

LASER PEENING OF RESORBABLE MAGNESIUM ALLOY

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

By

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(DEEMED TO BE UNIVERSITY)

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **S.SATHEESHWARAN (39860019)** and **ABISHEK JEREMIAH (39860001)** who have done the Project work as a team, who carried out the project entitled “**LASER PEENING OF RESORBABLE MAGNESIUM ALLOY**” under my / our supervision from AUGUST 2022 to 2023

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DECLARATION

We **Satheeshwaran S (39860019)** and **Abishek Jeremiah J (39860001)** hereby declare that the Project Report entitled **LASER PEENING 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.

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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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DESIGNING A MAGNESIUM ALLOY WITH
STRENGTH AND HIGH FORMABILITY

LASER PROCESSING OF METALS AND
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LASER PROCESSING OF MAGNESIUM
ALLOYS

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LIST OF ABBEREVIATIONS

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

The magnesium substance discussed in this chapter has the ability to displace steel, aluminium alloys, and plastic-based materials. Due to magnesium's superior rigidity and strength compared to the majority of frequently used metals and plastic-based materials, design engineering can achieve this goal.

MAGNESIUM

After steel and aluminium, magnesium is the third most popular construction material. The deepest grey of the alkaline earth series, magnesium is the 12th atomic chemical chain. Metals with magnesium content offer great strength in a range engineering uses, two-thirds the density of steel and aluminium at four volumes. Materials based on magnesium are heavily utilized in the business with substantial weight uses because of their low density and good mechanical qualities. Magnesium has also been used as a building element in fields like transportation, athletics, technology, and the cosmos. Products are used in permanent light metals based on how they affect the atmosphere. All metals from the alkaline atmosphere, including magnesium, have very low melting points (923 K (1,202 ° F)) and low boiling points (1994 ° F) at 1363 K. At ambient temperature, magnesium interacts with water, though it does so more slowly than calcium. Because magnesium is covered by a soft coating, it is impervious to water and challenging to remove oxides even though it is slightly diminished when exposed to air and has a distinct alkaline iron. Hydrogen bubbles are steadily created in the metal surface when submerged in water, and the reaction is quick. Better temps speed up reactions. Although it is challenging to burn in bulk or in bulk, it flames a lot, particularly if it is blossomed or shaved into thin threads. Magnesium metal and fires have a maximum temperature of 5,610 °F (3,100°C).

Such a fire is challenging to put out after burning because it consumes in nitrogen (to form Mg_3N_2), CO_2 (to form MgO and C), and water. (to form MgO and H). When magnesium burns in air with potent ultraviolet radiation, it emits a brilliant white light.

Uses Of Magnesium

Aluminum and magnesium are both marginally bulkier. When used as an alloyant, it enhances the welding, production, and equipment characteristics of aluminium. These alloys are useful in the manufacture of cars and aeroplanes. To make pigments, magnesium sulphate (MgSO_4) is employed as a composite ingredient. Magnesium hydroxide ($\text{Mg}(\text{OH})_2$) functions as a flame suppressant for polymers. To resist heat, bricks are combined with magnesium oxide (MgO). Other medications also contain the mineral magnesium (Mg). The pharmaceutical business also values other magnesium organic compounds. It is used in other foods and cultural goods as reagent reagents (organic chemical reactions), as required for biological growth. Mg is found in minerals like magnesium, dolomite, talc and carnallite and is primarily taken from salt water carrying calcium hydroxide ($\text{Ca}(\text{OH})_2$). Magnesium is used in goods like luggage, vehicle sets, cameras, computers and electrical tools because it is lightweight. To eliminate sulphur it is additionally provided molten metal and iron.

ALLOYS AND COMPOSITES

At least two chemicals are combined to create the alloy and composite substance. Alloys and composites are comparable in that they both show various qualities, the majority of which are characteristics of the materials used to create them. Alloys and composites are actually very different from one another, though, if you look a little closer. Examine the variations between the two metals and compounds in more detail.

