

LASER SURFACE MODIFICATION OF MAGNESIUM

ALLOYS AN INSIGHT

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Engineering degree in

Automobile Engineering

By

G.AKASHWARAN (Register No.38860001)

S.J.SAINATH (Register No.388600012)



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**

MAY-2022



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 ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of
G.AKASHWARAN (Register No.38860001) and S.J.SAINATH (Register
No.38860012) 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 G.AKASHWARAN (Register Number 38860001), S.J. SAINATH (Register Number 38860012) 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: 20/04/2022

PLACE: CHENNAI

G.AKASHWARAN



S.J.SAINATH



SIGNATURE OF THE GUIDE

SIGNATURE OF THE CANDIDATE

ACKNOWLEDGEMENT

I am pleased to acknowledge my sincere thanks to the Board of Management of **SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.

I convey my thanks to **Dr. S. Prakash, M.E., Ph.D.**, Dean, School of Mechanical Engineering, and **Dr. V.K. Bupesh Raja, M.E., Ph.D.**, Head of the department, Dept of Automobile Engineering for providing me necessary support and details at the right time during the progressive reviews.

I would like to express my sincere and deep sense of gratitude to my project guide **Dr. V.K. Bupesh Raja, M.E., Ph.D.**, for his valuable guidance, suggestions, and constant encouragement that paved way for the successful completion of my project work.

I wish to express my thanks to all teaching and Non-teaching staff members of the department of Automobile engineering who were helpful in many ways for the completion of the project.

CHAPTER 1

INTRODUCTION

This chapter is about magnesium, Aluminum alloys, steel, and plastic-based materials might all be replaced with this substance. It is possible for a design engineer to achieve because magnesium has a particular stiffness and strength that exceeds most widely used metals and plastic-based materials.

1.1 MAGNESIUM

Magnesium, after steel and aluminium, is the third most often used structural steel. Magnesium is the brightest grey of the alkaline earth series, and it is the 12th atomic chemical chain. In a variety of engineering applications, magnesium-based materials in metal materials provide high strength. Aluminum and steel have a four-volume density of two-thirds. Magnesium-based materials are heavily involved in the firm with considerable weight applications because to their low density and outstanding mechanical qualities. 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. All metals from an alkaline environment have a low melting point (923 K (1,202 ° F) and a low boiling point of 1363 K (1994 ° F). At room temperature, magnesium interacts with water, however more slowly than calcium. It is somewhat decreased when exposed to air, albeit with a different alkaline iron, but it maintains an oxygen-free environment because magnesium is coated by a soft coating that is waterproof and difficult to remove oxides. When a metal surface is submerged in water and locked up, hydrogen bubbles grow slowly in the metal surface, and the reaction is quick. With higher temperatures, reactions happen faster. 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 ($\text{Mg}(\text{OH})_2$) 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.

1.2 ALLOYS AND COMPOSITES

Each alloy and composite material is made up of at least two additions. Alloys and composites are similar in that they display varied properties, the majority of which are connected with the materials used to make them. However, if you look a little closer, you'll notice that alloys and composites are significantly different from one another. Examine the differences between the two alloys and composites in further detail.

1.2.1 Alloy

An alloy is a mixture of at least two elements, one of which must be metallic. Solids and solutions of the alloy are both possible. Binary alloys are those that contain two elements, while ternary alloys have three elements. The amount of specified detail interior of an alloy is typically measured in mass, with a percentage attached. Alloys are created by combining outstanding elements in order to improve the traits that are frequently associated with them. When two or more elements are combined, an alloy

is formed that degrades the element's purity. It is usually a metal characteristic because the alloy always comprises at least one metal aspect. However, one significant advantage of using alloys is that.

Examples of Alloys

Alloys come in a variety of forms. Metal is the most frequent. Because iron is made up of a combination of carbon and iron, it is much stronger than iron. One method of producing metal exists. Only carbon and iron are utilised in some circumstances, but other elements like as chromium, tungsten, and magnesium can also be employed or added. You can continuously modify the ductility and hardness in its sections by adjusting the mixture you employ while making a metallic-like mixture. Copper is another common example of an alloy. Brass is a zinc and copper alloy. Although both zinc and copper are widely used, copper has been shown to be more durable and effective.

1.2.2 Composite

A composite is a blend of at least two or more additions, similar to an alloy. Despite the fact that the alloy always contains metals, the compound is not present in the mix. Physically and chemically, combined additives differ from one another. Constituent material is a term used to describe certain components.

A combination is made up of two different types of composites. Reinforcement and matrix materials are the terms for them. 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. Despite their interaction, the chemical and physical diversity of these two components makes them distinct from the completed aggregate.

Examples of Composites

Ingredients in combinations can be synthetic or natural. This is an example of a natural wood combo. It is composed of cellulose, lignin, and fibres. Concrete is another

example of a composite material. By examining the elements that do not join together to form a new item, you may see the various elements included within it.

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.

Composites and alloys have certain characteristics, yet they are fundamentally different. Alloy Eagles is a company that specialises in supplying alloys to a variety of sectors, including chemical, aviation, and industrial.

1.3 MAGNESIUM ALLOYS

Magnesium alloys, the lightest structural alloys with a density around one-fourth that of steels, offer enormous potential for improving the strength performance of different car transportation systems. A range of magnesium alloys with an appropriate balance of ductility and strength, as well as remarkable corrosion resistance, have been developed during the previous decade as a consequence of several R&D initiatives. Although many magnesium alloys with high ductility exist, their formability at room temperature is often poor, restricting its usage in vehicles. Due to a variety of variables, including better basal texture from rolling (thermal mechanical treatment) and a restricted number of potential deformation modes due to Mg's hexagonal close-packed (hcp) structure, Mg alloys have poor formability. At high or hot temperatures, magnesium alloys are very formable.

Precipitation-hardened magnesium alloys have an energy-to-weight ratio equivalent to aluminium alloys or alloy steels. The alloy of magnesium, on the other hand, has a lower density, a higher load per unit of weight, and a high specific module. They're also utilised when a lot of energy isn't required, but if a thick, light form is wanted, more stiffness is needed. Complex castings, as well as aircraft casings or housings, and components for quickly revolving or reciprocating machineries, are examples. Extended temperatures reduce the strength of Mg alloys; temperatures as

low as 200 °F (93 °C) cause significant yield strength reduction. Mg alloys have the best machinability of any metal.

Magnox, which stands for "magnesium non-oxidizing," is made up of 99 percent Mg and 1% Al and is used to encase gas rods in magnox nuclear power reactors. Magnesium alloys are referred to by short codes (specified in ASTM B275) that reflect approximate chemical compositions by weight. AS41, for example, has 4% Al and 1% Si, whereas AZ81 has 7.5% Al and 0.75% Zn. If Al is available, Mn is nearly always present at approximately 0.2 percent by weight, which aids in grain form improvement; if Al and Mn are not present, zirconium is often introduced at around 0.8 percent for the same purpose, where the gain in energy justifies their higher relative costs.

Magnesium alloy names are frequently two letters followed by two numerals. (M=manganese, Z=zinc, A=aluminum, S=silicon, Z=zinc). The numbers represent the nominal alloying element compositions. The name AZ91, for example, implies a magnesium alloy having around 9% Al and 1% Zn. The actual composition should be revealed by reference standards. The majority of manufacturers employ a scheme that consists of one or two prefix letters, two or three digits, and a suffix letter. The prefix letters identify the two alloying metals, according to ASTM standard B275.

Al, Zn, Zr, and Th facilitate precipitation hardening, whereas Mn improves corrosion resistance and tin improves castability. Aluminium is the most frequent alloying element. The digits correspond to the rounded-off percentages of the two most important alloy components as more alloy compositions become widespread. The temper indicator is more like Al's. Using the –O, –F, –T4, –T5, –T6, and –H1 options. Sand permanent mould and die casting have both been developed for Mg alloys, with die casting being the most familiar. Despite the fact that Mg is twice as expensive as Al, its warm-chamber die-casting technology is easier, more cost-effective, and 40 to 50% quicker than Al's cold-chamber procedure. Although the material's forming conduct is weak at ambient temperature, it becomes brittle when heated to 450–700°F (232–371°C). Many formed magnesium products are made because those temperatures are simple to obtain and don't always necessitate the use

of a protective environment. Mg alloys have the best machinability of any commercial metal, and the cost reductions from machining often offset the material's higher cost in many applications. It is, however, vital to keep the instruments sharp and provide enough room for the chips. Mg alloys can be spot-welded exactly like Al alloys, although they need to be scratch-brushed or cleaned beforehand. Fusion welding is made as simple as feasible by using an inert protective atmosphere of argon or helium gas. When working with magnesium alloys, there is a lot of disinformation out there concerning the risk of fire. When coarsely broken into powder or thin shards, magnesium alloys are very combustible, and this threat should never be neglected. A non-combustible, oxygen-free atmosphere is essential to avoid burning beyond 800°F (427°C). Mg alloys require additional care during casting processes due to their reactivity with sand and water in sheet and bar extrusion; nonetheless, Mg alloys do not constitute a fire threat.

1.3.1 ALUMINIUM MAGNESIUM ALLOYS

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.

Although strong magnesium was adapted to military and space applications in the mid-1950s, alloys incorporating Thorium are seldom employed. More than 2% thorium concentration requires the element to be handled as a radioactive material.

1.3 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 MgZnHA

Hydroxyapatite (HAp) is a calcium phosphate with form and content identical to human hard tissues¹. It has a hexagonal structure^{2, 3} and the same Ca/P stoichiometric ratio of 1.67 as bone apatite^{2, 4, 5}. Researchers have demonstrated improved corrosion resistance, Using HA in the magnesium matrix boosted mechanical strength and cell viability.

