which affects the basic properties of these alloys. Plastic deformation of the hexagonal lattice is extra complicated than in cubic latticed metals like steel, steel and alumunium therefore, Mg alloys are commonlly used as cast alloys, but research of wrought alloys has been extra significant since 2003. Cast Mg alloys are used for many components of automobiles have been used in few high-performance vehicles; die-cast magnesium is likewise used for camera bodies and additives in lenses.

The energy to weight ratio of the precipitation-hardened Mg alloys is comparable with that of robust alloys of aluminium or with the alloy steels. However, the magnesium alloy has a lower density, and the load of the column per unit of weight is greater and has a high specific module. They are also used while considerable energy isn't necessary, however wherein a thick, light form is desired, higher stiffness is required. Examples are complicated castings, together with cases or housings for aircraft, and components for rapidly rotating or reciprocating machines. The strength of Mg alloys is decreased at extended temperatures; temperatures as low as 200 °F (93 °C) make

considerable reduction in the yield strength. The machinability of Mg alloys is the top of any commercial metal, and in many applications.

Practically, all of the commercial Mg alloys manufactured in the United States include Al (3 to 13 percent) and Mn (0.1 to 0.4 percent). It also contain Zn (0.5 to 3 percent) and some are harden capable through heat treatment. All the alloys can be used for more than one product form, however alloys AZ92 and AZ63 are maximum used for sand castings, AZ92 normally employed mold castings, and AZ91 for die castings. AZ61 is most used for forgings, and right here M1 alloy is employed where low strength is wanted and AZ80 for highest strength. For extrusions, a vast range of tubes, bars, and shapes are made from M1 alloy in which low power suffices or which welding to M1 castings is planned. Alloys AZ80, AZ61 and AZ31 are employed for extrusions in the order named, where increase in energy justifies their extended relative expenses.

Magnox, whose name is an acronym for “magnesium non-oxidizing”, is 99% Mg and 1% Al, and used in the cladding of gas rods in magnox nuclear power reactors. Mg alloys are referred by means of short codes (defined inASTMB275) which denote approximate chemical compositions by way of weight. For example, AS41 has 4% Al and 1% Si; AZ81 is 7.5% Al and 0.7% Zn. If Al is present, Mn component is nearly usually additionally present at approximately 0.2% by weight which serves enhance grain shape, if Al and Mn are absent, zirconium is commonly present at approximately 0.8% for this same purpose.

Magnesium alloys names are frequently given by 2 letters following by 2 numbers. Letters tell predominant alloying elements (Z=zinc,A=aluminium, S=silicon,M = manganese). Numbers imply respective nominal compositions of main alloying elements. Marking AZ91 for example coveys Mg alloy with roughly 9 percent weight Al and 1 percent weight Zn. Exact composition ought to be showed from reference standards. The designation for Mg alloys is not as nicely standardized as within the case of steels or Al alloys; most manufactures follow a system using 1 or 2 prefix letters, 2 or 3 numerals, and a suffix letter. The prefix letters designate the 2 alloying metals according to the layout developed in ASTM specification B275

Al, Zn, Zr, and Th promote precipitation hardening; Mn improves corrosion resistance; and tin improves castability. Al is the most common alloying element. The numerals correspond to the rounded-off percentage of the 2 important alloy elements, proceeding alphabetically as compositions become widespread. Temper designation is more the same as in the case of Al. Using –O, –F, –T4, –T5, –T6, and –H1. Sand permanent-mold, and die casting are well developed for Mg alloys, die casting being the most familiar. Although Mg is twice expensive as Al, its warm-chamber die-casting process is easier, most economical, and 40% to 50% faster than cold-chamber process wanted for Al. Forming conduct is bad at room temperature, but most conventional methods can be performed when material is heated to temperatures of 450–700°F (232–371 °C). As those temperatures are without difficulty attained and typically do no longer require a protective environment, many formed Mg products are produced. The machinability of Mg alloys is the best of any commercial metal, and in many applications, the savings in machining prices greater than compensate for the improved price of the material. It is essential, however, to maintain the tools sharp and to offer ample space for the chips. Mg alloys can be spot-welded nearly as easily as Al, but scratch brushing or cleaning is essential before the weld is formed. Fusion welding is done maximum without difficulty via techniques the use of an inert protecting atmosphere of argon or helium gas. Considerable misinformation exists regarding the fire hazard in processing Mg alloys. It is authentic that Mg alloys are especially combustible while in a finely divided form, consisting of powder or fine chips, and this hazard should never be ignored. Above 800°F (427°C), a non-combustible, oxygen-free atmosphere is need to suppress burning. Casting operations require additional precautions due to the reactivity of Mg with sand and water in sheet, bar extruded, however, Mg alloys present no actual fire hazard.

ALUMINIUM ALLOYS WITH MAGNESIUM

In automotive manufacturing, Al plays an important role in automotive manufacturing. All types of vehicles, from motorcycles to space, are made from Al. This metal allows you to travel across oceans, fly in the sky and leave our planet. Transportation also has a high percentage of Al 27% consumption.

Aluminum has always been considered a metal fly. Lightweight, sturdy and flexible, it has the perfect function of creating a heavier plane than air. There is a reason why in a few circles Al is called a 'winged metal'. Aluminum makes seventy-five percent and eighty percent of modern aircraft and apparently was first used in aircraft before the aircraft were invented.

To replace Al in the automotive and aerospace business, Mg is used, due to its soft weight. Magnesium is the simplest metal found in the world with a bright gray color marked Mg. It is the second most visible metal in the center of the earth's crust. It is about 34 percent lighter in volume than Al.

Birmabright, Magnalium, Al alloys containing Thorium are rarely used, so more than 2% thorium content requires the element to be treated as a radioactive substance, although strong magnesium was converted to military use and in space in the mid-1950s.

Mg alloys are used for both forged and cast components, with the Al-containing alloys normally used for casting and the Zn-containing ones for forgings, the Zn-based alloys may be used at better temperatures and popular in aerospace. Magnesium+yttrium+rare-earth+Zn alloys along with WE54 and WE43 (the latter with composition Mg 93.6%, Y 4%, Nd 2.25%, 0.15% Zr) can perform without creep at up to 300C and are moderately corrosion-resistant.

MAGNESIUM COMPOSITES

Magnesium Composites are emerging from interest because the habitats can be properly made of fibers over a wide range. Many single-of-a-kind fiber systems can be used as reinforcement. However, Alumina and Silicon-Carbide products are used as reinforcement. The newly developed Mg-Composites for Carbon Nanotube are now available. The reinforcement phase has a significant impact on the structures. Significantly, it is durable, strong and resilient. Mg Composites are derived from the great interest in technology use due to its small weight and great strength.

1.5.1 MgZnHA

Hydroxyapatite (HAp) is a calcium phosphate similar to the human hard tissues in morphology and composition¹. Particularly, it has a hexagonal structure ^{2, 3} and a stoichiometric Ca/P ratio of 1.67, which is identical to bone apatite ^{2, 4, 5}. HA has been successfully used by researchers in the magnesium matrix and they have reported enhanced corrosion protection, superior mechanical strength (both in the uncorroded and corroded state) and higher cell viability

DIFFERENCE BETWEEN ALUMINIUM AND MAGNESIUM

Corrosion

The Al metal is resistant to corrosion.

Magnesium tends to corrode, even if the corrosion speed is very slow.

Atomic number

Aluminium (Al)-The atomic number is 13.

Magnesium (Mg)-The atomic number is 12.

Cost effectiveness

The Aluminium alloy is cheaper and it has less die casting cost.

Mg alloys are expensive and die casting cost is quite high.

Biological role

Aluminum has no value within biological systems and there may be no evidence to show its role in any biochemical process. Although living organisms include a small amount of Al in them, there is no scientific evidence for their need in the human body.

Magnesium is important for both plants and animals. In plants, photosynthesis is not possible without Mg and in humans, Mg allows the activation of various enzymes.

People consume about 250-350 mg of Mg per day. It is almost kept in the bones of humans.

Specific gravity

Al has a specific gravity of 2.7, Mg has the specific gravity of 1.7.

Alloy properties

Aluminium alloys need longer term for the solidification and additionally provide an extended die life. Al is quite stable, much less costly and does no longer bend without underneath stress due to its being sturdy.

Mg alloys take lesser time to solidify. Mg is much less stable, very expensive and bends without difficulty while under stress because of being smooth.

Solubility

Al is not soluble in water at room temperature

Mg is highly soluble in water at room temperature and reacts with water.

APPLICATION OF MAGNESIUM ALLOYS

The pursuit of lightweight goods, especially in the automotive business, has created a renewed interest in modern magnesium packaging. This requirement has led to improved studies and development work in companies and research institutes to obtain an advanced material profile and better selection of alloy systems. Here, development trends and applied capabilities in specific fields such as the automotive business and communication technologies are discussed in a multi-sectoral framework.

Automotive Applications

- In 1920s, Mg parts made their way into racing cars.

- However, it became no longer until the 1930s that magnesium turned into in commercial together with the Volkswagen (VW) Beetle. The VW Beetle, returned, contained 20 kg of Mg alloy in the transmission housing and the crankcase.
- Over the beyond decade, the growing environmental and legislative pressures at the automotive industry to provide lighter, better fuel efficiency, and better overall performance vehicles have resulted in the surge inside the use of magnesium.
- Widely used in conventional steel parts are being changed through new advanced materials along with magnesium, aluminum, and metal matrix composites.
- Hyundai, Jaguar, Fiat, BMW and Kia Motors Corporation have used magnesium-based materials in their automotive parts.

Aerospace Applications

- In the aerospace business, weight loss is one of the most important goals due to the increased demand for pollution reduction and fuel efficiency.
- □ Weight loss will be followed by fatigue and constant tiredness.
- □ Many options for weight loss such as Al, fiber metal laminates, and structural plastics are introduced over time. However, advances in the development of aluminum alloys have made the same weight reduction work.
- □ Fiber steel laminates are also an expensive material and, as a result, for key structures with the best mechanical requirements.
- Low-density structural plastics have low impact and harm tolerance properties. They also showcase inferior properties when subjected to temperature

extremes. Thus, most of these boundaries have made magnesium an attractive alternative.

- Some applications incorporate the thrust reverser (for Boeing 737, 747, 757, 767), gearbox (Rolls-Royce), and helicopter transmission casings, etc. Military aircraft, also benefit from the lightweight characteristics of Mg alloys for transmission casings. There is likewise huge use of Mg in spacecraft and missiles due to the requirement for light-weight materials to reduce the lift-off weight.
- This is coupled with its excessive unique mechanical properties, ease of fabrication, and different appealing features which include its capability to resist (i) elevated temperatures, (ii) exposure to ozone, and (iii) bombardment of excessive-energy particles and small meteorites.

Sports Applications

- In the sporting enterprise, it is important that the sports equipment fits as much as the ever growing expectations of sports fanatics.
- The excellent specific strength and ability of Mg alloys and Mg composites to form complex shapes has led to numerous applications in sports equipment. For example, magnesium-based materials are used in the grips of archery bows, tennis rackets, and golf clubs.
- The lightweight and tremendous damping traits of magnesium-based materials have made them a popular material preference in bicycle frames and the chassis of in-line skates.
- Bicycle frames crafted from Mg alloys or composites are able to soaking up shock and vibration, therefore allowing the rider to exert less energy and enjoy a comfortable ride.