Alloy

An amalgam is a mixture of at least two elements, one of which must be solid. Solids and liquids are both possible forms of the alloy. Two-element alloys are known as binary alloys, and three-element alloys are known as ternary alloys. Typically, an alloy's internal chosen detail mass is quantified in mass with a percentage attached to it. Alloys are created using extraordinary ingredients to improve the characteristics that are typically connected with them. When two or more elements are combined, an amalgam is created that degrades the character of the original elements. It is typically a metal trait because the mixture will always contain at least one metal component. The fact that alloys don't have the same properties as steel because of the steel components contain is a significant benefit of using them. You might discover, for instance, metals don't have all have the same melting temperature. According to the components that make up an alloy, there are an enormous variety of melting temperatures.

Examples of Alloys

Alloys come in a variety of forms. Metal is the most typical. Iron is much harder than iron because it typically consists of a carbon and iron combination. There is only one method to make the metal. Sometimes, only carbon and iron are used to do this, but other substances like chromium, tungsten, and magnesium can also be used or introduced. The ductility and hardness of a metallic-like combination can be constantly changed by varying the mixture that is used to make it. Copper is a typical illustration of an alloy. Copper and zinc are combined to form brass. Despite the fact that copper and zinc are both widely used, copper has been shown to be superior and more robust. The metal was created for this reason. Many organizations have discovered that they can successfully control the look and feel of various components by using alloys.

Composite

Composite, which resembles a metal, is a combination of two or more substances. Although metals are always present in the alloy, the combination is not a

part of the blend. Additionally, combined compounds are visually and chemically distinct from one another. They are frequently referred to as component elements.

Matrix bonding materials are frequently used to carry reinforcing materials into a compound, resulting 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 variabilities.

Examples of Composites

Ingredients in combinations can be artificial or natural. Natural combination of wood can be taken as an example. It is made up of a combination of strands, cellulose and lignin. Concrete is frequently used as a mixed illustration. By focusing on the components that do not combine to create a new compound, you can see various elements that make it up.

This highlights yet another distinction between compounds and metals, Although the absence of iron in the compounds appears to be the primary distinction between the two, the makeup of the compounds and alloys varies significantly. Computer are heterogeneous and never make a homogeneous mixture, whereas alloys can neither be heterogeneous nor homogeneous

As demonstrated, composites and alloys are largely dissimilar, with a few minor parallels. Distributing alloys to businesses in a range of sectors, such as the chemical, aviation, and industrial, is the main focus of AlloyEagles.

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 in ASTMB275) 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 is nothazard.

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 becoming more and more popular because a variety of fibres can be used to make the homes effectively. As reinforcement, numerous unique fibre methods can be used. Products made of silicon-carbide and alumina are used as support, though. Mg-Composites for Carbon Nanotubes, recently created, are currently on the market. The period of reinforcement significantly affects the structures. Significantly, it is robust, sturdy, and long-lasting. Due to their light weight

and high strength, magnesium composites have generated a lot of attention in technology.

MgZn Alloy

As a biodegradable substance, a binary Mg-Zn magnesium alloy was investigated. A clean melting procedure and high quality raw materials were used to create a Mg-Zn alloy that had very low impurity levels. The Mg-Zn alloy's grain size was finer and a uniform single phase was obtained after solid solution treatment and heat working. The tensile strength and elongation obtained were 279.5 MPa and 18.8%, respectively, indicating that the mechanical properties of this Mg-Zn alloy were appropriate for implant applications.

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 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, a 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, a 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.

DESIGNING A MAGNESIUM ALLOY WITH HIGH STRENGTH

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 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. 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 need 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 μm.

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 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 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 alloyAZ91D.
- 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 In almost every area of engineering, alloys of various grades are used to learn more about characteristics and their applications. This will be particularly useful for studies conducted in vitro and in vivo, as well as for the automotive industry. Due to their combination of low density and high energy structures, magnesium-based alloys incorporating rare earth metals are crucial structural components. Their low construction weight makes them extremely desirable in the market, particularly when constructing machinery and aircraft. In order to create amorphous and other new materials, fast hardening is used in conjunction with metal matrix compounds and is treated separately from alloys created through processing methods. Finally, the use of magnesium alloys is examined along with present and projected future patterns and recent applications.

CHAPTER 4

MATERIALS AND METHODOLOGY

MATERIALS USED

Materials used in this process are



Fig.4.1 Samples of Different Grades.

SAMPLE	COMPOSITION
1	MgZn

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 5mm diameter



Fig.4.2 Sample Metal

LASER PEENING

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.4.3 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 laser. 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.