1.5.1 MgZnCa

In most technical applications, MgZnCa is an unwanted occurrence. Implants that 'biocorrode' are of particular relevance in the field of biomedical applications. They eliminate the need for implant removal surgery as well as the long-term risks of permanent implants¹. Magnesium is a fascinating biodegradable material in this context, but its corrosion is accompanied with hydrogen evolution, which is an issue in many biological applications. rix.

1.5.2 MgZn

In engineering applications, MgZnCa is typically an undesired occurrence. Implants that 'biocorrode,' Biomedical applications, on the other hand, are of tremendous interest. They eliminate the necessity for implant removal surgery and the long-term dangers associated with permanent implants¹. Magnesium is a biodegradable material in this regard, although it corrodes with hydrogen evolution, which is a problem in many biological applications.

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

The atomic number of aluminium (Al) is 13.

The atomic number of magnesium (Mg) is 12.

1.6.3 Cost effectiveness

The aluminium alloy is less expensive and requires less die casting.

Mg alloys are costly, and die casting costs are also significant.

1.6.4 Biological role

Aluminum has no biological use, and there is no evidence that it plays a function in any metabolic activity. Although Al is found in minuscule amounts in living creatures, there is no solid proof that it is required in the human body.

Magnesium is necessary for both plants and animals to survive. Photosynthesis is impossible in plants without Mg, while Mg facilitates the activation of several enzymes in humans. The average person consumes 250-350 mg of magnesium each day. It is almost preserved in human bones.

1.6.5 Specific gravity

The specific gravity of aluminium is 2.7, while that of magnesium is 1.7.

1.6.6 Alloy properties

Aluminium alloys require a longer time for solidification and also have a longer die life. Al is more stable, less expensive, and does not bend without being stressed because to its strength.

It takes less time for magnesium alloys to solidify. Mg is substantially less stable, more expensive, and bends easily under stress because to its smooth surface.

1.6.7 Solubility

At room temperature, Al is not soluble in water.

At room temperature, magnesium is very soluble in water and interacts with it.

1.7 APPLICATION OF MAGNESIUM ALLOYS

The desire for lighter goods, particularly in the automobile industry, has reignited interest in modern magnesium packaging. As a result of this demand, enterprises and research institutes have enhanced their researches and development work in order to acquire a more sophisticated material profile and a better range of alloy systems. In this multi-sectoral framework, development trends and applied competencies in specific industries such as the automobile business and communication technologies are examined.

1.7.1 Automotive Applications

- Mg parts first appeared in racing automobiles in the 1920s, but it wasn't until the 1930s that magnesium became commercially available with the Volkswagen (VW) Beetle.
- The gearbox housing and crankcase of the returning VW Beetle included 20 kg of magnesium alloy.
- Increased environmental and legal constraints on the automotive industry to produce lighter, more fuel-efficient, and higher-performance automobiles have resulted in an increase in magnesium use during the last decade.
- New sophisticated materials such as magnesium, aluminium, and metal matrix composites are replacing traditional steel parts.
- Hyundai, Jaguar, Fiat, BMW, and Kia Motors Corporation have all employed magnesium-based materials in car parts.

1.7.2 Aerospace Applications

- Due to the rising demand for pollution reduction and fuel efficiency, weight loss is one of the most significant goals in the aerospace industry.
- Fatigue and continuous exhaustion will accompany weight loss.
- Al, fibre metal laminates, and lightweight structural polymers are among the weight-loss solutions that have been offered over time. However, advancements in aluminium alloy development have made the same weight decrease possible.
- Fiber steel laminates are also a costly material, so they are reserved for important constructions with the highest mechanical demands.
- Impact and damage tolerance are low in low-density structural polymers. When exposed to temperature extremes, they also demonstrate poor properties. As a result of most of these limitations, magnesium has become a popular substitute.
- In some cases, thrust reversers , gearboxes (Rolls-Royce), and helicopter transmission casings are used.

- The lightweight properties of magnesium alloys for transmission casings assist military aircraft as well. Mg is also widely used in spacecraft and missiles, where light-weight materials are required to lower the lift-off weight.
- This is in addition to its exceptional mechanical capabilities, simplicity of fabrication, and other appealing features including its ability to survive high temperatures, ozone exposure, and bombardment by high-energy particles and small meteorites.

1.7.3 Applications in Sports

- A whole lot because the ever developing expectancies of sports activities fanatics.
- The amazing precision and capability of magnesium alloys and composites to mould complex geometries has resulted in a slew of new sporting equipment. Magnesium-based materials, for example, are utilised in the grips of archery bows, tennis rackets, and golf clubs.
- Magnesium-based completely substances have been a popular fabric choice in bicycle frames and in-line skate chassis because to their light weight and excellent damping improvements.
- Bicycle frames built of magnesium alloys or composites are capable of absorbing shock and vibration, allowing the rider to expend less energy and enjoy a more comfortable ride.

1.7.4 Applications in Electronics

- In the virtual system industry, it is fashionable to make products private and portable.
- As a result, it's vital that the system's components are light and long-lasting.
- Magnesium-based materials meet the essential standards since they are as light as plastic but have greater strength, heat transfer, and the capacity to shield electromagnetic and radio frequency interference as compared to their plastic counterparts.

- Mg-based materials are used in the housings of mobile phones, laptop computers, and portable media players.

1.7.5 Applications of Optics

- Magnesium is usually used to make eyeglassframe due to its lightness.
- Magnesium case of virtual camera , Magnesium's light-weight and optical strong features encompass the riflescopes and binoculars.

1.7.6 Applications in Medicine

- In the early half of the twentieth century, magnesium alloys were used as orthopaedic biomaterials for the first time.
- However, because to their low corrosion resistance, Mg-based completely substances acquire a considerable quantity of hydrogen throughout the plant throughout the corrosion system in vivo, restricting their broad usage as biomaterials.
- Despite this, magnesium has a number of desirable properties that make magnesium-based inorganic substances good candidates for use as implants in load-bearing systems in the therapeutic setting.
- Magnesium is an ion found naturally in the human body. It also aids in a variety of human metabolic processes while being safe for the human body.
- Mg is likewise utilized in few medications. Some herbal Mg compounds are also large withinside the chemical enterprise. It is used as a Grignard reagent and in numerous meals and way of life media because of the truth it's miles required for increase of organisms.
- Mg is extracted from sea water the usage of Ca(OH)_2 and exists in mineral form like dolomite, magnesite, carnallite, talc etc.

1.8 CREATING A MAGNESIUM ALLOY WITH HIGH STRENGTH AND FORMABILITY.

Despite the fact that magnesium alloys, being the lightest structural alloys, provide a lot of capacity for automotive projects, they are nonetheless limited by their poor formability at room temperature. There are no high-electricity Mg alloys with exact formability since the tactics employed to reinforce formability often result in a loss of electricity. Even when exposed to the perfect processing procedure, such a developed alloy demonstrates a combination of strength and formability that exceeds that of magnesium alloys previously. There are no high-electricity Mg alloys with exact formability since the tactics employed to reinforce formability often result in a loss of electricity. The alloy format idea employed in the gift look is essentially focused on the utilisation of alloying elements that can cause precipitation, as well as maximising the segregation of various texture-controlling alloying elements. Such a created alloy is expected to boost the software of magnesium alloy sheets, which are presently gaining popularity in the automotive industry.

CHAPTER 2

LITERATURE SURVEY

- J.C.Betts, 2010 - Laser surface cladding adds desirable surface qualities to an existing substrate by creating a new surface on top of it. The procedure necessitates additional supplies and delivery methods, as well as considerations for health, safety, and hygiene. Although significant increases in material surface qualities are feasible, the addition of ceramic particles can improve wear resistance even further.
- ASHISH SINGH and SANDIP P. HARIMKAR, 2012 - The goal of laser surface engineering is to enhance the surface properties of magnesium alloys. The corrosion, wear, and fatigue properties of magnesium alloys have been proven to improve using laser surface engineering techniques such as LSM, LSA, LCS, LSC, and LSP. The majority of these improvements are the consequence of composition adjustments. To learn more about laser–material interaction effects such selective vaporisation of elements, grain refinement, melt pool dilution, second-particle penetration, residual stresses, and solidification faults, we need to do extensive experimental and computational study. While overlapping parallel tracks of laser altered regions might be utilised to modify large portions of Mg substrates, the microstructure and features of these overlapping regions are expected to have an influence on the system's overall performance.
- Chengpeng Maa, Ge Pengb, Lu Niec, Haifeng Liub, Yingchun Guan- 2018 - The matrix is made up of Mg phase particles, which are dispersed in the matrix along the extrusion direction. The solidification microstructure was converted to Mg phase after laser surface modification, and no phase granules precipitated at grain boundaries. The laser-modified layer had a thickness of 360μm. Initial galvanic corrosion occurred predominantly in the α-Mg matrix surrounding phase and expanded into extensive corrosion holes in the as-received specimen
- Yuhang Lia, Srinivasan Arthanaria,b , Yingchun Guana, 2019 - The surface and electrochemical corrosion properties of MB26 and AZ80 magnesium alloys