Electronic Applications

- The trend within the digital equipment industry is to make products personal and portable.
- Therefore, it's vital that the additives that make up the equipment are light weight and durable.
- Mg-based materials meet the important necessities as they may be as light as plastic, but exhibit tremendous improvement in strength, heat transfer, and the ability to protect electromagnetic interference and radio frequency interference, in comparison with their plastic counter parts.
- Mg-based materials are used in housings of Mobile phones,laptops, and portable media players.

Optical Applications

- Magnesium is commonly used to make eyeglassframe because of its lightness.
- Magnesium case of digital camera , Magnesium's lightweight and optical stable features include the riflescopes and binoculars.

Medical Applications

- Mg alloys were first introduced as orthopedic biomaterials within the first half of the last century.
- However, due to its low resistance to corrosion, a large amount of hydrogen accumulates around the plant during the corrosion process in vivo, limiting the widespread use of Mg-based materials as biomaterials.
- Despite this, Mg still possesses many attractive characteristics that make magnesium based materials potential candidates for use as implants for load-bearing applications in the medical enterprise.

- Magnesium is a natural ion in the human body. It additionally assists in many human metabolic reactions and is nontoxic to the human body.
- Mg is also used in few medications. Some natural Mg compounds also are big in the chemical enterprise. It is used as a Grignard reagent and in several food and subculture media due to the fact it's miles required for growth of organisms. Mg is extracted from sea water using Ca(OH)_2 and exists in mineral shape like dolomite, magnesite, carnallite, talc etc.

DESIGNING A MAGNESIUM ALLOY WITH HIGH STRENGTH AND HIGH FORMABILITY

Despite the fact that Mg alloys, as the lightest structural alloys, offer significant capability for automotive applications, their applications remain restricted of their terrible formability at room temperature. Since the techniques used for enhancing formability normally result in a degradation of power, there aren't any high power Mg alloys showing good formability. Here Such designed alloy while subjected to the precise processing approach suggests a aggregate of strength and formability that surpasses those of magnesium alloys so far. The alloy layout idea used inside the present have a look is based at the utilization of alloying factors that may result in precipitation, in addition to maximize the segregation of other texture-controlling alloying elements. Such evolved alloy is expected to expand the application of Mg alloy sheets, which are now starting to gain acceptance through automotive industries.

CHAPTER 2

LITERATURE SURVEY

- J.C.Betts, 2010 - Laser surface cladding creates a new surface over the existing substrate, thereby contributing the desired surface properties. The process requires investment in added materials and delivery systems, as well as the corresponding issues of health, safety and cleanliness. Although impressive improvements to the material surface properties are possible, the resistance to wear can be enhanced still further by the inclusion of ceramic particles.
- ASHISH SINGH and SANDIP P. HARIMKAR, 2012 - Laser surface engineering is expected to play an important role in improving the surface properties of Mg alloys. Most of the laser surface engineering approaches such as LSM, LSA, LCS, LSC, and LSPhave demonstrated effectiveness in improving corrosion, wear, and fatigue properties of Mg alloys. These property improvements are primarily the result of modification of composition. Detailed experimental and computational investigations on laser-material interaction effects such as selective vaporization of elements, grain refinement, melt pool dilution, second-particle penetration, residual stresses, and solidification defects needs to be conducted to advance the understanding. Whereas it is possible to modify large area of Mg substrates using overlapping parallel tracks of laser modified regions, the microstructure and properties of these overlapping regions are expected to influence the overall performance of the laser modified surfaces.
- Chengpeng Maa, Ge Pengb, Lu Niec, Haifeng Liub, Yingchun Guan- 2018 - Mg phase as the matrix and Mg5Gd phase particles distributed in the matrix along extrusion direction. After laser surface modification, solidification microstructure was changed to Mg phase, and no phase grains precipitated along grain boundaries. The thickness laser-modified layer was about 360 μ m. For as-received specimen, initial galvanic corrosion occurred preferentially in a-Mg matrix around phase and extended into deep corrosion holes.
- Yuhang Lia, Srinivasan Arthanaria,b , Yingchun Guana, 2019 - Laser surface melting of MB26 and AZ80 magnesium alloys were carried and their surface

and electrochemical corrosion properties were systematically evaluated; 1. Surface roughness values of LSMed alloys were reduced in particular, the reduction was relatively higher for MB26 alloy due to the variation in cooling rate during laser processing. 2. Cross-sectional morphologies revealed that LSMed layer thickness was significantly varied and melted layer thickness value of AZ80

- Xiyu Yaa , Jincheng Tangb , Yinghao Zhoua , , Andrej Atrens , Matthew S. Darguschc , Bjoern Wiese, Thomas Ebel , Ming Yan, 2020 -The biomedical Mg-0.6Ca had simultaneously increases microhardness and decreased corrosion rate due to the surface modification by SLM. The main reason for the enhanced microhardness (20% increment) was attributed to the surface residual stress. The corrosion rate decreased because of confined impurity elements, the presence of MgO and the correspondingly increased selfcorrosion potential. The biomedical Mg-0.5Zn-0.3Ca alloy exhibited increased microhardness (17% increment). Its H₂ release amount was slightly higher than the as-extruded state in the initial immersion time period but decreased significantly after ~72 h of testing, this was attributed to the combined result of varying residual stress states, refined microstructure and confined impurity elements.
- H. Pereira , O. Carvalho , G. Miranda & F. S. Silva,2020 - mg is gaining attention as a biomaterial and it is extremely important to functionalise its surface due to its rapid corrosion. This study describes laser surface treatment of pure Mg as well as the characterisation of the different surface outcomes, namely texturing and remelting, as a function of laser parameters. Different combinations of laser power, scan speed and line spacing were tested and found to influence Mg surface. The use of a line spacing of 0.05 mm is more suitable to obtain a textured surface while a line spacing of 0.02 mm is more appropriated for remelting surfaces.
- Rakeshkumar Karunakaran, Sam Ortgies, Ali Tamayol, Florin Bobaru, Michael P. Sealy -Magnesium alloys are a promising new class of living organisms with similar bone strength, which reduces the harmful effects of stress protection.

The use of biodegradable magnesium implants is eliminated the need for a second operation to repair or remove it.

- Aruvi Kruusing-Underwater and water-assisted laser processing:general features, steam cleaning and shock processing
- ASHISH SINGH¹ and SANDIP P. HARIMKAR- Magnesium (Mg) and its alloys are well known for their high specific strength and low density. However, widespread applications of Mg alloys in structural components are impeded by their insufficient wear and corrosion resistance.
- B. Ratna Sunil a, T.S. Sampath Kumar a,□, Uday Chakkingal ,V. Nandakumar the role of different grain sizes produced by equal channel angular pressing (ECAP) on the degradation behavior of magnesium alloy using in vitro and in vivo studies
- Bhaskar Manne ,Harish Thiruvayapatia Magnesium-based alloys have attracted significant attention for biomedical applications due to its biodegradability as well as density and elastic modulus which are close to those of human bone. However, the uncontrolled biodegradation and hydrogen evolution are of major concern.
- A.J.Lopez -A high power diode laser (HPDL) was used to produce laser surface melting (LSM) treatments on the surface of the Mg alloy AZ91D.
- C. X. Wang -. It is regarded that pulsed-laser ablation PLA was employed as a route to prepare thin solid films.
- Chengpeng Ma-Magnesium alloy has attracted much attention as biodegradable material for medical devices including implants and stents in recent years
- Daoli Zhao-Monitoring the biodegradation process of magnesium and its alloys in vivo is challenging. Currently, this process is monitored by micro-CT and X-ray imaging in vivo, which require large and costly instrumentation.
- Omid Savabi-Magnesium has been recently introduced as a novel biodegradable material for bone healing. However,the fast degradation of this material results in the fast release of hydrogen which limits its clinical applications.

- David Omans-Pulsed laser ablation in liquids (PLAL) has become an attractive method for the synthesis of nanodiamond. This work deals with the growth kinetics study of structures of nano-diamonds embedded in sp² carbon synthesized by this method
- Yang Liu-Biodegradable magnesium (Mg) has garnered attention for its use in orthopaedic implants due to mechanical properties that closely match to those of bone.
- Dongfang Zhang- Microstructure, composition, in vitro degradation and cytocompatibility of coating were examined systematically.
- Dhruba Babu Subedi-This study reports on the effect of the addition of Glycine to Hank's solution on the in-vitro corrosion behavior of AZ31 magnesium (Mg) alloy at 37 °C and a pH of 7.4 studied by using potentiodynamic polarization (PDP).
- F. Amerstorfer -the long-term effects of degrading magnesium implants on bone tissue in a growing rat skeleton using continuous in vivo micro-Computed Tomography, histological staining and Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS). Two different magnesium alloys—one rapidly degrading (ZX50)
- Frank Witte-The in vivo corrosion of magnesium alloys might provide a new mechanism which would allow degradable metal implants to be applied in musculo-skeletal surgery. This would particularly be true if magnesium alloys with controlled in vivo corrosion rates could be developed.

CHAPTER 3

AIM AND SCOPE

AIM

Aim of this assignment is to create surface texturing on Mg alloys/composite materials without liquid and under liquid medium, to observe the surface roughness using AFM (Atomic Force Microscope),

SCOPE

Mg Alloys / Composites have shown superior strength in many engineering systems, for example: - Wide use of Mg Alloys is expected due to its very high bio performance and light weight. As a result of their strength, durability, and mechanical behavior, materials considerations, modeling, and engineering, raw and renewable materials, and biological life cycle considerations, special materials (such as medicine, energy., Aerospace, and nanotechnology)

Different Grades of Mg Alloys

Mg Alloys of different grades are used to learn more about parameters and the use of alloys in almost all fields of engineering. This will be especially helpful in in-vitro and in-vivo studies as well as in the automotive sector. Mg-based alloys containing rare earth metals are important structural elements, as they combine low density with high energy structures. This makes them very attractive in the industry, especially when low construction weight is important, such as when building aircraft and equipment. Alloys produced by processing techniques are treated separately and discussed with metal matrix compounds as well as the use of fast hardening to produce amorphous and other new materials. Finally, current and future trends in the use of magnesium alloys are explored along with examples of recent applications.

CHAPTER 4

MATERIALS AND METHODOLOGY

MATERIALS USED

Materials used in this process are 3 types, they are



Fig 4.1 The samples of different grades.

SAMPLE	COMPOSITION
1	MgZnHA

Table 4.1 Grade and Composition of Materials Used

METHODOLOGY

Mg alloy with blocks of different degrees of length 280mm, width 100mm and thickness 100mm. Initially, the Mg block undergoes a wire cutting process to magnesium material of sample size 2mm thickness 8mm diameter

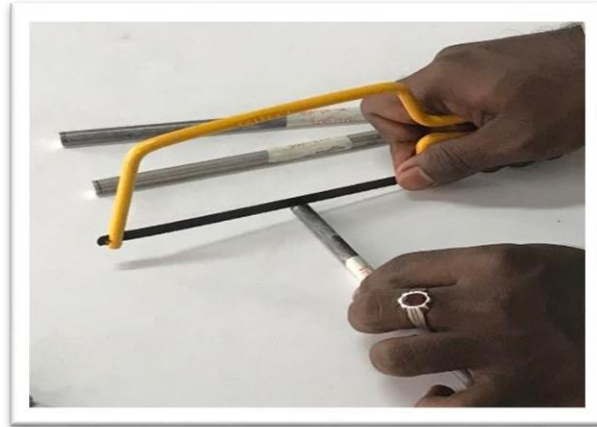


Fig:4.2 :Cutting Process



Fig:4.3 :sample size 2mm thickness 8mm diameter

LASER ETCHING

A laser engraving machine can be of 3 main parts: a laser, a controller, and a surface. The laser is like an pencil, the beam emitted by it allows the controller to draw the patterns on the surface. The controller direction, intensity, speed of movement, and spread of the laser beam directed towards the surface. The surface is chosen according to match what the laser can act on.