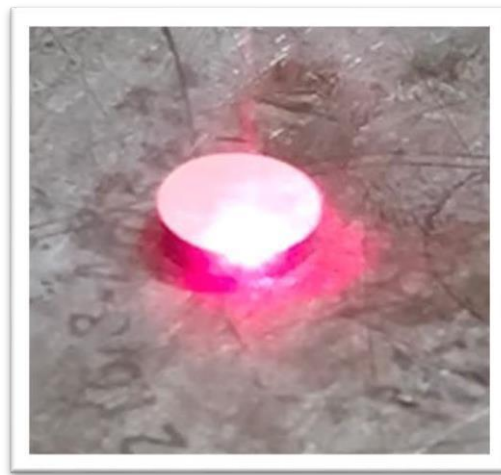
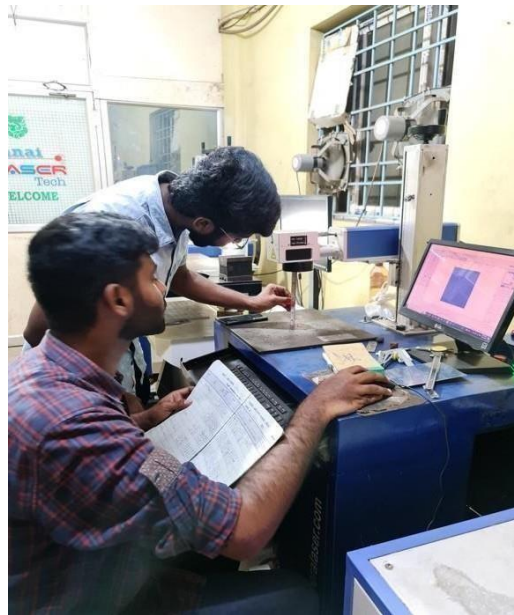


Fig.4.4 Laser processing on sample

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.

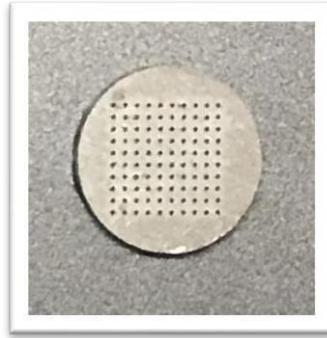


Fig.4.5 Laser Engraving (square pattern)

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.4.6 Fabricated Setup

CHAPTER 5

RESULTS AND DISCUSSION

ATOMIC FORCE MICROSCOPE

In AFM uses interacting forces between the atoms of a sharp tip placed on a flexible cantilever and the atoms in the sample to detect the surface. During the measurement, the cantilever and tip are either lowered towards the sample or the sample is raised and pointed until "contact" is made, based on the microscope model. A laser beam reflected from the upper side of the cantilever onto a photodetector is used to measure the displacement of the cantilever. Any variation in the cantilever's deflection, which results from the interaction forces that move the laser's tip, is registered as a difference in the output voltage of the photodetector. The sample's overhang is moved over it in some manner (typically with lines), and surface data is then gathered. The spatial resolution, which is on the order of a nanometer, relies on the shape of the tip and the type of microscope. Correct calibration resulted in changes to the pattern topography or other factors when voltage adjustments were made. Surface structure has so far been investigated using a variety of imaging techniques. They operate under various force regimes, are founded on various standards, and can provide a variety of 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.