- were systematically evaluated after laser surface melting; 1. Surface roughness values of LSMed alloys were reduced in particular, with the reduction being relatively higher for MB26 alloy due to the variation in cooling rate during laser processing. 2. Cross-sectional morphologies indicated that the thickness of LSMed layers varied substantially, with a melted layer thickness value of AZ80.
- Xiyu Yaoa , Jincheng Tangb , Yinghao Zhoua, , Andrej Atrons , Matthew S. Darguschc , Bjoern Wiese, Thomas Ebel , Ming Yan, 2020 - Due to the surface modification by SLM, the biomedical Mg-0.6Ca has increased microhardness while decreasing corrosion rate. The surface residual stress was shown to be the primary cause of the increased microhardness (20 percent increase). Because of limited impurity elements, the presence of MgO, and the resulting higher selfcorrosion potential, the corrosion rate reduced. Microhardness was raised in the biomedical Mg–0.5Zn–0.3Ca alloy (17 percent increment).
 - H. Pereira , O. Carvalho , G. Miranda & F. S. Silva,2020 - Because of its quick corrosion, it's becoming more popular as a biomaterial, and it's critical to functionalize its surface. The characterization of the distinct surface results, namely texturing and remelting, as a function of laser settings is described in this research of laser surface treatment of pure Mg. The impact of several combinations of laser power, scan speed, and line spacing on the Mg surface was investigated. A line spacing of 0.05 mm is better for achieving a textured surface, whilst a line spacing of 0.02 mm is better 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 -. PLA is said to have been used to produce thin solid films using pulsed laser ablation.
- Chengpeng Ma - In recent years, magnesium alloy has received a lot of interest as a biodegradable material for medical devices including implants and stents.
- Daoli Zhao - It's difficult to track the biodegradation of magnesium and its alloys in vivo. Currently, this process is tracked in vivo using micro-CT and X-ray imaging, both of which require huge and expensive equipment.
- Omid Savabi - Magnesium has just been presented as a new biodegradable bone mending substance. However, because this material degrades quickly, hydrogen is released quickly, limiting its therapeutic applicability.
- David Omans - For the manufacture of nanodiamonds, pulsed laser ablation in liquids (PLAL) has become a popular approach. This paper examines the growth dynamics of nano-diamond formations implanted in sp² carbon synthesized using this approach.
- Yang Liu- Because of its mechanical qualities, biodegradable magnesium (Mg) has gotten a lot of interest for its usage in orthopaedic implants.
- Dongfang Zhang- The coating's microstructure, composition, in vitro degradation, and cytocompatibility were all thoroughly investigated.

- Dhruva Babu Subedi- The impact of adding Glycine to Hank's solution on the in-vitro corrosion behaviour of the AZ31 magnesium (Mg) alloy at 37 degrees Celsius and a pH of 7.4 was investigated using potentiodynamic polarisation .
- F.Amerstorfer - Continuous in vivo micro-Computed Tomography, histological staining, and Laser Ablation Inductively Coupled Plasma Mass Spectrometry were used to investigate the long-term effects of degrading magnesium implants on bone tissue in a developing rat skeleton (LA-ICP-MS). Two magnesium alloys, one of which is progressively deteriorating (ZX50)
- Frank Witte- In vivo corrosion of magnesium alloys may provide a novel method for the application of degradable metal implants in musculoskeletal surgery. This would be especially true if it were possible to manufacture magnesium alloys with regulated in vivo corrosion rates.

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),

3.2 SCOPE

Mg Alloys / Composites have proven advanced energy in lots of engineering systems, for example: - Wide use of Mg Alloys is predicted because of its very excessive bio overall performance and mild weight. As a end result in their energy, durability, and mechanical behavior, substances considerations, modeling, and engineering, uncooked and renewable substances, and organic lifestyles cycle considerations, unique substances (along with medicine, energy., Aerospace, and nanotechnology)

3.2.1 Different Grades of Mg Alloys

Mg Alloys of various grades are used to research greater approximately parameters and using alloys in nearly all fields of engineering. This might be specially beneficial in in-vitro and in-vivo research in addition to withinside the automobile sector. Mg-primarily based totally alloys containing uncommon earth metals are crucial structural elements, as they integrate low density with excessive strength structures. This makes them very appealing withinside the industry, specially while low creation weight is crucial, together with while constructing plane and equipment. Alloys produced through processing strategies are dealt with one after the other and mentioned with steel matrix compounds in addition to using speedy hardening to provide amorphous and different new materials. Finally, present day and destiny traits withinside the use of magnesium alloys are explored together with examples of new 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.

Table 4.1 Grade and Composition of Materials Used

SAMPLE	COMPOSITION
1	MgZnHA
2	MgZnCa
3	MgZn

Base metal MgZn

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

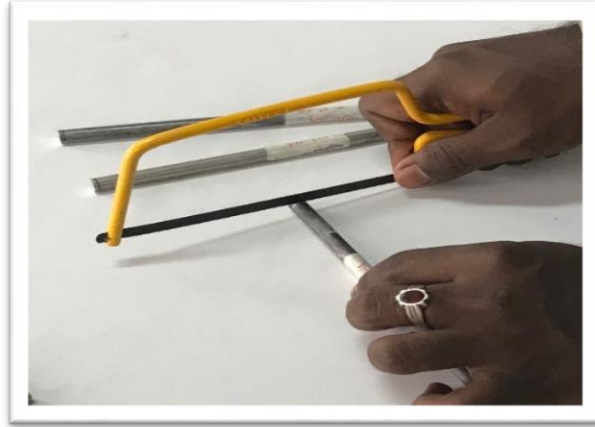


Fig 4.2 Cutting Process



Fig 4.3 Sample size 2mm thickness 8mm diameter

4.2.1 LASER ETCHING

A laser engraving machine is made up of three basic components: the laser, the controller, and the surface. The laser is similar to a pencil in that the controller may draw patterns on the surface using the laser's beam. The laser beam's direction, strength, speed of movement, and spread are all controlled by this device. The surface is chosen to match the laser's operating range.



Fig 4.4 Laser engraving machine

Recording gear is divided into three categories: The X-Y desk is the most peculiar surface because the laser optics flows around the X and Y axes, causing the laser beam to attract vectors. Even after the laser is switched off, the process continues. The work is moved by the Y axis and the laser inside the X axis. The second type is the work cylinder pieces, in which the laser cuts the tiny helix effectively and the on/off laser pulsing creates a popular image based on the raster. The fixed plane of the laser optical system must be the point at which the laser reaches the top, which is usually the same as its focus point. This point is usually quite little, less than half a millimetre in diameter. The laser's energy transforms the material's surface into a concentrated region. It may burn the surface and then evaporate the active ingredient, or it could break (known as "glass") and shrink away from the surface. A section of the metal is frequently laser-engraved when cutting with it.

A laser beam can be extremely efficient if it is designed to deliver energy to the surface in a way that converts a high proportion of light energy into heat. The beam is considerably focussed and collimated on non-reflective surfaces such as wood, plastic, and enamel.

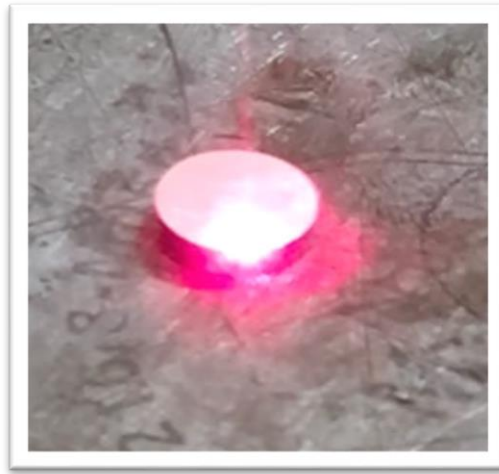


Fig 4.5 Laser processing on sample

By modifying the controller to move a laser beam over time, different patterns may be recorded. To get constant removal depth, the laser beam track is carefully controlled. Cross-paths are avoided, for example, to guarantee that each recorded region is laser-recorded just once, allowing the same amount of content to be extracted. When carving designs, the speed with which it goes through the material is also considered. Construction may be made more flexible by changing the thickness and spread of the beam.

It is not essential to put impediments in place to keep the laser from straying from the recorded pattern since laser positioning is correctly understood using a controller. As a result, there is no need for a blocking mask while recording with lasers, especially As a result, no blocking mask is required for laser recording, despite the fact that this approach differs from previous 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.

4.2.2 FABRRICATION

In this case, the circular base plate is made of steel and is tailored to fit the socket's inner diameter. The metal plate is 3mm in diameter and is located on the front. The need of being watchful was emphasised. A support foot screw system may be used to modify the height of the base plate. The 4mm diameter hole is drilled with a thermometer. To hold the work in the centre of the plate, clamps are utilised.

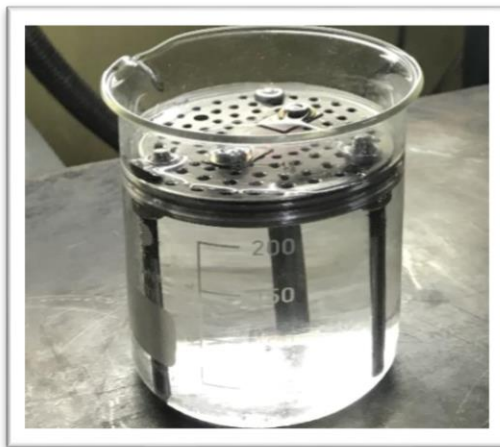


Fig 4.7 The fabricated setup is placed in the beaker

4.3 ETCHING ON METALS

Metals are heat resistant, therefore metal marking necessitates the use of extremely powerful laser beams. In general, low laser power induces melting, whereas high laser power causes the material to evaporate.

The worst laser-engraved artefacts began to resemble traditional beautiful carvings. A short wavelength laser was used to overcome the problem. Metals may now be easily recorded using CO₂ lasers, Yb: Fiber Lasers, Nd: YVO₄ or Nd: YAG lasers. The sample is given the square of the matrix and the dot pattern to make it stand out. The given lines cross the matrix points at the sample's centre, forming a diamond structure with vertical intervals between each series of cuts. The applied power is approximately 55% of 60 W. The laser beam travels at a speed of 100 mm per second. Heat is applied to a sample at a frequency of around 20 KHz. To be able to characterise and target, all data must be input correctly. The sample is illuminated with a laser, and the required form is recorded.



Fig 4.8 Etching process

Inside the beam, close to the magnetic field, is a built-in metal plate with support legs. The stirrer is used to introduce flow into propanol and prevent graphite particles from being incorporated into the beaker. Because graphite powder includes a high proportion of carbon, it aids in mixing and improves the mixture's thermal characteristics during lasing. The entire system, including the beaker, is put on a heat plate to maintain a consistent temperature in the liquid medium. The laser settings are then established, and the laser beam is permitted to penetrate the target region.