Fig:4.4 :Laser engraving machine

There are 3 principals of recording equipment: The most unusual surface is the X-Y desk where, in general, the surface is vertical and the laser optics flows around the X and Y directions, directing the laser beam to attract vectors. Sometimes the laser is stopped and the piece of work is moving. The piece of work moves between the Y axis and the laser inside the X-axis. The second style is the work cylinder pieces where the laser effectively cuts the fine helix and the on / off laser pulsing produces a popular image on the basis of the raster. The point at which the laser reaches the top must be the fixed plane of the laser optical system and is usually the same as its focus point. This point is usually small, probably less than half a millimeter. The energy generated by the laser converts the surface of the material into a focused area. It may burn the surface and then evaporate the active substance, or perhaps break (known as "glass") and shrink from the surface. Cutting with a metal part of the metal is usually laser-engraved.

A laser can be extremely efficient, since a laser beam can be designed to bring energy to the surface in a way that converts a high percentage of light energy into heat. The beam is very concentrated and collimated - on non-reflective materials such as wood, plastic and enamel on top.

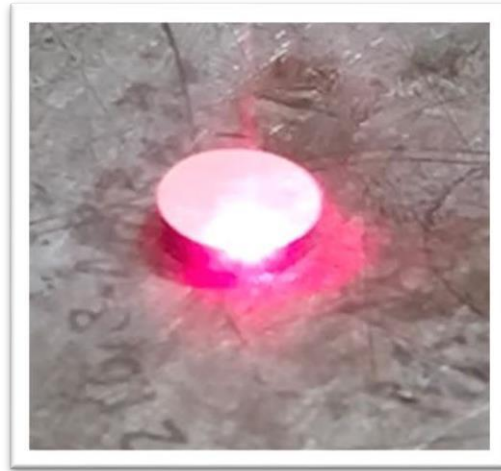


Fig:4.5 :Laser processing on sample

Different patterns can be recorded by adjusting the controller to move a certain laser beam over time. The laser beam track is carefully adjusted to obtain consistent removal depth. For example, cross-paths are avoided to ensure that each recorded area is laser-recorded only once, in order to extract the same amount of material. The speed at which it moves on the material is also taken into account when constructing carved patterns. Changing the thickness and spread of the beam allows for greater flexibility in construction.

Since laser placement is accurately understood using a controller, it is not necessary to add obstacles in place to save the laser from deviating from the recorded pattern. Therefore, no blocking mask is required for laser recording especially because this method is different from the old recording methods.



Fig:4.6 :Laser Engraving (square pattern)

The Spot diameter kept on Specimen is 0.1mm, dot depth 0.2mm and dot diameter is 0.1mm.

FABRRICATION

In this case the circular base plate is made of steel according to the inner diameter of the socket. The metal plate is mounted on the front with a diameter of 3mm. Provided support to stay on the lookout. A support foot screw system is provided to help adjust the base plate height up or down. The 4mm diameter is drilled with a thermometer. Clamps are made on the plate to hold the work in the center.

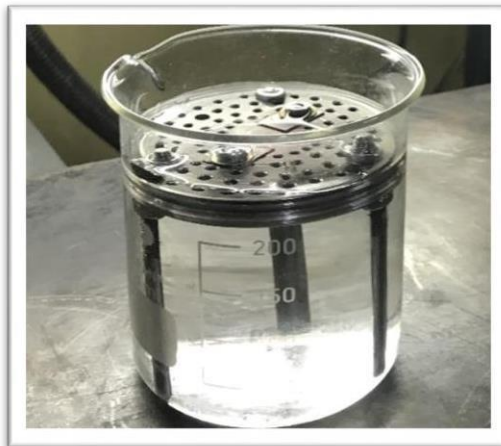


Fig 4.7 Fabricated Setup

ETCHING ON METALS

Metals are heat-resistant, metal marking requires very strong laser beams. Basically, the intermediate laser power leads to melting and high power causes the material to evaporate.

Traditional fine carvings began to be the worst laser-engraved objects. This problem has now been resolved using short wavelength laser. Using CO₂ laser, Yb: Fiber Lasers, Nd: YVO₄ or Nd: YAG lasers, metals can now be easily recorded. The square of the matrix and the dot pattern are assigned to the sample to stand out. The lines provided intersect the matrix points in the center and form a diamond structure in the sample with vertical spaces between each series of cuts. The applied power is about 55% of 60 W. The laser beam velocity is 100 mm / sec. The frequency used to heat over a sample is approximately 20 KHz. All data must be properly entered in order to be able to describe and target. Laser is shown in the sample and the desired shape is recorded.



Fig 4.8 Etching process

A built-in metal plate with support legs is found inside the beam next to the magnetic field in it. The stirrer is used to introduce the flow into propanol and allows to prevent the incorporation of graphite powder into the beaker. As graphite powder contains a good percentage of carbon it helps to blend better and enhance the thermal properties of the mixture during lasing. . The whole setup with the beaker is placed on a heat plate used to keep the liquid medium temperature constant. Thereafter the laser parameters are set and the laser beam is allowed to enter the target area.

4.8.1 Etching parameters

4.2 Laser parameters of line and matrix etching

RPM	1900
Power	33w
Frequency	20KHz
Speed	100mm/sec

The RPM is maintained around 1900 with the power of 55% at 60W with the speed of 100 mm/sec with the frequency of 20KHz. These parameters provide the best results. The desired shape structure is acquired during etching is done under these parameters.

CHAPTER 5

RESULTS AND DISCUSSION

ATOMIC FORCE MICROSCOPE

In AFM, the surface is visualised based on sensing the interacting forces between the atoms of a sharp tip mounted on a flexible cantilever and the atoms in the sample. During the dimension, depending on the microscope model, the cantilever and the tip are lowered towards the sample or the sample is raised towards and pointed until “contact” is made. The displacement of the cantilever is detected by a laser beam reflected from the top side of the cantilever onto a photodetector. Any change in cantilever deflection is the response to varying interaction forces acting on the tip causing the laser beam to move, and it is detected as a change in photodetector output voltage. The overhang is moved over the sample in some way (usually lines) and the surface information is collected. The spatial resolution depends on the shape of the tip and the model of the microscope, but is of the order of a Nanometer. With a right calibration, adjustments within the voltage converted into changes of the pattern topography or other parameters. So far, many imaging modalities have been used to study surface structure. They are based on different standards, function in difference force regimes and are capable of providing range in different information about the pattern.

Tapping mode for detecting surface

AFM tapping mode TM Unlike the contact mode, in TM cantilever imaging oscillates at (or near) the resonant frequency or amplitude A . If the tip is removed from the sample area, A is equal to the free amplitude of A_0 . When a tip is lowered into a template during a local scan, A_0 is reduced by the interaction between the tip title and the location. Near the surface, the amplitude is reduced to a minimum. In a specific tap mode test, the volume of the oscillation fluid at which the "contact" setting is set is defined by the set amplitude of the element. In terms of setpoint $(A_{sp} / A_0) \times 100\%$. Generally, a high point value means a slight decrease, and because the width and the dependence of the force are related, it also means less energy applied to the sample and obtained by the tip.

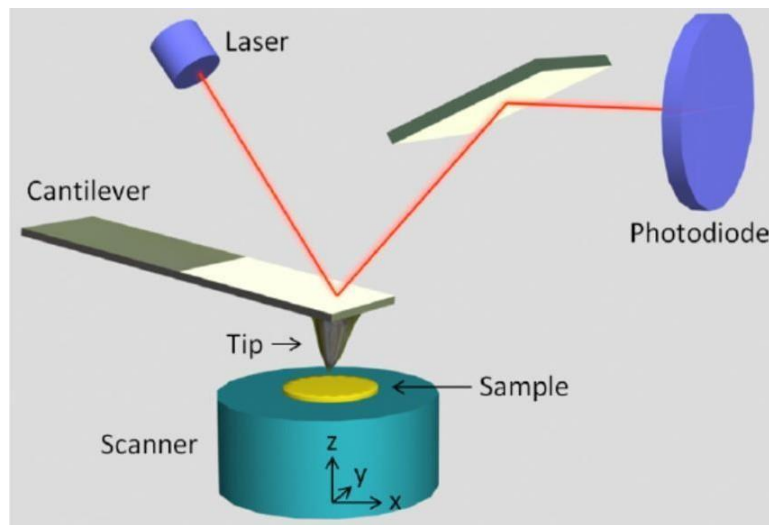
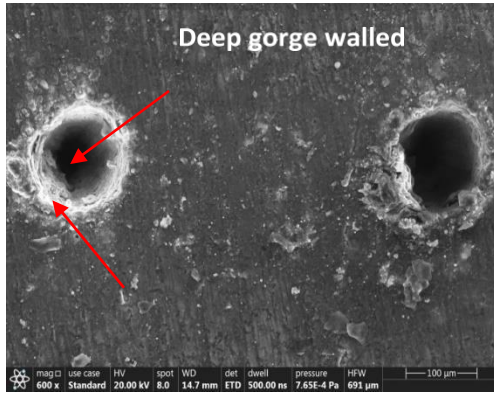


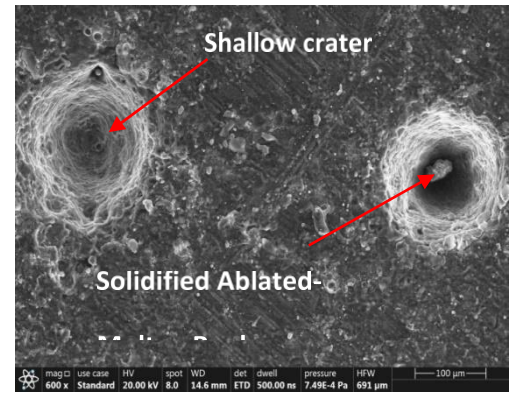
Fig 5.0 Atomic Force Microscopy

When using AFM to visualize a sample, the tip is attached to the sample and the sample is scanned with a raster with an xy grid. Typically, a digital voice loop is used to maintain the probe pattern pressure during a certain scanning time. This feedback circuit has a cantilever deviation as its input and output controls the distance to the z axis between the probe holder. As long as the tip stays connected to the sample and the sample is scanned on the xy plane, the changes in the sample length will change the cantilever deviation. The response then adjusts the probe holder length so that the deviation is reset to the user-defined value. A well-tuned feedback loop continues to adjust the sample manager separation during the sweeping movement, so that the deviation remains constant.