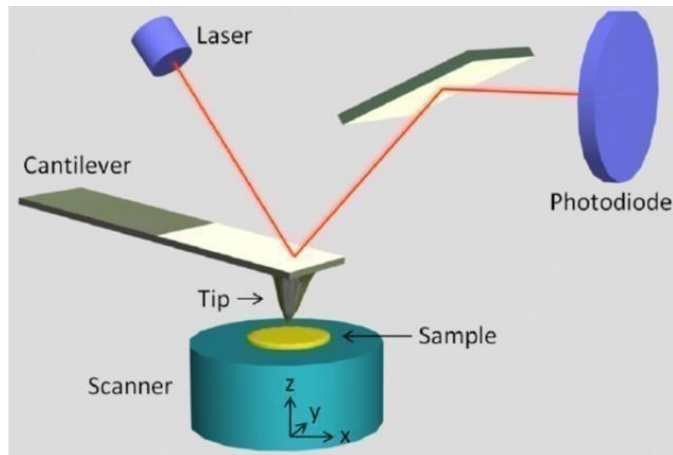


Fig.5.0 AFM

The sample's overhang is moved over it in some manner (typically with lines), and surface data is then gathered. The spatial resolution, which is on the order of a nanometer, relies on the shape of the tip and the type of microscope. Correct calibration resulted in changes to the pattern topography or other factors when voltage adjustments were made. Surface structure has so far been investigated using a variety of imaging techniques. They operate under various force regimes, are founded on various standards, and can provide a variety of information about the pattern separation during the sweeping movement, so that the deviation remains constant.

Scanning Electron Microscope

A scanning electron microscope is a type of microscope used for studying the surface of solid objects. It uses an electron probe that is periodically scanned over the specimen and a focused electron beam of comparatively low energy. Similar to those outlined for the transmission electron microscope, the beam is created and focused by an electron source and electromagnetic lenses. (TEM). High-energy backscattered

electrons and low-energy secondary electrons are stimulated to emit from the specimen's surface by the action of the electron stream.

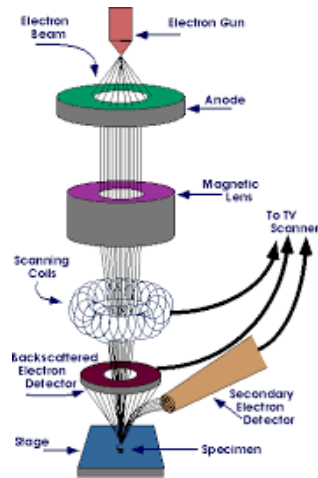
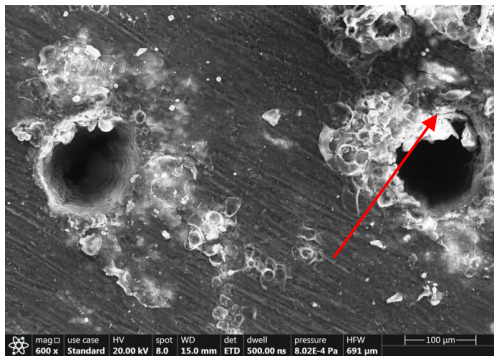


Fig: 5.1 : Scanning Electron Microscope

RESULTS OF AFM ANALYSIS:

CRATER MORPHOLOGY:

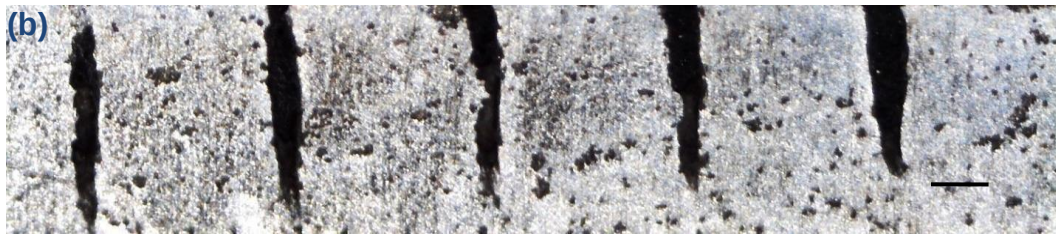


(a)



(b)

Fig.5.1 Magnesium alloy and composites surfaces treated by laser ablation were subjected to SEM examination. (a)MgZn in air medium, (b) MgZn in water medium