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

The floor is seen using AFM by measuring the interaction forces between the atoms of a sharp tip mounted on a bendy cantilever and the atoms inside the pattern. During the dimension, the cantilever and top are decreased near the pattern or the pattern is elevated toward and directed until "contact" is created, based on the microscope version. The displacement of the cantilever is measured using a laser beam projected from the cantilever's pinnacle onto a photodetector. Any extrade in cantilever deflection is the result of numerous interaction forces acting at the tip, causing the laser beam to shift, and it's detected as a difference in photodetector output voltage. The overhang is moved across the pattern in a few different ways (mostly lines), and the surface recordings are gathered. The spatial decision is based on the top's shape and the microscope's version, but it is on the order of a nanometer. Changes in the voltage were translated into changes in the sample topography or various parameters with correct calibration. Many imaging techniques have been utilised to examine floor structure thus far. They are generally based entirely on unique standards, have separate pressure regimes, and are capable of providing variability in unique information about the sample.

5.1.1 Tapping mode for detecting surface

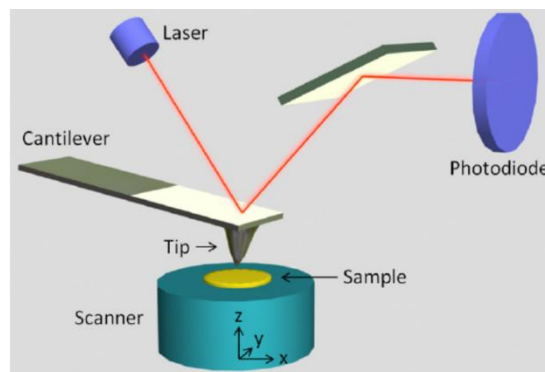


Fig 5.0 shows the procedure of AFM

- AFM tapping mode TM Unlike the touch mode, in TM cantilever imaging oscillates at (or near) the resonant frequency or amplitude A.
- If the top is eliminated from the pattern area, A is same to the loose amplitude of A₀ .
- When a tip is decreased right into a template throughout a nearby scan, A₀ is decreased through the interplay among the top name and the location. Near the surface, the amplitude is decreased to a minimum.
- In a selected faucet mode test, the extent of the oscillation fluid at which the "touch" placing is about is described through the set amplitude of the element. In phrases of setpoint (A_{sp} / A_0) x 100%. Generally, a excessive factor fee manner a moderate decrease, and due to the fact the width and the dependence of the pressure are related, it additionally manner much less strength implemented to the pattern and acquired through the top.
- When the usage of AFM to visualise a pattern, the top is hooked up to the pattern and the pattern is scanned with a raster with an xy grid. Typically, a virtual voice loop is used to preserve the probe sample strain throughout a sure scanning time.
- This remarks circuit has a cantilever deviation as its enter and output controls the gap to the z axis among the probe holder.
- As lengthy because the tip remains related to the pattern and the pattern is scanned at the xy plane, the adjustments withinside the pattern period will alternate the cantilever deviation.
- The reaction then adjusts the probe holder period in order that the deviation is reset to the user-described fee.
- A well-tuned remarks loop keeps to alter the pattern supervisor separation throughout the sweeping movement, in order that the deviation stays constant.

5.2 RESULTS OF AFM ANALYSIS ABOVE WATER: The scan size is $5\mu\text{m} \times 5\mu\text{m}$.

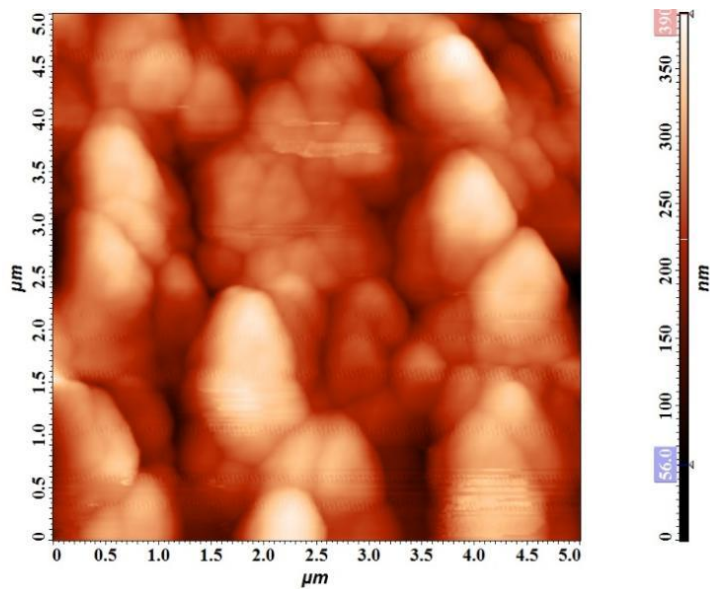


Fig 5.1 The 2Da AFM image of magnesium grade 1 Sample etched in water. The scan size is $5\mu\text{m} \times 5\mu\text{m}$.

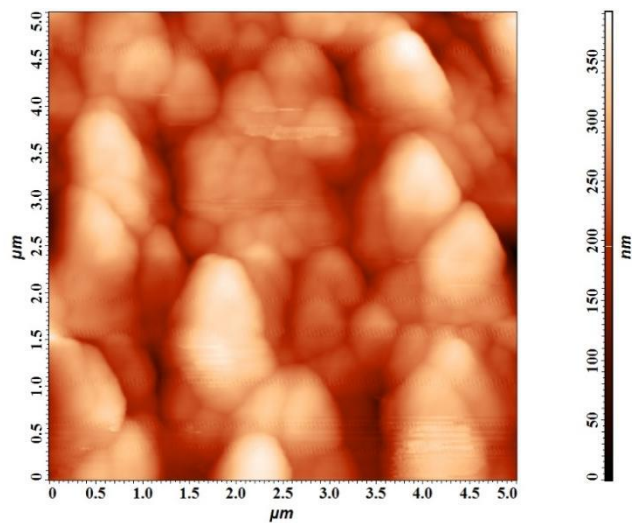


Fig 5.2 The 2D AFM image of magnesium grade 1 sample etched in water. The scan size is $5\mu\text{m} \times 5\mu\text{m}$.

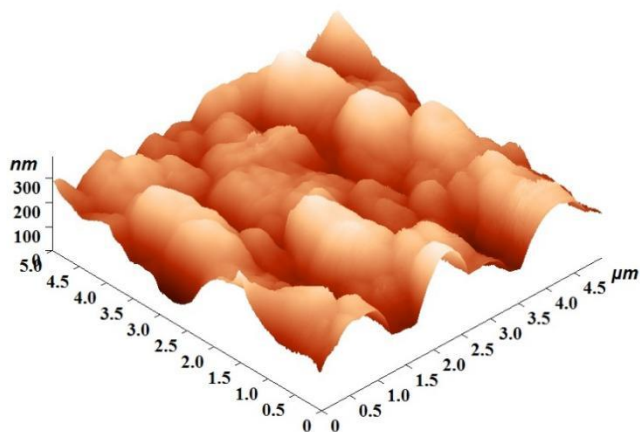


Fig 5.3 The 3Da AFM image of magnesium grade 1 Sample Etched in water. The scan size is $5\mu\text{m} \times 5\mu\text{m}$.

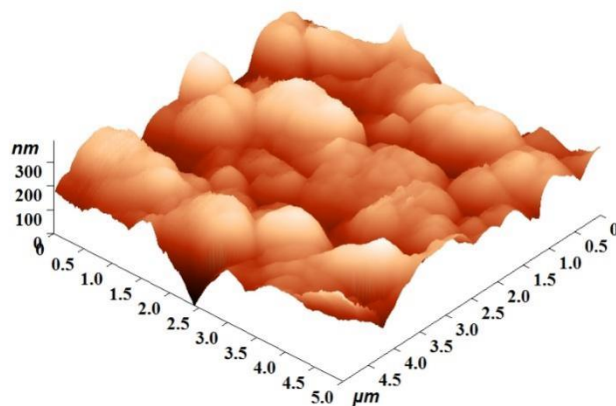


FIG 5.4 The 3Da AFM image of magnesium grade 1 Sample etched in water. The scan size is $5\mu\text{m} \times 5\mu\text{m}$

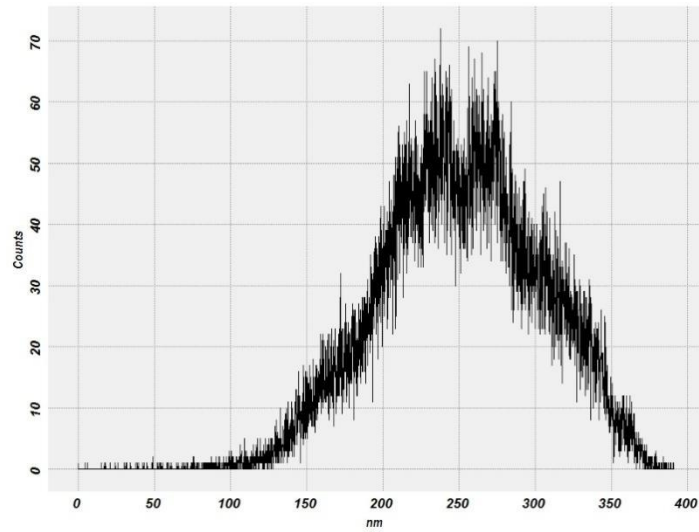


Fig 5.5 The Histogram AFM image of magnesium grade 1 Sample etched in water. The scan size is $5\mu\text{m} \times 5\mu\text{m}$.