RESULTS OF AFM ANALYSIS:



(a) MgZnHA in air medium



(b) MgZnHA in water medium

Fig 5.1 SEM analysis of the top surface of laser ablation treated magnesium alloy and nanocomposite



(a) MgZnHA in air medium

Fig 5.2 SEM analysis of the top surface of laser ablation treated magnesium alloy and nanocomposite



(b) MgznHA in water medium

Fig 5.3 SEM analysis of the top surface of laser ablation treated magnesium alloy and nanocomposite

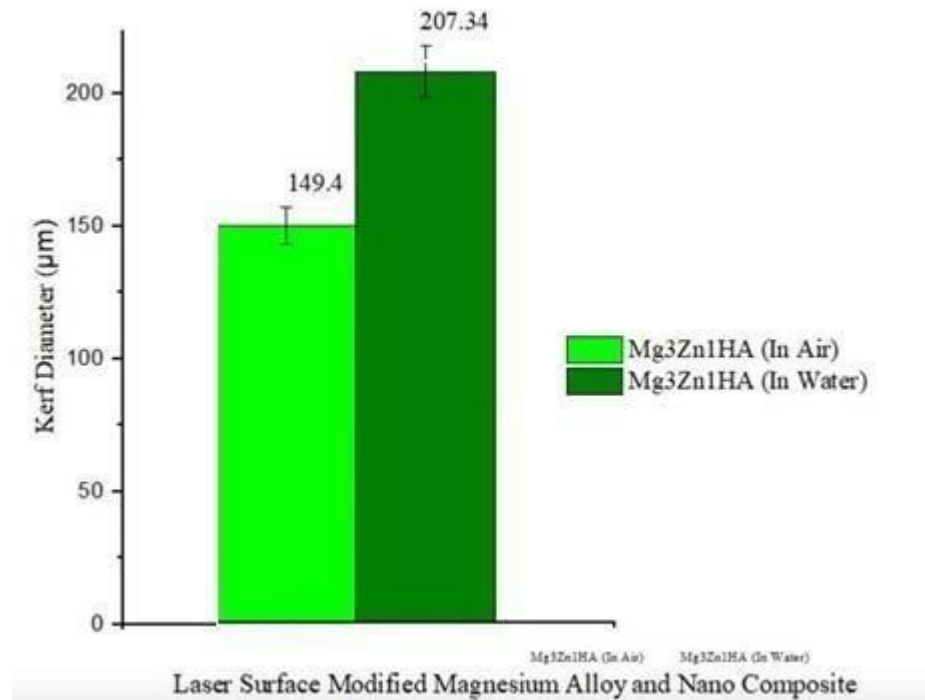


FIG 5.4 . Kerf diameter of craters formed in laser ablated Mg3Zn1HA nanocomposite under air and water medium

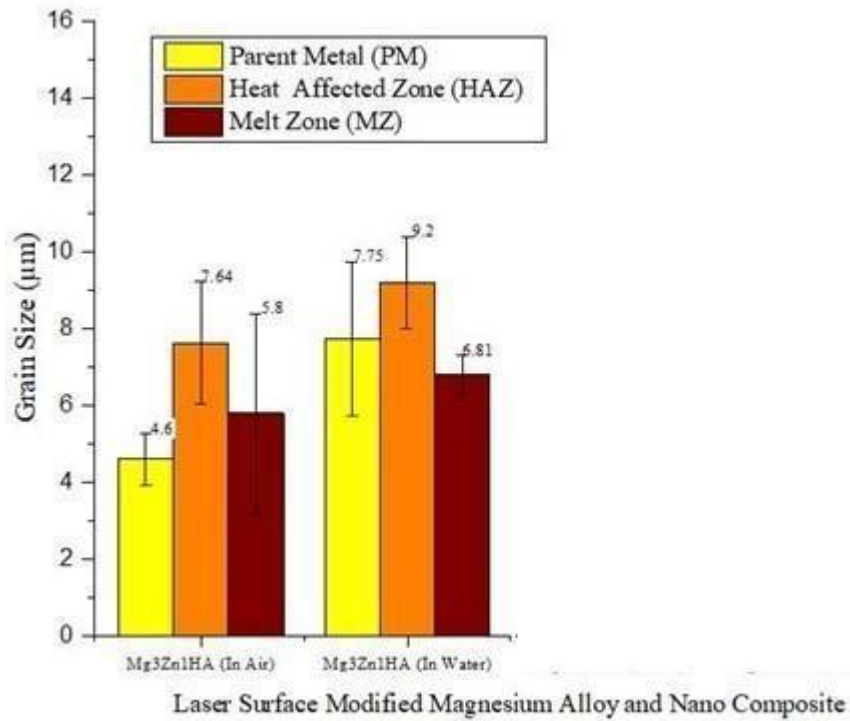


Fig 5.5 The grain size Mg3Zn1HA nanocomposite subjected to laser ablation under air and water medium.

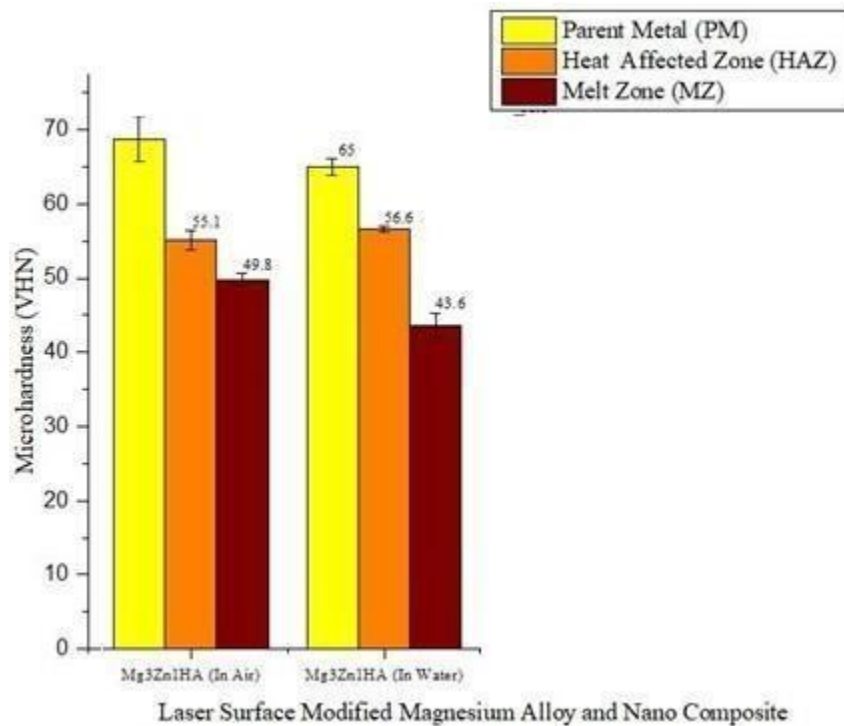
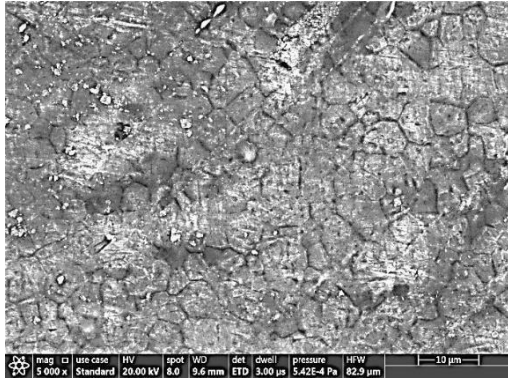
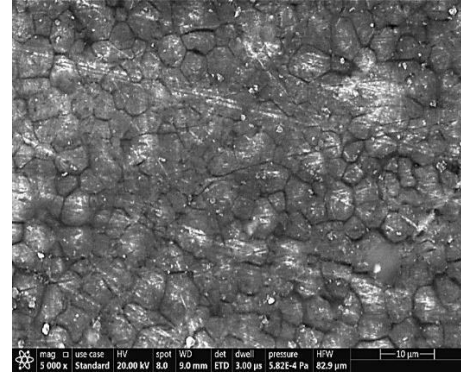


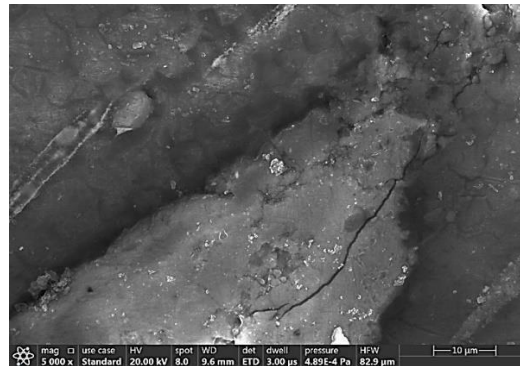
Fig 5.6 Microhardness of MgZnHA nanocomposite subjected to laser ablation under air and water medium.



(a)



(b)



(c)

Fig 5.7 . Scanning electron micrograph of Mg₃Zn₁HA nanocomposite: (a) Parent metal (PM); (b)Heat Affected Zone(HAZ); (c) cross-section of laser ablated region under air medium.

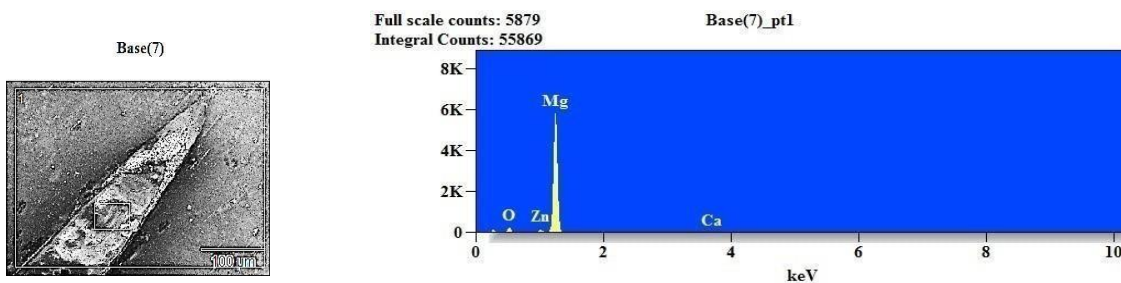


Fig 5.8 Energy dispersion spectroscopy analysis of Mg3Zn1HA nanocomposite laser ablated region under air medium.

Table 1. Energy dispersion spectroscopy elemental analysis in weight percentage.

295

	O	Mg	Zn	Ca
Mg3Zn1HA (In Air)	13.09	84.36	2.28	0.27
Mg3Zn1HA (In Water)	18.43	79.92	1.27	0.38

Table 2: AFM surface topographical readings of laser ablated MgZnHA nano-composite specimens

	Peak to peak (nm)	Ten Point height (nm)	Average Roughness (nm)	Root mean square (nm)
MgZnHA (Medium:Air)	1538.9	766.26	108.96	146.9
Mg3ZnHA (Medium : water)	390.1	199.40	251.07	52.3

Conclusions :

This study is an effort to explore laser ablation as a surface modification route for magnesium-based bio-implant materials. The scope for nano texturing of Mg3Zn1HA nanocomposite induced by laser ablation medium is studied. The highlights of this study are

1. Successful surface modification was achieved on Mg3Zn1HA nanocomposite created using the fragmented melt deposition approach by laser ablation utilizing a CO2 laser in an environment of air and water.
2. The laser ablation created craters on the surface of the Mg3Zn1HA nanocomposite. The laser ablated specimens processed in water medium exhibit shallow craters which are attributed to the diffraction of the laser by the water medium which also facilitates the removal of debris. Whereas laser ablated specimens processed in an air medium exhibit deep gorge-walled craters with geometrically circular profiles at the entry and the presence of ablation debris is observed.
3. The grain size of the laser ablated Mg3Zn1HA nanocomposite exhibited refinement when compared with the Mg3Zn alloy which is attributed to the nucleation of more.