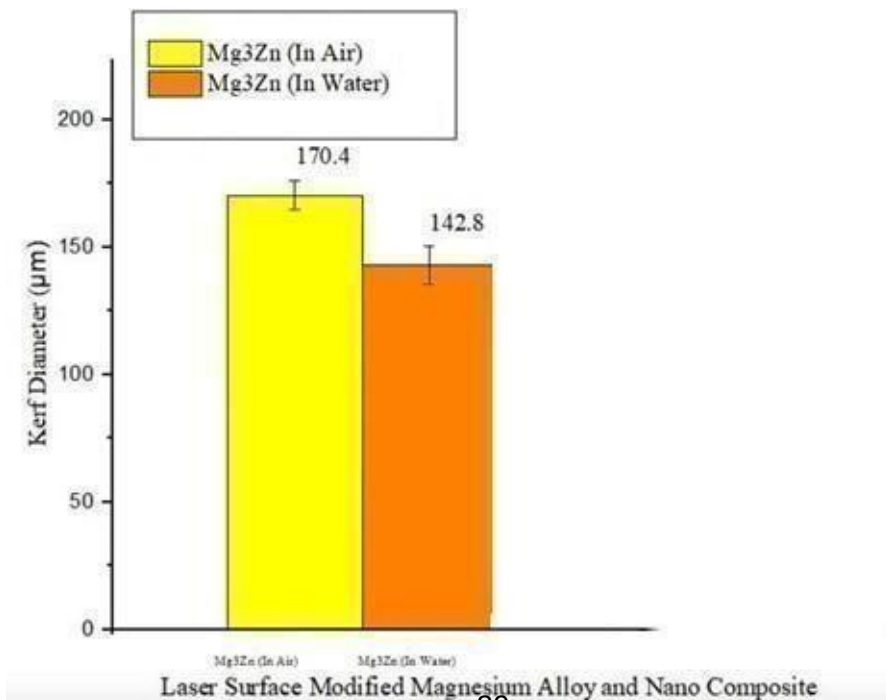


(a)

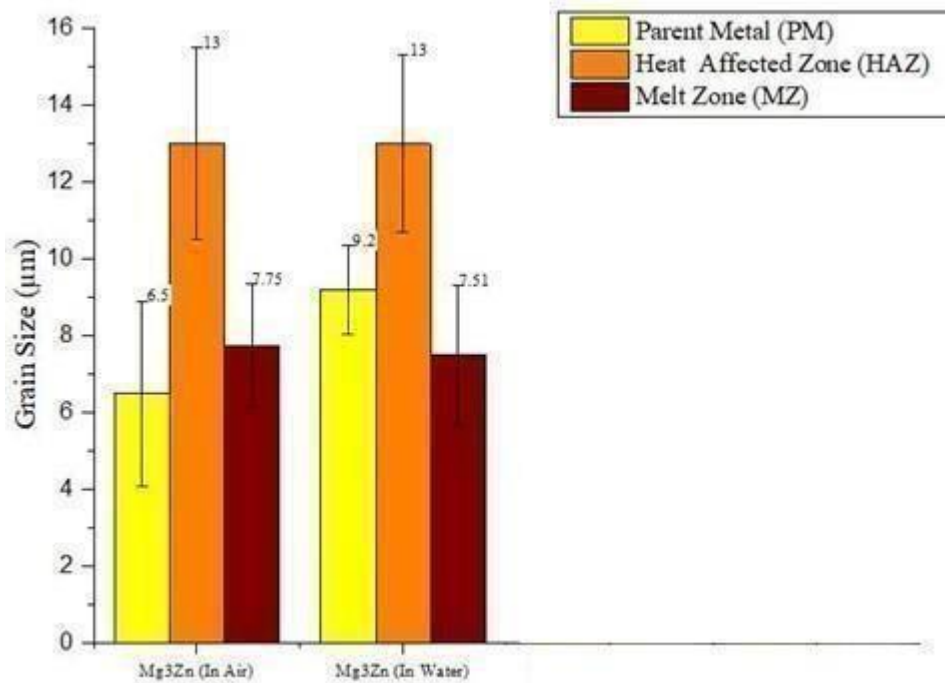


(b)

Fig.5.2 Magnesium alloy and composites surfaces treated by laser ablation were subjected to SEM examination. (a)MgZn in air medium, (b) MgZn in water medium