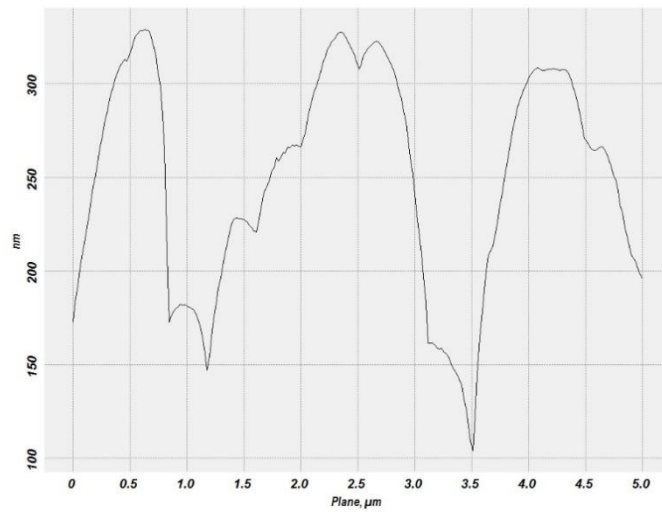


Fig 5.6 The X section@780nm line profile AFM image of magnesium grade 1 Sample etched in water. The scan size is $5\mu\text{m} \times 5\mu\text{m}$.

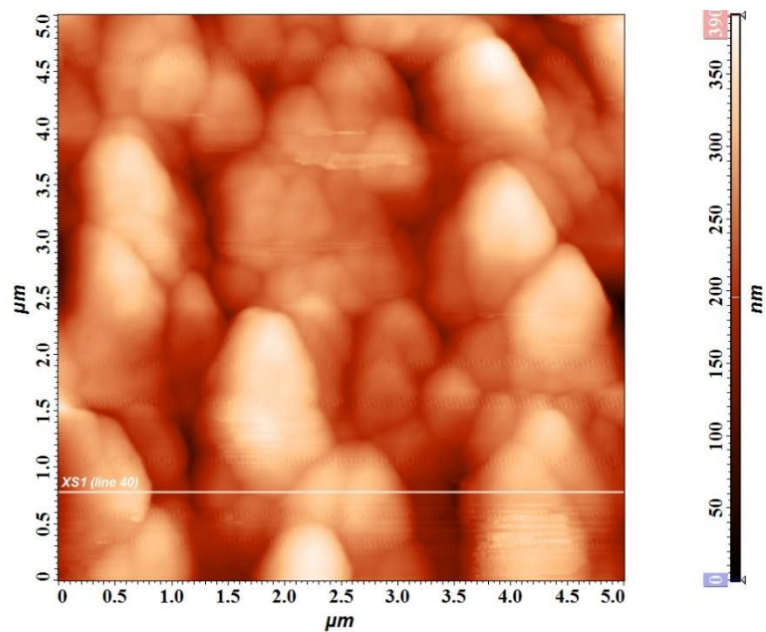


Fig 5.7 The X section@780nm AFM image of magnesium grade 1 Sample etched in water. The scan size is 5μm× 5μm.

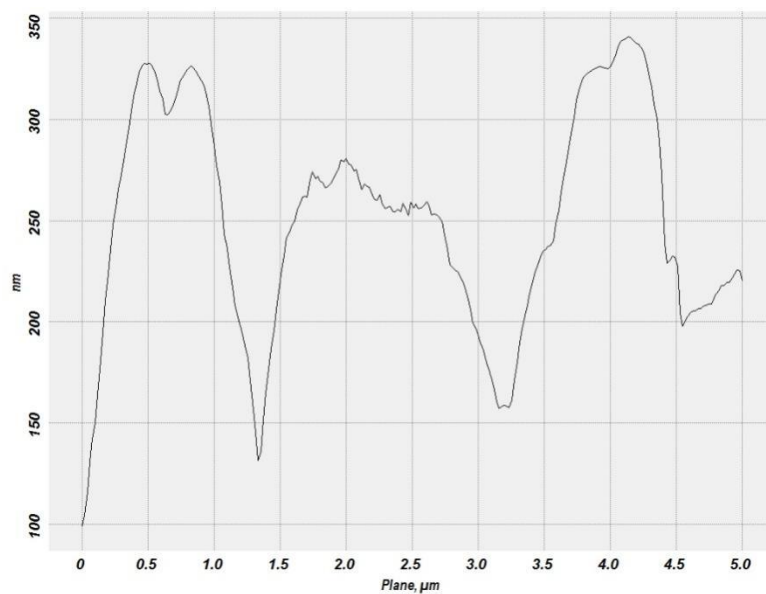


Fig 5.8 The X section@2980nm line profile AFM image of magnesium grade 1 Sample etched in water. The scan size is 5μm× 5μm

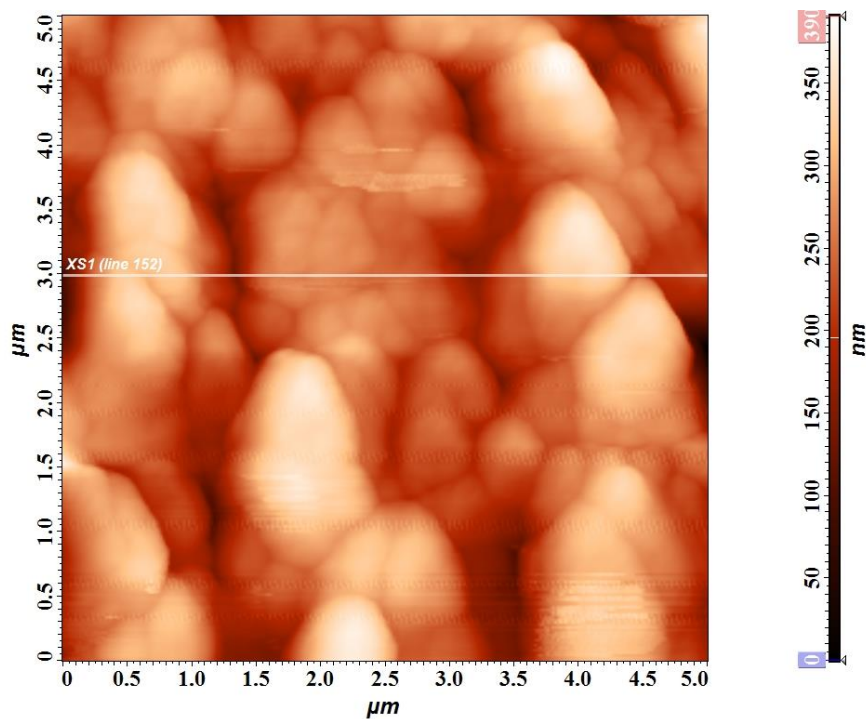


Fig 5.9 The X section@2980nmAFM image of magnesium grade 1 Sample etched in water. The scan size is 5μm× 5μm.

Table 5.1 AFM Roughness Analysis Sample (1)

Amount of sampling	65536
Max	390.868 nm
Min	0 nm
Peak-to-peak, Sy	390.868 nm
Ten point height, Sz	199.401 nm
Average	251.068 nm
Average Roughness, Sa	42.4398 nm
Root Mean Square, Sq	52.3126 nm
Second moment	65771.6
Surface skewness, Ssk	-0.130159
Coefficient of kurtosis, Ska	-0.261598
Entropy	10.9377
Redundance	-0.270812

5.4 RESULTS OF AFM ANALYSIS ABOVE WATER: *The scan size is $10\mu\text{m} \times 10\mu\text{m}$*

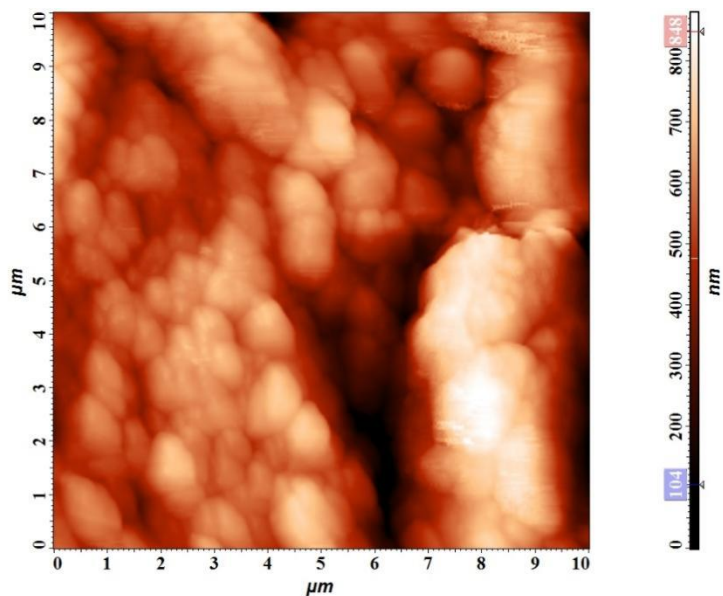


Fig 5.10 *The 2Da AFM image of magnesium grade 1 Sample etched in water. The scan size is $10\mu\text{m} \times 10\mu\text{m}$.*

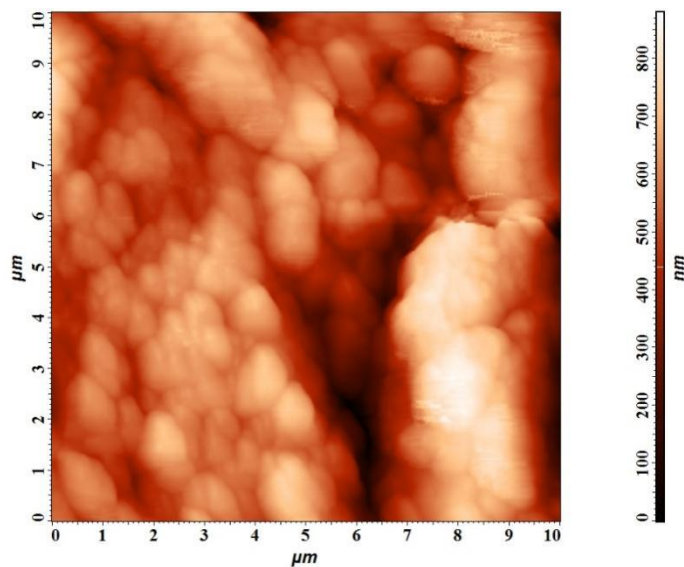


Fig 5.11 *The 2D AFM image of magnesium grade 4 Sample etched in water. The scan size is $10\mu\text{m} \times 10\mu\text{m}$.*

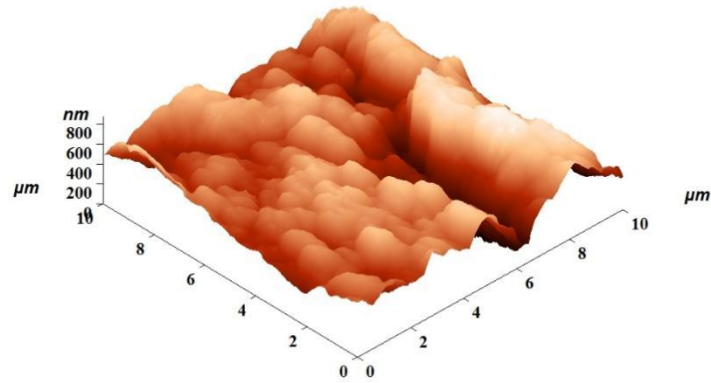


Fig 5.12 The 3Da AFM image of magnesium grade 1 Sample etched in water. The scan size is 10μm× 10μm.