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SURFACE MODIFICATION OF RESORBABLE MAGNESIUM ALLOY

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Engineering degree in Automobile Engineering By

AKASH SUNDARESWAR (Register No.38860004)

DEPARTMENT OF AUTOMOBILE ENGINEERING SCHOOL OF MECHANICAL ENGINEERING

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC JEPPIAR NAGAR, RAJIV GANDHI SALAI, CHENNAI-600 119

MARCH -2023

DEPARTMENT OF AUTOMOBILE ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of AKASH SUNDARESWAR (Register No.38860004) who carried out the project entitled “ LASER SURFACE MODIFICATION OF MAGNESIUM ALLOYS AN INSIGHT ” under my supervision from October 2021 to May 2022.

Internal Guide Dr. V.K. Bupesh Raja, M.E., Ph.D

Head of the department Dr. V.K. Bupesh Raja, M.E., Ph.D

Submitted for Viva voce Examination held on

Internal Examiner External Examiner

DECLARATION

We AKASH SUNDARASWAR (Register Number 38860004) hereby declare that the project report entitled “ LASER SURFACE MODIFICATION OF MAGNESIUM ALLOYS AN INSIGHT “ done by me under the guidance of Dr. V.K. Bupesh Raja, M.E., Ph.D. at Sathyabama institute of science and technology, Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai-600 119 is submitted in partial fulfilment of the requirements for the award of bachelor of Engineering degree in Automobile.

DATE: 30/04/2023

PLACE: CHENNAI AKASH SUNDARESWAR

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ABSTRACT

Magnesium alloy have recently attracted significant attention for fabrication of biodegradable orthopedic implants and cardiovascular stents. Mg Zn alloy is treated under water (O) and without water (W) via laser etching process. We present a surface modification strategy to tailor the degradation rate of Mg alloy under physiological condition. SEM (Scanning Electron Microscope) is used to identify the Mg alloy's microstructure, grain size hardness and edax (element composition). After treating the Mg alloy, Melt zone (Mz) Heat affected zone(HAZ) and Parent material is viewed.

KEYWORDS

Mg Zn Alloy, grain size, melt zone,

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AFM Surface topographical readings of Laser ablated MgZn alloy nano Composite specimens

LIST OF ABBREVIATIONS

SCC Stress Corrosion

GMAW Gas Metal Arc Welding Cracking

LSP Laser Shock Peening

MMC Metal Matrix Composite

HAZ Heat Affected Zone

DMD Disintegrated Melt Deposition

PM Parent Metal

SEM Scanning Electron Microscopy

AFM Atomic Force Microscopy

F Focal position(mm)

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CHAPTER 1 INTRODUCTION This chapter is about magnesium material that has the potential to replace aluminum alloys, steel, and plastic-based materials. It is achievable for a design engineer as the specific stiffness and strength of magnesium that exceeds most of commonly used metals and plastic-based materials. 1.1 MAGNESIUM Magnesium is the third most widely used structural metal, steel and aluminum. Magnesium is the 12th atomic chemical chain, and magnesium is the brightest gray of the alkaline earth series. Magnesium-based materials in metal materials provide high strength in a variety of engineering applications. Two-thirds of the four-volume density of aluminum and steel. Due to the low density and high mechanical properties, magnesium-based materials are strongly involved in the company with significant weight applications. Magnesium has been used as another building material in applications such as automotive, sports, electronics and the universe. Depending on the environmental impact of the products, the products are used in permanent light alloys. Magnesium is a very low melting point (923 K (1,202 ° F)) and a low boiling point at 1363 K (1994 ° F) of all metals from the alkaline environment. Magnesium reacts with water at room temperature, although it reacts more slowly than calcium. When exposed to air, it is slightly reduced, although with a different alkaline iron, but it retains an oxygen-free environment, because magnesium is protected by a soft layer, this is waterproof and difficult to eliminate oxides. When immersed in water, when locked up, hydrogen bubbles are slowly formed in the metal surface, and the reaction is rapid. Reactions occur faster with better temperatures. It burns a lot, especially if it is blossomed or shaved into thin strands, though it is difficult to burn in bulk or in bulk. Temperatures of magnesium alloy and magnesium flames can reach 5,610 ° F (3,100 ° C). After combustion, such a fire is difficult to extinguish, as it burns in nitrogen (to form Mg_3N_2), CO_2 (to form MgO and C), and water (to form MgO and H). Magnesium produces a bright white light, when it burns in the air containing strong ultraviolet waves.

1.1.1 Uses of magnesium

Magnesium is slightly thicker than aluminum. It improves machinery, production and welding properties of aluminum when used as an alloyant. These alloys are beneficial in the production of aircraft and automobiles. Magnesium sulfate ($MgSO_4$) is used as a composite agent to prepare dyes. Magnesium hydroxide ($Mg(OH)_2$) acts as a plastic flame retardant. Magnesium oxide (MgO) is mixed with bricks to withstand heat. Magnesium (Mg) is also used in other medicines. Other organic compounds of Mg are also important in the chemical industry. It is used as reagent reagents (organic chemical reactions) in other food and cultural products, as needed for biological development. Mg is extracted mainly from seawater containing calcium hydroxide ($Ca(OH)_2$) and is present in minerals, such as magnesite, dolomite, talc, carnallite etc.

Magnesium used in products is lightweight, for example luggage, car seats, cameras, laptops and electrical appliances. It is also supplied with molten metal and iron to remove sulfur.

1.2 ALLOYS AND COMPOSITES The alloy and composite material are each made up of a combination of at the least two additives. Alloys and composites also are similar, in which they exhibit different properties and most belong properties associated with materials for making them. However, if you appearance a bit deeper, you will locate that alloys and composites are true ly very special from one another. Take a closer look at the differences between the two alloys and composites.

1.2.1 Alloy An alloy is a combination of at least elements with one of these elements being a metallic. The Alloy can be in the form solids and solutions. Alloy containing two elements called binary alloys, Those with 3 elements are called as ternary alloys. The amount of selected detail interior of an alloy is noramally measured in mass with percentage connected to it. Alloys are made from exceptional factors on the way to enhance the qualities commonly associated with them. When you blend two or more elements together, you get an alloy that drags the quality of the element. Since the alloy always contains at least one metal aspect, it is generally a metal characteristic. However, one massive advantage of the use of alloys is that they don't have the same homes because the steel elements in them. For instance, you may locate that alloys don't have one set melting point. There are huge variety of melting points related to allots, depending upon which elements are inner of them.

Examples of Alloys There are many examples of alloys. The most common is metal. Iron is usually composed of a mixture of carbon and iron, which is why iron is much stronger than iron. The metal can be produced in one way. In some cases, only carbon and iron are used to do so, but there are other elements such as chromium, tungsten, and magnesium, or they can be added. By changing the mixture, which you use when creating a metallic-like mixture, you can continuously alter the ductility and hardness in its areas. Another common example of an alloy is copper. Brass is a mixture of zinc and copper. Although zinc and copper are both prominent, copper has been proven to be more durable and better than zinc. That is why the alloy exists first. Many organizations have found that by using alloys, they can effectively control the appearance and feel of many different elements.

1.2.2 Composite

Composite similar to an alloy, is a mixture of at least two or more additives. However, although the alloy always contains metals there, the compound is not included in the mixture. Combined additives also differ physically and chemically from each other. These materials are often called constituent material. There are two different styles of composites that make up a combination. They are known as reinforcement and matrix materials. Matrix bonding materials are often used to carry reinforcing materials into a compound. This results in stronger compounds than their composite properties than the original components. However, despite the interaction between these two components, they remain indistinguishable from the finished aggregate due to their chemical and physical variability..

Examples of Composites

Combinations can contain synthetic or natural ingredients. An example of a natural combination of wood. It consists of a mixture of cellulose lignin and fibers. Concrete is often referred to as a composite example as well. You can see the different elements contained within it by looking at those elements that do not come together to form a new object. This indicates another major difference between compounds and alloys. Although the main difference between the two is apparently the lack of iron in the compounds, the composition of the compounds and alloys is also very different. Alloys can be heterogeneous or homogeneous mixtures, whereas composites are heterogeneous and never form a homogeneous mixture. As evidenced, composites and alloys have a few similarities, but for the most part, they are quite different.

Alloy Examples

Alloy Examples is focused on distributing alloys to companies in a variety of industries, including chemical, aviation and industrial.

1.3 MAGNESIUM ALLOYS

Magnesium alloys, the lightest structural alloys having a density approximately one-fourth that of steels, provide enormous capacity for improving strength performance of diverse transportation systems with cars. Numerous R&D efforts within the ultimate decade have brought the development of numerous sorts of magnesium alloys having properly combination of ductility and strength extraordinary corrosion resistance. Although there are many versions of magnesium alloys displaying big ductility, however, they typically show bad formability at room temperature, hindering their big applications in automobiles. Poor formability of Mg alloys arises from numerous elements; improvement of robust basal texture all through rolling (thermo mechanical treatment) and restrained variety of available deformation modes due to Mg having hexagonal close-packed (hcp) structure. Although Mg alloys are quite formable at high or warm temperatures despite their bad formability at room temperature, forming at warm or excessive temperatures is pretty intensive and inefficient. Therefore, to make Magnesium alloys appealing for applications in automobiles, their formability at room temperature should be progressed. There is a lot of effort have to improve the chances of launching magnesium alloy, and it has shown that the formability of Magnesium alloys can be improved through a random structure of strong basic structure of conventional magnesium alloys, generally modifying the mechanical processing temperature and the elements of the rare earth. The randomized texture of REE-containing alloys is beneficial for formability, however also effects in low strength. Such inverse relationship among formability and energy is likewise applicable to different non-REE containing Magnesium alloys. It is plain that the conventional methods that enhance formability have unfavourable results on strength or vice versa. Consequently, new alloy layout and processing ideas have to be applied to develop excessive energy Mg alloys with excellent formability at room temperature. Mg is the lightest structural metal. Mg alloys have a hexagonal structure of the lattice, which affects the basic properties of these alloys. Plastic deformation of the hexagonal lattice is extra complicated than in cubic latticed metals like steel, steel and aluminium therefore, Mg alloys are commonly used as cast alloys, but research of wrought alloys has been extra significant since 2003. Cast Mg alloys are used for many components of automobiles have been used in few high-performance vehicles; die-cast magnesium is likewise used for camera bodies and additives in lenses. The energy to weight ratio of the precipitation-hardened Mg alloys is comparable with that of robust alloys of aluminium or with the alloy steels. However, the magnesium alloy has a lower density, and the load of the column per unit of weight is greater and has a high specific module. They are also used while considerable energy isn't necessary, however wherein a thick, light form is desired, higher stiffness is required. Examples are complicated castings, together with cases or housings for aircraft, and components for rapidly rotating or reciprocating machines. The strength of Mg alloys is decreased at extended temperatures; temperatures as low as 200 °F (93 °C) make considerable reduction in the yield strength. The machinability of Mg alloys is the top of any commercial metal, and in many applications. Practically, all of the commercial Mg alloys manufactured in the United States include Al (3 to 13 percent) and Mn (0.1 to 0.4 percent). It also contain Zn (0.5 to 3 percent) and some are harden capable through heat treatment. All the alloys can be used for more than one product form, however alloys AZ92 and AZ63 are maximum used for sand castings, AZ92 normally employed mold castings, and AZ91 for die castings. AZ61 is most used for forgings, and right here M1 alloy is employed where low strength is wanted and AZ80 for highest strength. For extrusions, a vast range of tubes, bars, and shapes are made from M1 alloy in which low power suffices or which welding to M1 castings is planned. Alloys AZ80, AZ61 and AZ31 are employed for extrusions in the order named, where increase in energy justifies their extended relative expenses. Magnox, whose name is an acronym for "magnesium non-oxidizing", is 99% Mg and 1% Al, and used in the cladding of gas rods in magnox nuclear power reactors. Mg alloys are referred by means of short codes (defined in ASTM B275) which denote approximate chemical compositions by way of weight. For example, AS41 has 4% Al and 1% Si; AZ81 is 7.5% Al and 0.7% Zn. If Al is present, Mn component is nearly usually additionally present at approximately 0.2% by weight which serves enhance grain shape, if Al and Mn are absent, zirconium is commonly present at approximately 0.8% for this same purpose. Magnesium alloys names are frequently given by 2 letters following by 2 numbers. Letters tell predominant alloying elements (Z=zinc, A=aluminium, S=silicon, M = manganese). Numbers