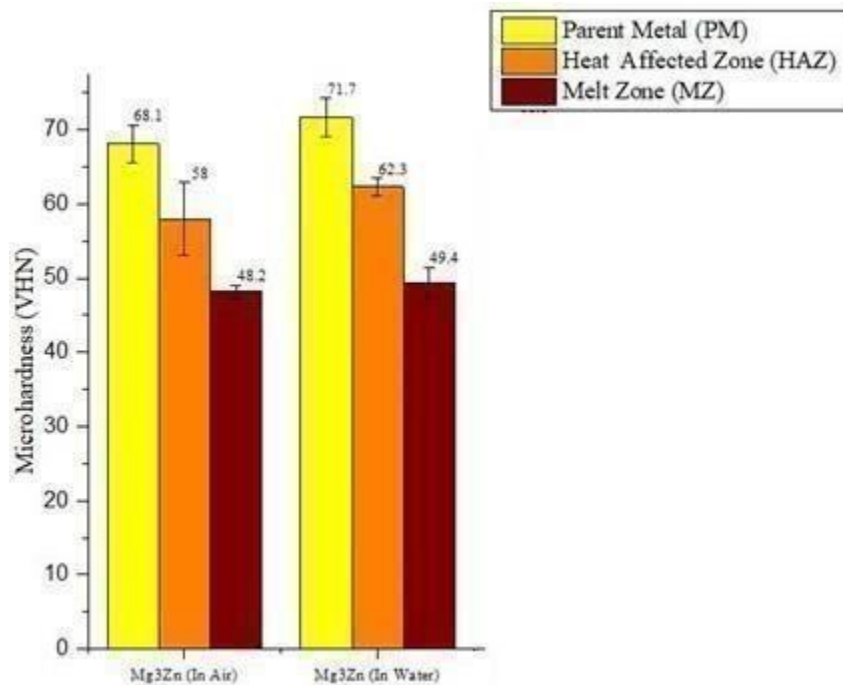
GRAIN SIZE :



Laser Surface Modified Magnesium Alloy and Nano Composite

Fig:5.3 : The laser-ablated Mg3Zn alloy and nanocomposite's grain size in the presence of oxygen and water

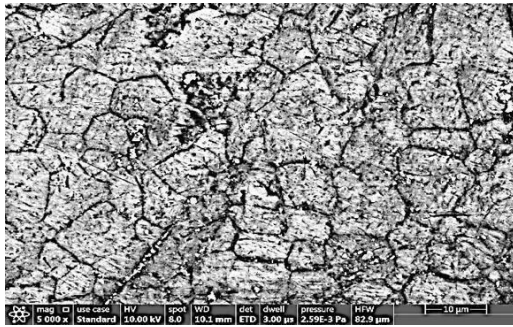
MICROHARDNESS:



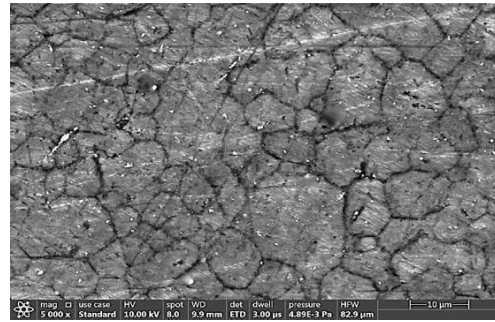
Laser Surface Modified Magnesium Alloy and Nano Composite

Fig:5.4 : Microhardness of MgZn nanocomposite is laser ablation under O₂ & H₂O

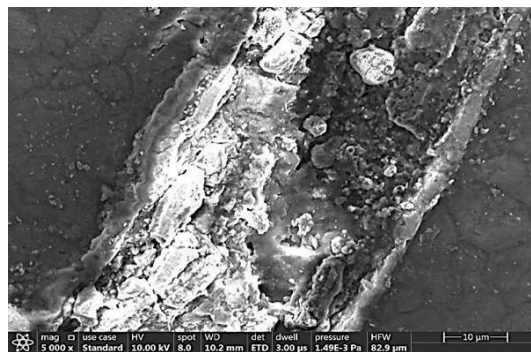
MICROSTRUCTURE:



(a) Parent metal



(b) Heat Affected Zone



(c) Cross- section of laser ablated region under air medium

Fig 5.5 Scanning electron micrography of MgZn Alloy

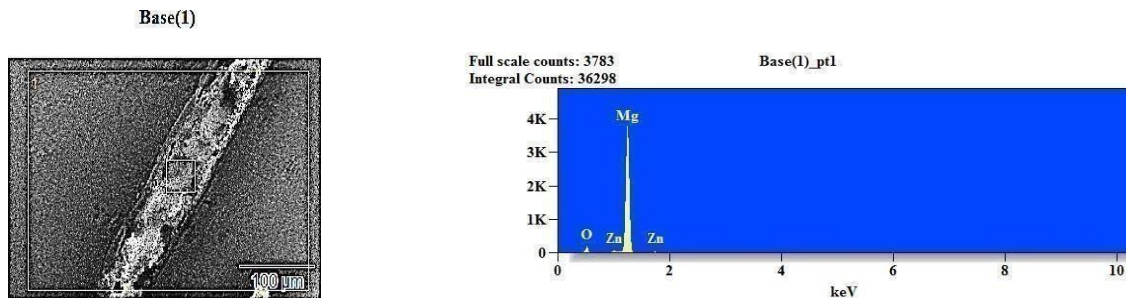
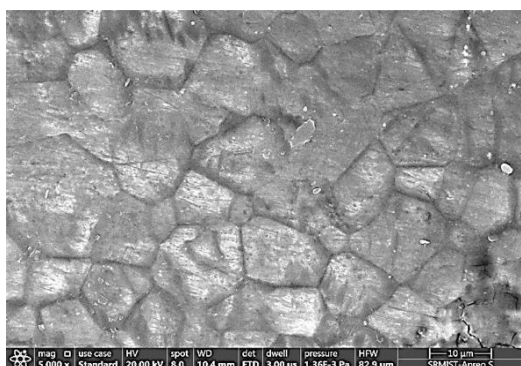
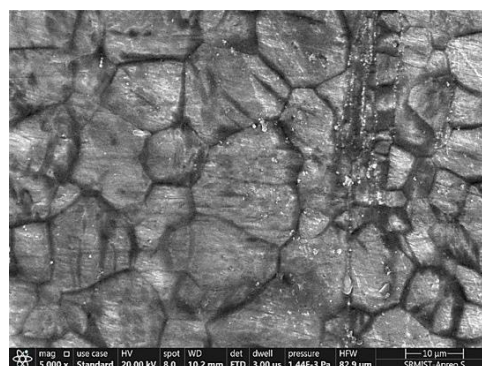


Fig 5.6 Energy dispersion spectroscopy analysis of MgZn Alloy laser ablated region

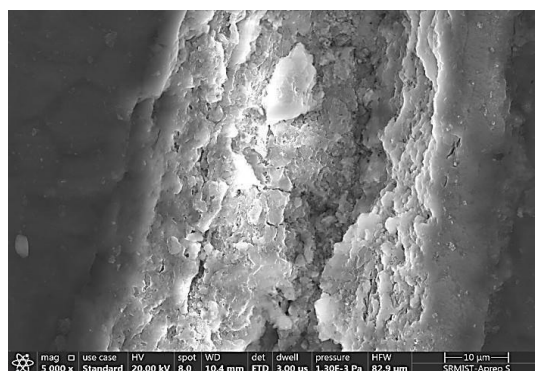
Mg3Zn alloy laser ablated under water medium



(a) Parent Metal



(b) Heat Affected Zone



(c) cross-section of laser ablated region

Fig.5.7 :Scanning Electron Micrograph of MgZn alloy

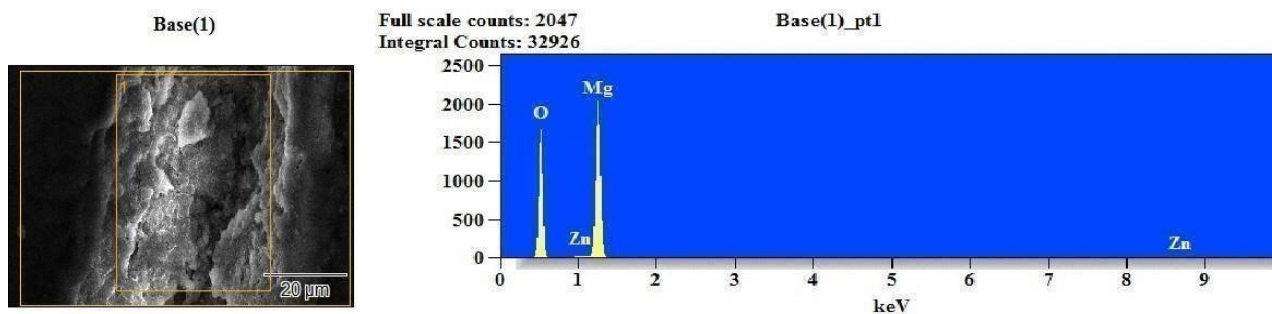


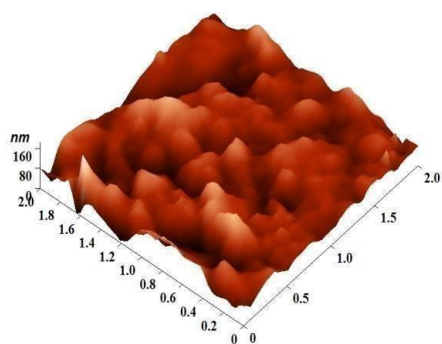
Fig:5.8 :Energy dispersion spectroscopy analysis of MgZn laser ablated region under