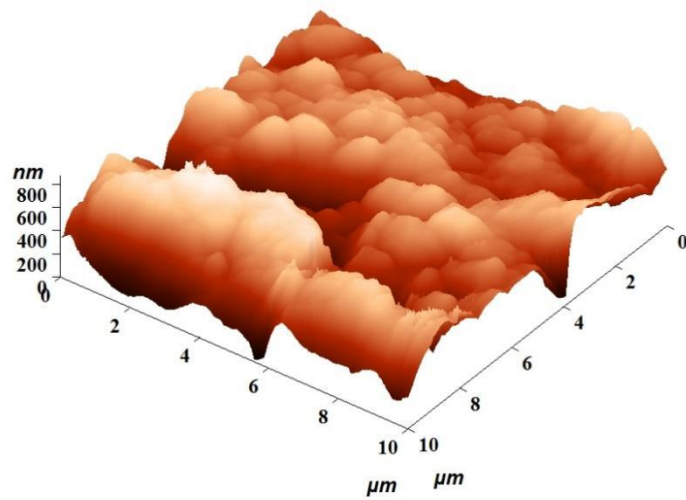


Fig 5.13 The 3D AFM image of magnesium grade 1 Sample etched in water. The scan size is 10μm× 10μm.

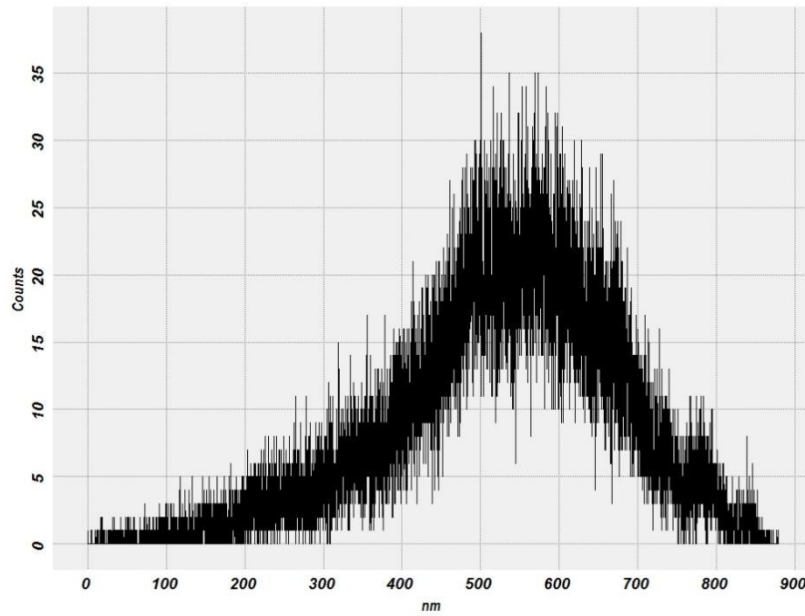


Fig 5.14 The Histogram AFM image of magnesium grade 1 Sample etched in water. The scan size is $10\mu\text{m} \times 10\mu\text{m}$.

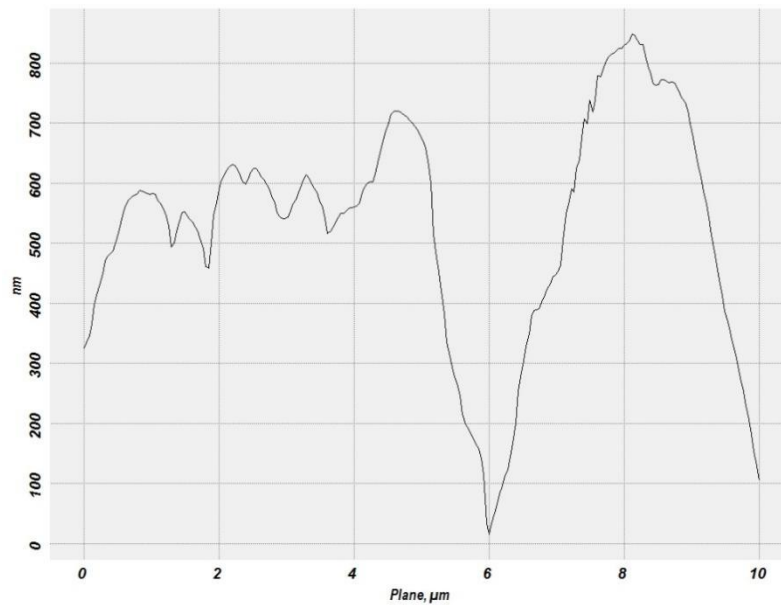


Fig 5.15 The X section@2080nm line profile AFM image of magnesium grade 1 Sample etched in water. The scan size is $10\mu\text{m} \times 10\mu\text{m}$.

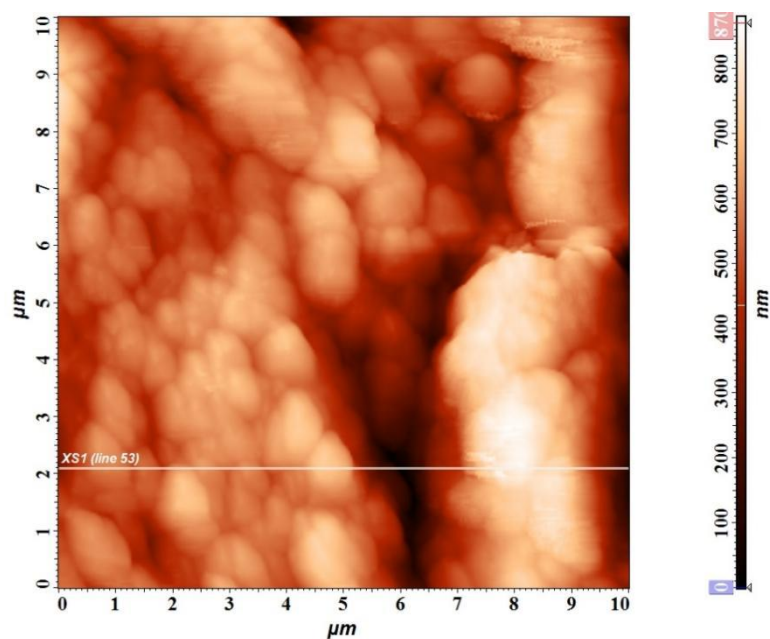


Fig 5.16 The X section@2080 AFM image of magnesium grade 1 Sample etched in ware. The scan size is 10µm× 10µm.

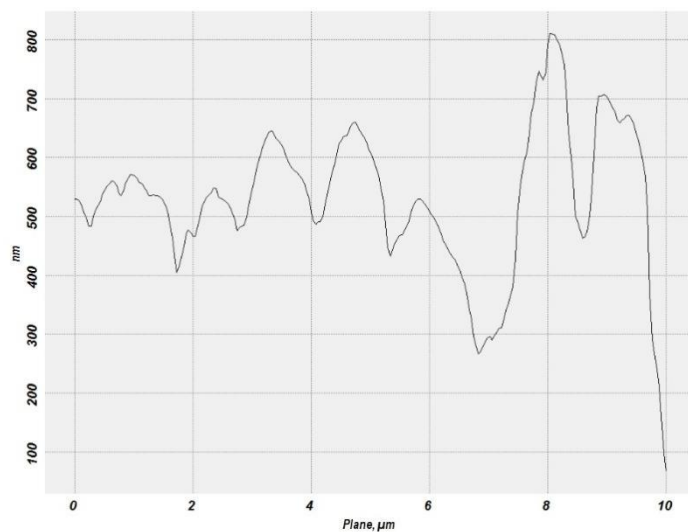


Fig 5.17 The X section@5840nm line profile AFM image of magnesium grade 4 Sample etched in water. The scan size is 10µm× 10µm.