imply respective nominal compositions of main alloying elements. Marking AZ91 for example conveys Mg alloy with roughly 9 percent weight Al and 1 percent weight Zn. Exact composition ought to be showed from reference standards. The designation for Mg alloys is not as nicely standardized as within the case of steels or Al alloys; most manufactures follow a system using 1 or 2 prefix letters, 2 or 3 numerals, and a suffix letter. The prefix letters designate the 2 alloying metals according to the layout developed in ASTM specification B275 Al, Zn, Zr, and Th promote precipitation hardening; Mn improves corrosion resistance; and tin improves castability. Al is the most common alloying element. The numerals correspond to the rounded-off percentage of the 2 important alloy elements, proceeding alphabetically as compositions become widespread. Temper designation is more the same as in the case of Al. Using -O, -F, -T4, -T5, -T6, and -H1. Sand permanent-mold, and die casting are well developed for Mg alloys, die casting being the most familiar. Although Mg is twice expensive as Al, its warm-chamber die-casting process is easier, most economical, and 40% to 50% faster than cold-chamber process wanted for Al. Forming conduct is bad at room temperature, but most conventional methods can be performed when material is heated to temperatures of 450–700°F (232–371 °C). As those temperatures are without difficulty attained and typically do no longer require a protective environment, many formed Mg products are produced. The machinability of Mg alloys is the best of any commercial metal, and in many applications, the savings in machining prices greater than compensate for the improved price of the material. It is essential, however, to maintain the tools sharp and to offer ample space for the chips. Mg alloys can be spot-welded nearly as easily as Al, but scratch brushing or cleaning is essential before the weld is formed. Fusion welding is done maximum without difficulty via techniques the use of an inert protecting atmosphere of argon or helium gas. Considerable misinformation exists regarding the fire hazard in processing Mg alloys. It is authentic that Mg alloys are especially combustible while in a finely divided form, consisting of powder or fine chips, and this hazard should never be ignored. Above 800°F (427°C), a non-combustible, oxygen-free atmosphere is need to suppress burning. Casting operations require additional precautions due to the reactivity of Mg with sand and water in sheet, bar extruded, however, Mg alloys present no actual fire hazard.

1.3 ALUMINIUM ALLOYS WITH MAGNESIUM

In automotive manufacturing, Al plays an important role in automotive manufacturing. All types of vehicles, from motorcycles to space, are made from Al. This metal allows you to travel across oceans, fly in the sky and leave our planet. Transportation also has a high percentage of Al 27% consumption. Aluminum has always been considered a metal fly. Lightweight, sturdy and flexible, it has the perfect function of creating a heavier plane than air. There is a reason why in a few circles Al is called a 'winged metal'. Aluminum makes seventy-five percent and eighty percent of modern aircraft and apparently was first used in aircraft before the aircraft were invented. To replace Al in the automotive and aerospace business, Mg is used, due to its soft weight. Magnesium is the simplest metal found in the world with a bright gray color marked Mg. It is the second most visible metal in the center of the earth's crust. It is about 34 percent lighter in volume than Al. Birmabright, Magnalium, Al alloys containing Thorium are rarely used, so more than 2% thorium content requires the element to be treated as a radioactive substance, although strong magnesium was converted to military use and in space in the mid-1950s. Mg alloys are used for both forged and cast components, with the Al-containing alloys normally used for casting and the Zn-containing ones for forgings, the Zn-based alloys may be used at better temperatures and popular in aerospace. Magnesium+yttrium+rare-earth+Zn alloys along with WE54 and WE43 (the latter with composition Mg 93.6%, Y 4%, Nd 2.25%, 0.15% Zr) can perform without creep at up to 300C and are moderately corrosion-resistant.

1.4 MAGNESIUM COMPOSITES

Magnesium Composites are emerging from interest because the habitats can be properly made of fibers over a wide range. Many single-of-a-kind fiber systems can be used as reinforcement. However, Alumina and Silicon-Carbide products are used as reinforcement. The newly developed Mg-Composites for Carbon Nanotube are now available. The reinforcement phase has a significant impact on the structures. Significantly, it is durable, strong and resilient. Mg Composites are derived from the great interest in technology use due to its small weight and great strength.

1.5.1 MgZnHA Hydroxyapatite (HAp) is a calcium phosphate similar to the human hard tissues in morphology and composition¹.

Particularly, it has a hexagonal structure 2, 3 and a stoichiometric Ca/P ratio of 1.67, which is identical to bone apatite 2, 4, 5. HA has been successfully used by researchers in the magnesium matrix and they have reported enhanced corrosion protection, superior mechanical strength (both in the uncorroded and corroded state) and higher cell viability

1.6 DIFFERENCE BETWEEN ALUMINIUM AND MAGNESIUM

1.6.1 Corrosion

The Al metal is resistant to corrosion. Magnesium tends to corrode, even if the corrosion speed is very slow.

1.6.2 Atomic number

Aluminium (Al)-The atomic number is 13. Magnesium (Mg)-The atomic number is 12.

1.6.3 Cost effectiveness

The Aluminium alloy is cheaper and it has less die casting cost. Mg alloys are expensive and die casting cost is quite high.

1.6.4 Biological role

Aluminum has no value within biological systems and there may be no evidence to show its role in any biochemical process. Although living organisms include a small amount of Al in them, there is no scientific evidence for their need in the human body. Magnesium is important for both plants and animals. In plants, photosynthesis is not possible without Mg and in humans, Mg allows the activation of various enzymes. People consume about 250-350 mg of Mg per day. It is almost kept in the bones of humans.

1.6.5 Specific gravity

Al has a specific gravity of 2.7, Mg has the specific gravity of 1.7.

1.6.6 Alloy properties

Aluminium alloys need longer term for the solidification and additionally provide an extended die life. Al is quite stable, much less costly and does no longer bend without underneath stress due to its being sturdy. Mg alloys take lesser time to solidify. Mg is much less stable, very expensive and bends without difficulty while under stress because of being smooth.

1.6.7 Solubility Al is not soluble in water at room temperature Mg is highly soluble in water at room temperature and reacts with water.

1.7 APPLICATION OF MAGNESIUM ALLOYS The pursuit of lightweight goods, especially in the automotive business, has created a renewed interest in modern magnesium packaging. This requirement has led to improved studies and development work in companies and research institutes to obtain an advanced material profile and better selection of alloy systems. Here, development trends and applied capabilities in specific fields such as the automotive business and communication technologies are discussed in a multi-sectoral framework.

1.7.1 Automotive Applications • In 1920s, Mg parts made their way into racing cars. • However, it became no longer until the 1930s that magnesium turned into in commercial together with the Volkswagen (VW) Beetle. The VW Beetle, returned, contained 20 kg of Mg alloy in the transmission housing and the crankcase.

- Over the beyond decade, the growing environmental and legislative pressures at the automotive industry to provide lighter, better fuel efficiency, and better overall performance vehicles have resulted in the surge inside the use of magnesium.
- Widely used in conventional steel parts are being changed through new advanced materials along with magnesium, aluminum, and metal matrix composites.
- Hyundai, Jaguar, Fiat, BMW and Kia Motors Corporation have used magnesium-based materials in their automotive parts.

Aerospace Applications • In the aerospace business, weight loss is one of the most important goals due to the increased demand for pollution reduction and fuel efficiency. • ? Weight loss will be followed by fatigue and constant tiredness. • ? Many options for weight loss such as Al, fiber metal laminates, and lightweight structural plastics are introduced over time. However, advances in the development of aluminum alloys have made the same weight reduction work. • ? Fiber steel laminates are also an expensive material and, as a result, are used for key structures with the best mechanical requirements. • Low-density structural plastics have low impact and harm tolerance properties. They also showcase inferior properties when subjected to temperature extremes. Thus, most of these boundaries have made magnesium an attractive alternative. • Some applications incorporate the thrust reverser (for Boeing 737, 747, 757, 767), gearbox (Rolls-Royce), and helicopter transmission casings, etc. Military aircraft, also benefit from the lightweight characteristics of Mg alloys for transmission casings. There is likewise huge use of Mg in spacecraft and missiles due to the requirement for light-weight materials to reduce the lift-off weight.

- This is coupled with its excessive unique mechanical properties, ease of fabrication, and different appealing features which include its capability to resist (i) elevated temperatures, (ii) exposure to ozone, and (iii) bombardment of excessive-energy particles and small meteorites.

Sports Applications • In the sporting enterprise, it is important that the sports equipment fits as much as the ever growing expectations of sports fanatics. • The excellent specific strength and ability of Mg alloys and Mg composites to form complex shapes has led to numerous applications in sports equipment. For example, magnesium-based materials are used in the grips of archery bows, tennis rackets, and golf clubs.

- The lightweight and tremendous damping traits of magnesium-based materials have made them a popular material preference in bicycle frames and the chassis of in-line skates
- Bicycle frames crafted from Mg alloys or composites are able to soaking up shock and vibration, therefore allowing the rider to exert less energy and enjoy a comfortable ride.

Electronic Applications

- The trend within the digital equipment industry is to make products personal and portable. • Therefore, it's vital that the additives that make up the equipment are light weight and durable.
- Mg-based materials meet the important necessities as they may be as light as plastic, but exhibit tremendous improvement in strength, heat transfer, and the ability to protect electromagnetic interference and radio frequency interference, in comparison with their plastic counter parts.
- Mg-based materials are used in housings of Mobile phones, laptops, and portable media players.

Optical Applications

- Magnesium is commonly used to make eyeglass frame because of its lightness. • Magnesium case of digital camera, Magnesium's lightweight and optical stable features include the riflescopes and binoculars.