Table 5.1 Elemental analysis using energy dispersion spectroscopy and weight%

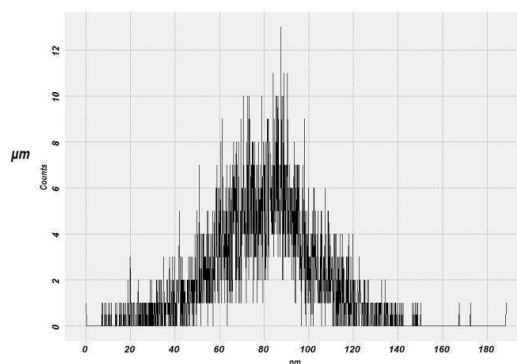
	O	Mg	Zn	Ca
Mg3Zn (In Air)	13.94	83.69	2.37	-
Mg3Zn (In Water)	55.25	43.62	1.13	-

Table 5.2 AFM Laser-ablated Mg3Zn alloy nano-composite specimen surface topographical measurements

	F	Ten Point height (nm)	Average (nm)	Average Roughness (nm)	Root Mean Square (nm)
Mg Zn (Medium : Air)	188.59	85.97	79.81	18.01	23.22
Mg Zn (Medium : Water)	134.31	73.70	94.24	10.64	14.24

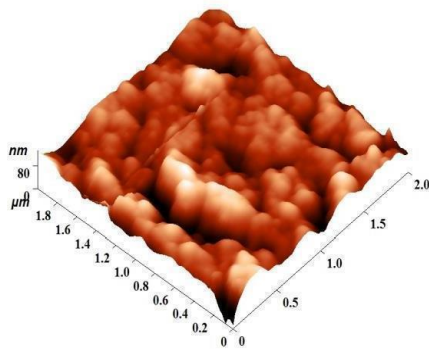


(a) Surface Topography

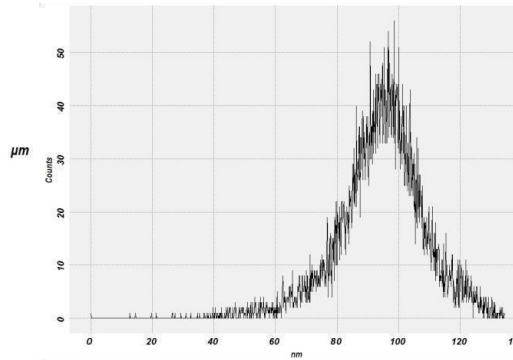


(b) Surface Histogram

Fig :5.9 : Results of a laser ablation of a Mg3Zn alloy's surface under an air medium using an atomic force microscope



(a) Surface topography



(b) Surface Histogram

Fig:6.0 :Results of a laser ablation of a Mg3Zn alloy's surface under water medium using an atomic force microscope.

CONCLUSIONS :

This study is an effort to explore laser ablation as a surface modification route for magne- 439 sium-based bio-implant materials. The scope for nano texturing of Mg3Zn alloy and nanocomposite induced by laser ablation medium is studied. The highlight of this study are

1. Successful surface modification was achieved on the Mg3Zn alloy nanocomposite created using the fragmented melt deposition approach by laser ablation utilising a CO2 laser in an environment of air and water.
2. On the surface of the Mg3Zn alloy nanocomposite, the laser ablation etched craters. The shallow craters on the specimens that have been laser ablated and treated in water medium are caused by the laser's diffraction by the water medium, which also makes it easier to remove debris. While specimens that have been laser ablated and then treated in an air medium show deep gorge-walled craters with geometrically circular profiles at the entry and ablation debris is seen in those specimens
3. When compared to the Mg3Zn alloy, the laser-ablated nanocomposite's grain size showed refinement.

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