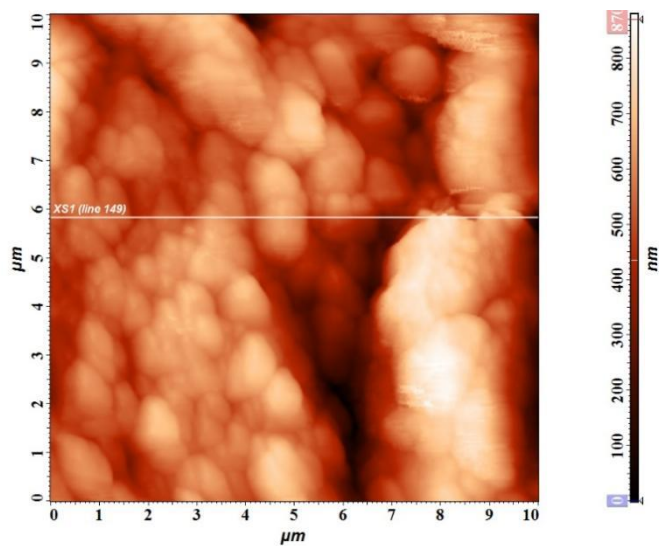


Fig 5.18 The X section@5840nm AFM image of magnesium grade 1 Sample

Roughness analysis	
Amount of sampling	65536
Max	878.684 nm
Min	0 nm
Peak-to-peak, Sy	878.684 nm
Ten point height, Sz	440.891 nm
Average	529.713 nm
Average Roughness, Sa	110.767 nm
Root Mean Square, Sq	141.44 nm
Second moment	300602
Surface skewness, Ssk	-0.506461
Coefficient of kurtosis, Ska	0.3063
Entropy	12.2874
Redundance	-0.256693

Table 5.2 AFM Roughness Analysis of Sample (1)

5.5 RESULTS OF AFM ANALYSIS WITHOUT WATER: The scan size is $5\mu\text{m} \times 5\mu\text{m}$.

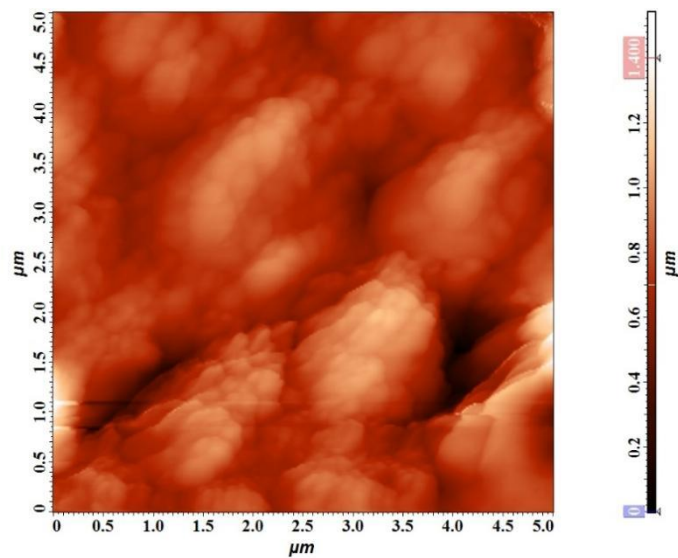


Fig 5.19 The 2Da AFM image of magnesium grade 1 Sample etched without water. The scan size is $5\mu\text{m} \times 5\mu\text{m}$.

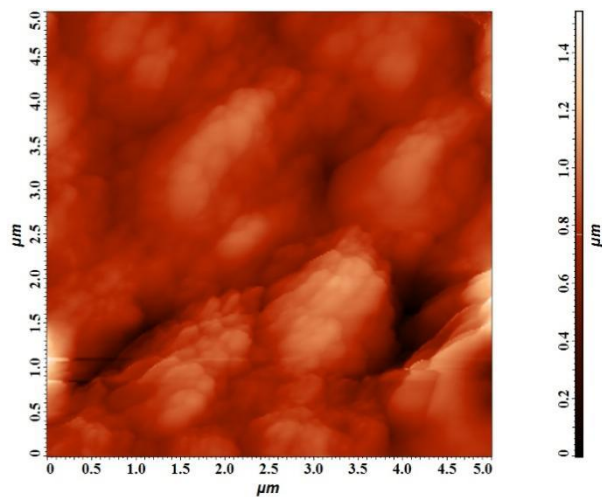


Fig 5.20 The 2D AFM image of magnesium grade 1 Sample etched without water. The scan size is $5\mu\text{m} \times 5\mu\text{m}$.

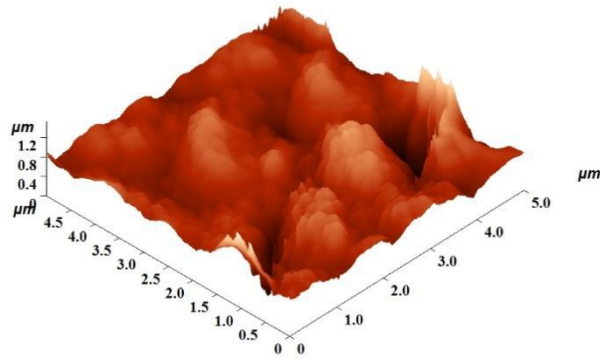


Fig 5.21 The 3Da AFM image of magnesium grade 1 Sample etched without water. The scan size is 5μm× 5μm.

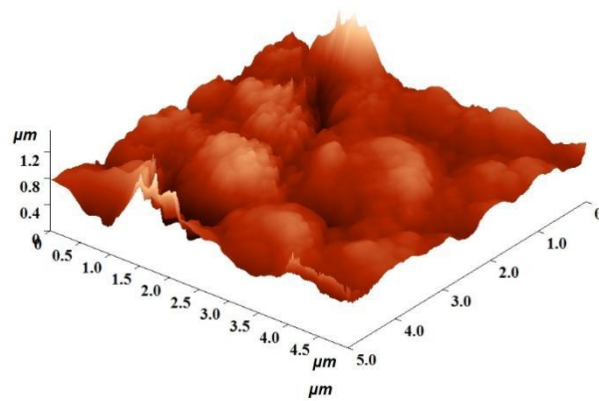


Fig 5.22 The 3D AFM image of magnesium grade 1 Sample etched without water. The scan size is 5μm× 5μm.

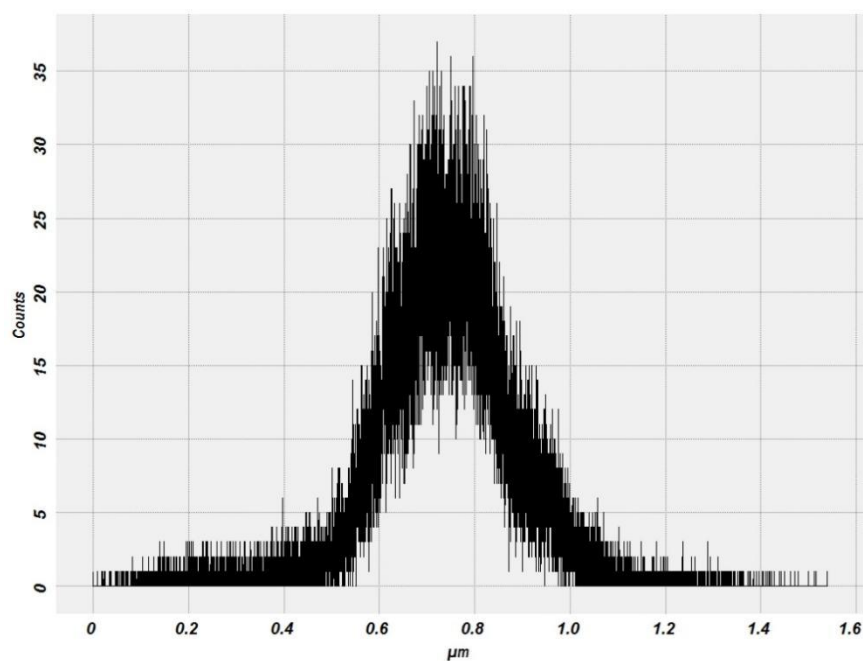


Fig 5.23 The Histogram AFM image of magnesium grade 1 Sample etched without water. The scan size is $5\mu\text{m} \times 5\mu\text{m}$.

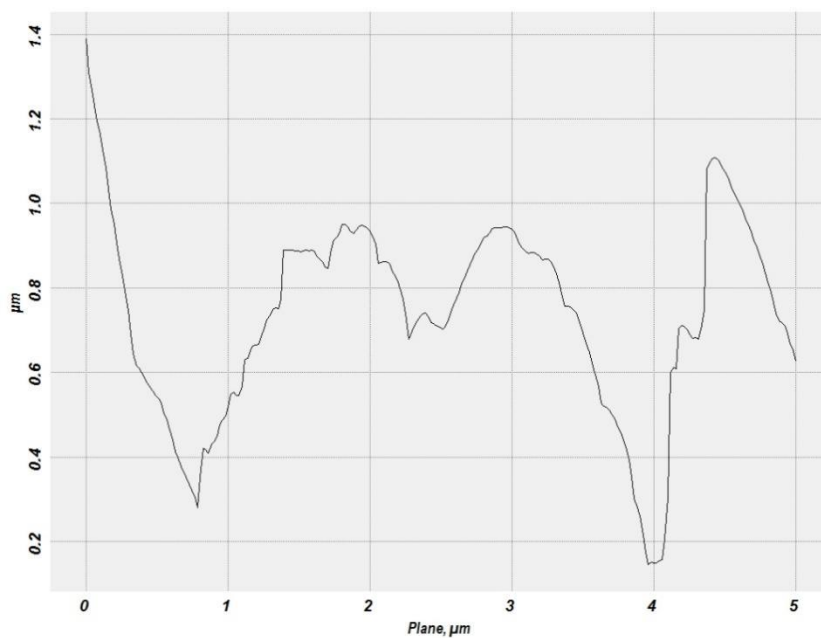


Fig 5.24 The X section@1140nm line profile AFM image of magnesium grade 1 Sample etched without water. The scan size is $5\mu\text{m} \times 5\mu\text{m}$.