Medical Applications

- Mg alloys were first introduced as orthopedic biomaterials within the first half of the last century. • However, due to its low resistance to corrosion, a large amount of hydrogen accumulates around the plant during the corrosion process in vivo, limiting the widespread use of Mg-based materials as biomaterials.
- Despite this, Mg still possesses many attractive characteristics that make magnesium based materials potential candidates for use as implants for load-bearing applications in the medical enterprise.
- Magnesium is a natural ion in the human body. It additionally assists in many human metabolic reactions and is nontoxic to the human body.
- Mg is also used in few medications. Some natural Mg compounds also are big in the chemical enterprise. It is used as a Grignard reagent and in several food and subculture media due to the fact it's miles required for growth of organisms. Mg is extracted from sea water using Ca(OH)_2 and exists in mineral shape like dolomite, magnesite, carnallite, talc etc.

1.8

Despite the fact that Mg alloys, as the lightest structural alloys, offer significant capability for automotive applications, their applications remain restricted of their terrible formability at room temperature. Since the techniques used for enhancing formability normally result in a degradation of power, there aren't any high power Mg alloys showing good formability. Here Such designed alloy while subjected to the precise processing approach suggests a aggregate of strength and formability that surpasses those of magnesium alloys so far. The alloy layout idea used inside the present have a look is based at the utilization of alloying factors that may result in precipitation, in addition to maximize the segregation of other texture-controlling alloying elements. Such evolved alloy is expected to expand the application of Mg alloy sheets, which are now starting to gain acceptance through automotive industries. CHAPTER 2 LITERATURE SURVEY • J.C.Betts, 2010 - Laser surface cladding creates a new surface over the existing substrate, thereby contributing the desired surface properties. The process requires investment in added materials and delivery systems, as well as the corresponding issues of health, safety and cleanliness. Although impressive improvements to the material surface properties are possible, the resistance to wear can be enhanced still further by the inclusion of ceramic particles. • ASHISH SINGH and SANDIP P. HARIMKAR, 2012 -

92%

MATCHING BLOCK 2/15

W

Laser surface engineering is expected to play an important role in improving the surface properties of Mg alloys. Most of the laser surface engineering approaches such as LSM, LSA, LCS, LSC, and LSP have demonstrated effectiveness in improving corrosion, wear, and fatigue properties of Mg alloys. These property improvements are primarily the result of modification of composition.

100%

MATCHING BLOCK 3/15

W

Detailed experimental and computational investigations on laser-material interaction effects such as selective vaporization of elements, grain refinement, melt pool dilution, second-particle penetration, residual stresses, and solidification defects needs to be conducted to advance the understanding. Whereas it is possible to modify large area of Mg substrates using overlapping parallel tracks of laser modified regions, the microstructure and properties of these overlapping regions are expected to influence the overall performance of the laser modified surfaces. •

Chengpeng Maa, Ge Pengb, Lu Niec, Haifeng Liub, Yingchun Guan- 2018 - Mg phase as the matrix and Mg5Gd phase particles distributed in the matrix along extrusion direction. After laser surface modification, solidification microstructure was changed to Mg phase, and no phase grains precipitated along grain boundaries. The thickness laser-modified layer was about 360µm. For as-received specimen, initial galvanic corrosion occurred preferentially in a-Mg matrix around phase and extended into deep corrosion holes.

• Yuhang Lia, Srinivasan Arthanaria,b , Yingchun Guana, 2019 -

100%

MATCHING BLOCK 4/15

W

Laser surface melting of MB26 and AZ80 magnesium alloys were carried and their surface and electrochemical corrosion properties were systematically evaluated; 1. Surface roughness values of LSMed alloys were reduced in particular, the reduction was relatively higher for MB26 alloy due to the variation in cooling rate during laser processing. 2. Cross-sectional morphologies revealed that LSMed layer thickness was significantly varied and melted layer thickness value of AZ80 •

Xiyu Yaoa , Jincheng Tangb , Yinghao Zhoua , , Andrej Atrens , Matthew S. Darguschc , Bjoern Wiese, Thomas Ebel , Ming Yan, 2020 -The biomedical Mg-0.6Ca had simultaneously increases microhardness and decreased corrosion rate due to the surface modification by SLM. The main reason for the enhanced microhardness (20% increment) was attributed to the surface residual stress. The corrosion rate decreased because of confined impurity elements, the presence of MgO and the correspondingly increased self-corrosion potential. The biomedical Mg-0.5Zn-0.3Ca alloy exhibited increased microhardness (17% increment). Its H₂ release amount was slightly higher than the as-extruded state in the initial immersion time period but decreased significantly after ~72 h of testing, this was attributed to the combined result of varying residual stress states, refined microstructure and confined impurity elements.

• H. Pereira , O. Carvalho , G. Miranda & F. S. Silva, 2020 - mg is gaining attention as a biomaterial and it is extremely important to functionalise its surface due to its rapid corrosion. This study describes laser surface treatment of pure Mg as well as the characterisation of the different surface outcomes, namely texturing and remelting, as a function of laser parameters. Different combinations of laser power, scan speed and line spacing were tested and found to influence Mg surface. The use of a line spacing of 0.05 mm is more suitable to obtain a textured surface while a line spacing of 0.02 mm is more appropriated for remelting surfaces.

• Rakeshkumar Karunakaran, Sam Ortgies, Ali Tamayol, Florin Bobaru,

100%

MATCHING BLOCK 5/15

W

Michael P. Sealy -Magnesium alloys are a promising new class of

living organisms with similar bone strength, which reduces the harmful effects of stress protection. The use of biodegradable magnesium implants is eliminated the need for a second operation to repair or remove it.

- Aruvi Kruusing-Underwater and water-assisted laser processing:general features, steam cleaning and shock processing
- ASHISH SINGH1 and SANDIP P. HARIMKAR-

100%

MATCHING BLOCK 6/15

W

Magnesium (Mg) and its alloys are well known for their high specific strength and low density. However, widespread applications of Mg alloys in structural components are impeded by their insufficient wear and corrosion resistance. •

- B. Ratna Sunil a, T.S. Sampath Kumar a, , Uday Chakkingal ,V. Nandakumar the role of different grain sizes produced by equal channel angular pressing (ECAP) on the degradation behavior of magnesium alloy using in vitro and in vivo studies
- Bhaskar Manne ,Harish Thiruvayapatia Magnesium-based alloys have attracted significant attention for biomedical applications due to its biodegradability as well as density and elastic modulus which are close to those of human bone. However, the uncontrolled biodegradation and hydrogen evolution are of major concern.
 - A.J.Lopez -

100%

MATCHING BLOCK 7/15

W

A high power diode laser (HPDL) was used to produce laser surface melting (LSM) treatments on the surface of the Mg alloy AZ91D. •

- C. X. Wang -. It is regarded that pulsed-laser ablation PLA was employed as a route to prepare thin solid films.
- Chengpeng Ma-Magnesium alloy has attracted much attention as biodegradable material for medical devices including implants and stents in recent years
 - Daoli Zhao-Monitoring the biodegradation process of magnesium and its alloys in vivo is challenging. Currently, this process is monitored by micro-CT and X-ray imaging in vivo, which require large and costly instrumentation.
 - Omid Savabi-Magnesium has been recently introduced as a novel biodegradable material for bone healing. However, the fast degradation of this material results in the fast release of hydrogen which limits its clinical applications.
 - David Omans-Pulsed laser ablation in liquids (PLAL) has become an attractive method for the synthesis of nanodiamond. This work deals with the growth kinetics study of structures of nano-diamonds embedded in sp² carbon synthesized by this method
 - Yang Liu-Biodegradable magnesium (Mg) has garnered attention for its use in orthopaedic implants due to mechanical properties that closely match to those of bone.
 - Dongfang Zhang- Microstructure, composition, in vitro degradation and cytocompatibility of coating were examined systematically.
 - Dhruva Babu Subedi-This study reports on the effect of the addition of Glycine to Hank's solution on the in-vitro corrosion behavior of AZ31 magnesium (Mg) alloy at 37 °C and a pH of 7.4 studied by using potentiodynamic polarization (PDP).
 - F.Amerstorfer -the long-term effects of degrading magnesium implants on bone tissue in a growing rat skeleton using continuous in vivo micro-Computed Tomography, histological staining and Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA - ICP-MS). Two different magnesium alloys—one rapidly degrading (ZX50)
 - Frank Witte-

100%

MATCHING BLOCK 8/15

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The in vivo corrosion of magnesium alloys might provide a new mechanism which would allow degradable metal implants to be applied in musculo-skeletal surgery. This would particularly be true if magnesium alloys with controlled in vivo corrosion rates could be developed.

CHAPTER 3 AIM AND SCOPE 3.1 AIM Aim of this assignment is to create surface texturing on Mg alloys/composite materials without liquid and under liquid medium, to observe the surface roughness using AFM (Atomic Force Microscope),

SCOPE Mg Alloys / Composites have shown superior strength in many engineering systems, for example: - Wide use of MgAlloys is expected due to its very high bio performance and light weight. As a result of their strength, durability, and mechanical behavior, materials considerations, modeling, and engineering, raw and renewable materials, and biological life cycle considerations, special materials (such as medicine, energy, Aerospace, and nanotechnology)

Different Grades of Mg Alloys Mg Alloys of different grades are used to learn more about parameters and the use of alloys in almost all fields of engineering. This will be especially helpful in in-vitro and in-vivo studies as well as in the automotive sector. Mg-based alloys containing rare earth metals are important structural elements, as they combine low density with high energy structures. This makes them very attractive in the industry, especially when low construction weight is important, such as when building aircraft and equipment. Alloys produced by processing techniques are treated separately and discussed with metal matrix compounds as well as the use of fast hardening to produce amorphous and other new materials. Finally, current and future trends in the use of magnesium alloys are explored along with examples of recent applications.

CHAPTER 4 MATERIALS AND METHODOLOGY

4.1 MATERIALS USED

Materials used in this process are 3 types, they are

Fig 4.1 The samples of different grades. SAMPLE COMPOSITION 1 MgZnHA Table 4.1 Grade and Composition of Materials Used

4.2 METHODOLOGY

Mg alloy with blocks of different degrees of length 280mm, width 100mm and thickness 100mm. Initially, the Mg block undergoes a wire cutting process to magnesium material of sample size 2mm thickness 8mm diameter

Cutting Process

sample size 2mm thickness 8mm diameter 4.2.1 LASER ETCHING

A laser engraving machine can be of 3 main parts: a laser, a controller, and a surface. The laser is like a pencil, the beam emitted by it allows the controller to draw the patterns on the surface. The controller direction, intensity, speed of movement, and spread of the laser beam directed towards the surface. The surface is chosen according to match what the laser can act on.

Laser engraving machine

There are 3 principals of recording equipment: The most unusual surface is the X-Y desk where, in general, the surface is vertical and the laser optics flows around the X and Y directions, directing the laser beam to attract vectors. Sometimes the laser is stopped and the piece of work is moving. The piece of work moves between the Y axis and the laser inside the X-axis. The second style is the work cylinder pieces where the laser effectively cuts the fine helix and the on / off laser pulsing produces a popular image on the basis of the raster. The point at which the laser reaches the top must be the fixed plane of the laser optical system and is usually the same as its focus point. This point is usually small, probably less than half a millimeter. The energy generated by the laser converts the surface of the material into a focused area. It may burn the surface and then evaporate the active substance, or perhaps break (known as "glass") and shrink from the surface. Cutting with a metal part of the metal is usually laser-engraved.

A laser can be extremely efficient, since a laser beam can be designed to bring energy to the surface in a way that converts a high percentage of light energy into heat. The beam is very concentrated and collimated - on non-reflective materials such as wood, plastic and enamel on top.

Laser processing on sample Different patterns can be recorded by adjusting the controller to move a certain laser beam over time. The laser beam track is carefully adjusted to obtain consistent removal depth. For example, cross-paths are avoided to ensure that each recorded area is laser-recorded only once, in order to extract the same amount of material. The speed at which it moves on the material is also taken into account when constructing carved patterns. Changing the thickness and spread of the beam allows for greater flexibility in construction.

Since laser placement is accurately understood using a controller, it is not necessary to add obstacles in place to save the laser from deviating from the recorded pattern. Therefore, no blocking mask is required for laser recording especially because this method is different from the old recording methods.

Laser Engraving (square pattern) The Spot diameter kept on Specimen is 0.1mm, dot depth 0.2mm and dot diameter is 0.1mm.

4.2.2 FABRICATION In this case the circular base plate is made of steel according to the inner diameter of the socket. The metal plate is mounted on the front with a diameter of 3mm. Provided support to stay on the lookout. A support foot screw system is provided to help adjust the base plate height up or down. The 4mm diameter is drilled with a thermometer. Clamps are made on the plate to hold the work in the center.

Fig 4.8 The fabricated setup is placed in the beaker

4.3 ETCHING ON METALS Metals are heat-resistant, metal marking requires very strong laser beams. Basically, the intermediate laser power leads to melting and high power causes the material to evaporate.

Traditional fine carvings began to be the worst laser-engraved objects. This problem has now been resolved using short wavelength laser. Using CO2 laser, Yb: Fiber Lasers, Nd: YVO4 or Nd: YAG lasers, metals can now be easily recorded. The square of the matrix and the dot pattern are assigned to the sample to stand out. The lines provided intersect the matrix points in the center and form a diamond structure in the sample with vertical spaces between each series of cuts. The applied power is about 55% of 60 W. The laser beam velocity is 100 mm / sec. The frequency used to heat over a sample is approximately 20 KHz. All data must be properly entered in order to be able to describe and target. Laser is shown in the sample and the desired shape is recorded.

Fig 4.11 Etching process

A built-in metal plate with support legs is found inside the beam next to the magnetic field in it. The stirrer is used to introduce the flow into propanol and allows to prevent the incorporation of graphite powder into the beaker. As graphite powder contains a good percentage of carbon it helps to blend better and enhance the thermal properties of the mixture during lasing. The whole setup with the beaker is placed on a heat plate used to keep the liquid medium temperature constant. Thereafter the laser parameters are set and the laser beam is allowed to enter the target area.

4.8.1 Etching parameters

4.2 Laser parameters of line and matrix etching

RPM

1900

Power

33w

Frequency

20KHz

Speed

100mm/sec

The RPM is maintained around 1900 with the power of 55% at 60W with the speed of 100 mm/sec with the frequency of 20KHz. These parameters provide the best results. The desired shape structure is acquired during etching is done under these parameters.

CHAPTER 5 RESULTS AND DISCUSSION 5.1 ATOMIC FORCE MICROSCOPE In AFM, the surface is visualised based on sensing the interacting forces between the atoms of a sharp tip mounted on a flexible cantilever and the atoms in the sample. During the dimension, depending on the microscope model, the cantilever and the tip are lowered towards the sample or the sample is raised towards and pointed until "contact" is made. The displacement of the cantilever is detected by a laser beam reflected from the top side of the cantilever onto a photodetector. Any change in cantilever deflection is the response to varying interaction forces acting on the tip causing the laser beam to move, and it is detected as a change in photodetector output voltage. The overhang is moved over the sample in some way (usually lines) and the surface information is collected. The spatial resolution depends on the shape of the tip and the model of the microscope, but is of the order of a Nanometer. With a right calibration, adjustments within the voltage converted into changes of the pattern topography or other parameters. So far, many imaging modalities have been used to study surface structure. They are based on different standards, function in difference force regimes and are capable of providing range in different information about the pattern.

5.1.1 Tapping mode for detecting surface AFM tapping mode TM Unlike the contact mode, in TM cantilever imaging oscillates at (or near) the resonant frequency or amplitude A. If the tip is removed from the sample area, A is equal to the free amplitude of A_0 . When a tip is lowered into a template during a local scan, A_0 is reduced by the interaction between the tip title and the location. Near the surface, the amplitude is reduced to a minimum. In a specific tap mode test, the volume of the oscillation fluid at which the "contact" setting is set is defined by the set amplitude of the element. In term s of setpoint $(A_{sp} / A_0) \times 100\%$. Generally, a high point value means a slight decrease, and because the width and the dependence of the force are related, it also means less energy applied to the sample and obtained by the tip.

Fig 5.0 shows the procedure of AFM When using AFM to visualize a sample, the tip is attached to the sample and the sample is scanned with a raster with an xy grid. Typically, a digital voice loop is used to maintain the probe pattern pressure during a certain scanning time. This feedback circuit has a cantilever deviation as its input and output controls the distance to the z axis between the probe holder. As long as the tip stays connected to the sample and the sample is scanned on the xy plane, the changes in the sample length will change the cantilever deviation. The response then adjusts the probe holder length so that the deviation is reset to the user-defined value. A well-tuned feedback loop continues to adjust the sample manager separation during the sweeping movement, so that the deviation remains constant.

5.2 RESULTS OF AFM ANALYSIS:

Shallow crater Solidified Ablated- Molten Pool

Deep gorge walled crater

(a) MgZnHA in air medium (b) MgZnHA in water medium

Fig 5.1 SEM analysis of the top surface of laser ablation treated magnesium alloy and nanocomposite

10X (a)MgZnHA in air medium Fig 5.2 SEM analysis of the top surface of laser ablation treated magnesium alloy and nanocomposite

10 X

(b) MgznHA in water medium Fig 5.3 SEM analysis of the top surface of laser ablation treated magnesium alloy and nanocomposite

FIG 5.4 . Kerf diameter of craters formed in laser ablated Mg3Zn1HA nanocomposite under air and water medium

Fig 5.5 The grain size Mg3Zn1HA nanocomposite subjected to laser ablation under air and water medium.

Fig 5.6 Microhardness of MgZnHA nanocomposite subjected to laser ablation under air and water medium.

(a) (b)

(c)

Fig 5.7 . Scanning electron micrograph of Mg3Zn1HA nanocomposite: (a) Parent metal (PM); (b)Heat Affected Zone(HAZ); (c) cross-section of laser ablated region under air medium.

Fig 5.8 Energy dispersion spectroscopy analysis of Mg3Zn1HA nanocomposite laser ablated region under air medium.

Table 1. Energy dispersion spectroscopy elemental analysis in weight percentage. 295

O Mg Zn Ca Mg3Zn1HA (In Air) 13.09 84.36 2.28 0.27 Mg3Zn1HA (In Water) 18.43 79.92 1.27 0.38

Table 2: AFM surface topographical readings of laser ablated MgZnHA nano-composite specimens

Peak to peak (nm) Ten Point height (nm) Average Roughness (nm) Root mean square (nm) MgZnHA (Medium:Air) 1538.9 766.26 108.96 146.9 Mg3ZnHA (Medium : water) 390.1 199.40 251.07 52.3

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	Laser surface engineering is expected to play an important role in improving the surface properties of Mg alloys. Most of the laser surface engineering approaches such as LSM, LSA, LCS, LSC, and LSP have demonstrated effectiveness in improving corrosion, wear, and fatigue properties of Mg alloys. These property improvements are primarily the result of modification of composition.		Laser surface engineering is expected to play an important role in improving the surface properties of Mg alloys. Most of the laser surface engineering approaches such as LSM, LSA, LCS, LSC, and LSP have demonstrated effectiveness in improving corrosion, wear, and fatigue properties of Mg alloys. These property improvements are primarily the result of modification of composition (	
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	Detailed experimental and computational investigations on laser–material interaction effects such as selective vaporization of elements, grain refinement, melt pool dilution, second-particle penetration, residual stresses, and solidification defects needs to be conducted to advance the understanding. Whereas it is possible to modify large area of Mg substrates using overlapping parallel tracks of laser modified regions, the microstructure and properties of these overlapping regions are expected to influence the overall performance of the laser modified surfaces. •		Detailed experimental and computational investigations on laser–material interaction effects such as selective vaporization of elements, grain refinement, melt pool dilution, second-particle penetration, residual stresses, and solidification defects needs to be conducted to advance the understanding. Whereas it is possible to modify large area of Mg substrates using overlapping parallel tracks of laser modified regions, the microstructure and properties of these overlapping regions are expected to influence the overall performance of the laser modified surfaces.	
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	Laser surface melting of MB26 and AZ80 magnesium alloys were carried and their surface and electrochemical corrosion properties were systematically evaluated; 1. Surface roughness values of LS Med alloys were reduced in particular, the reduction was relatively higher for MB26 alloy due to the variation in cooling rate during laser processing. 2. Cross-sectional morphologies revealed that LS Med layer thickness was significantly varied and melted layer thickness value of AZ80 •		Laser surface melting of MB26 and AZ80 magnesium alloys were carried and their surface and electrochemical corrosion properties were systematically evaluated; 1. Surface roughness values of LS Med alloys were reduced in particular, the reduction was relatively higher for MB26 alloy due to the variation in cooling rate during laser processing. 2. Cross-sectional morphologies revealed that LS Med layer thickness was significantly varied and melted layer thickness value of AZ80	
	https://www.sciencedirect.com/science/article/pii/S0257897219309533			
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	Michael P. Sealy -Magnesium alloys are a promising new class of		Michael P. Sealy ... Magnesium alloys are a promising new class of	
	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9538561/			

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Magnesium (Mg) and its alloys are well known for their high specific strength and low density. However, widespread applications of Mg alloys in structural components are impeded by their insufficient wear and corrosion resistance. •		Magnesium (Mg) and its alloys are well known for their high specific strength and low density. However, widespread applications of Mg alloys in structural components are impeded by their insufficient wear and corrosion resistance.		
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7/15	SUBMITTED TEXT	32 WORDS	100% MATCHING TEXT	32 WORDS
A high power diode laser (HPDL) was used to produce laser surface melting (LSM) treatments on the surface of the Mg alloy AZ91D. •		A high power diode laser (HPDL) was used to produce laser surface melting (LSM) treatments on the surface of the Mg alloy AZ91D.		
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8/15	SUBMITTED TEXT	61 WORDS	100% MATCHING TEXT	61 WORDS
The in vivo corrosion of magnesium alloys might provide a new mechanism which would allow degradable metal implants to be applied in musculo-skeletal surgery. This would particularly be true if magnesium alloys with controlled in vivo corrosion rates could be developed.		The in vivo corrosion of magnesium alloys might provide a new mechanism which would allow degradable metal implants to be applied in musculo-skeletal surgery. This would particularly be true if magnesium alloys with controlled in vivo corrosion rates could be developed.		
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