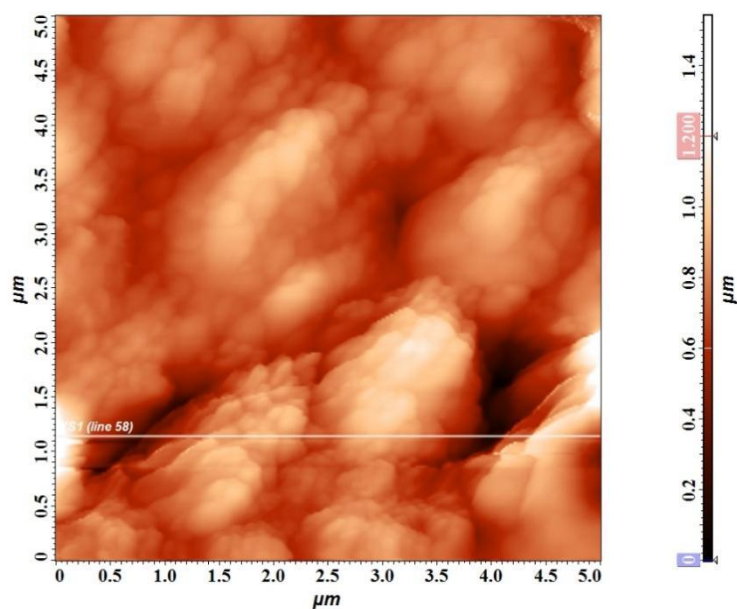


Fig 5.25 The X section@1140nm AFM image of magnesium grade 1 Sample etched without water. The scan size is 5µm× 5µm.

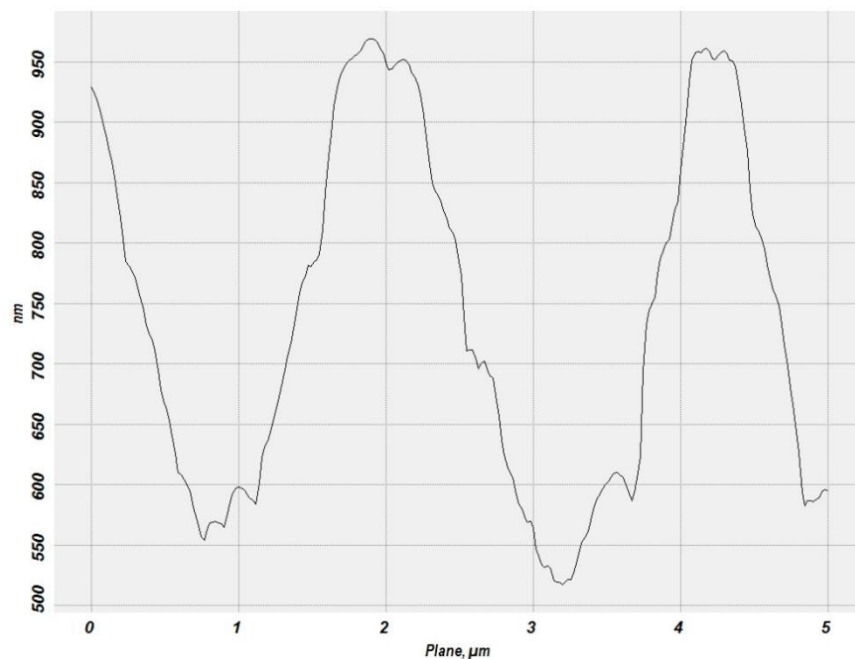


Fig 5.26The X section@3550nm line profile AFM image of magnesium grade 1 Sample etched without water. The scan size is 5µm× 5µm.

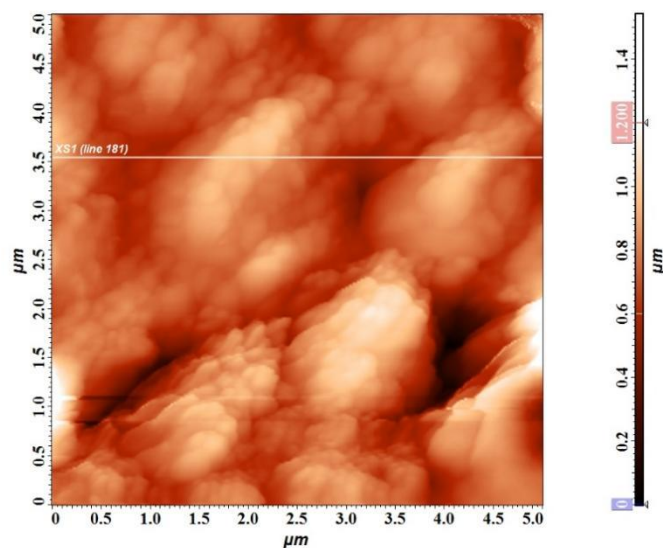


Fig 5.27 The X section@3550nm AFM image of magnesium grade 1 Sample etched without water. The scan size is 5μm× 5μm.

Roughness analysis	
Amount of sampling	65536
Max	1538.86 nm
Min	0 nm
Peak-to-peak, Sy	1538.86 nm
Ten point height, Sz	766.26 nm
Average	738.035 nm
Average Roughness, Sa	108.381 nm
Root Mean Square, Sq	146.838 nm
Second moment	566257
Surface skewness, Ssk	-0.395141
Coefficient of kurtosis, Ska	2.41848
Entropy	12.2675
Redundance	-0.15876

Table 5.3 AFM Roughness Analysis of Sample (1)

5.6 RESULTS OF AFM ANALYSIS WITHOUT WATER: The scan size is $10\mu\text{m} \times 10\mu\text{m}$.

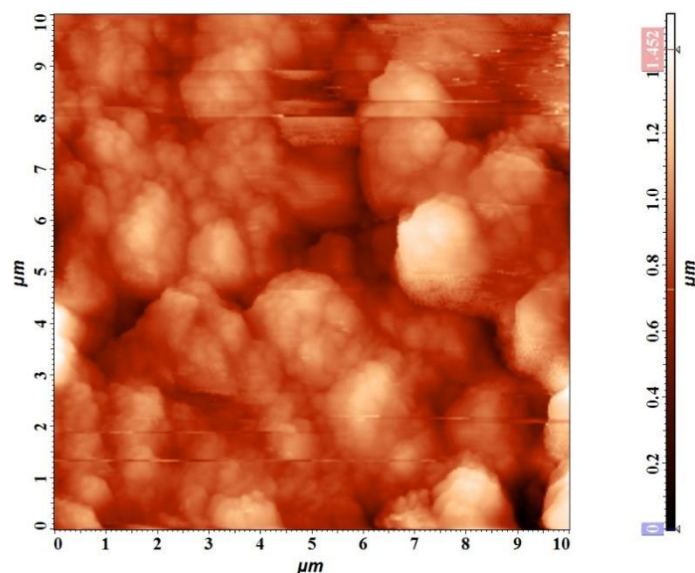


Fig 5.28 The 2Da AFM image of magnesium grade 1 Sample etched without water. The scan size is $10\mu\text{m} \times 10\mu\text{m}$.

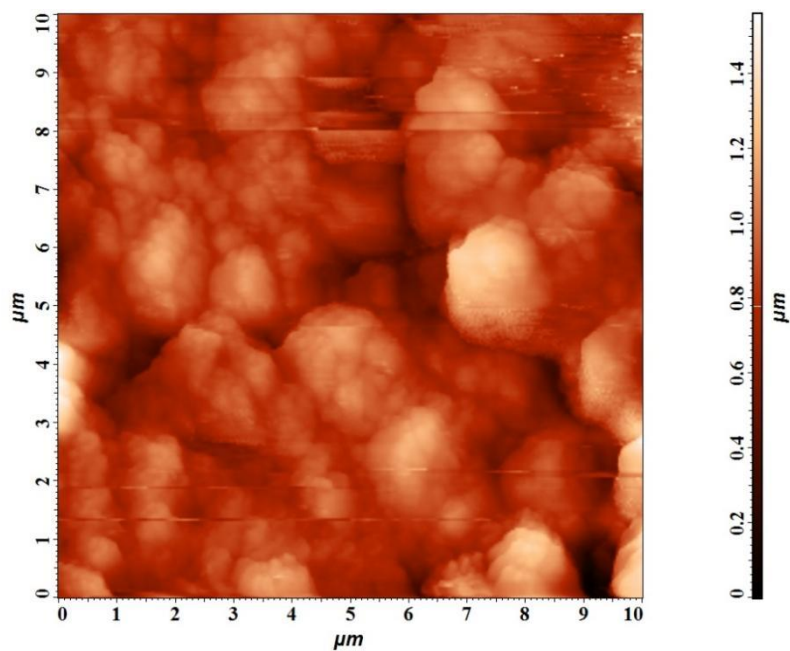
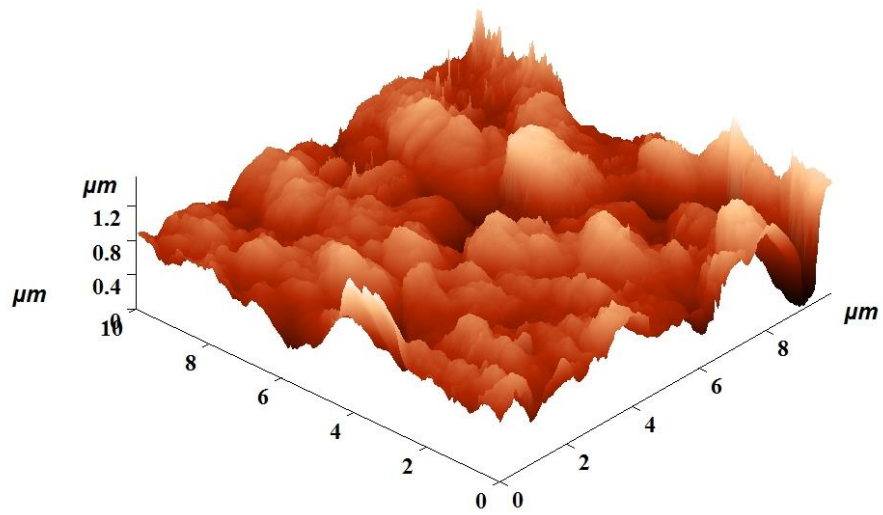
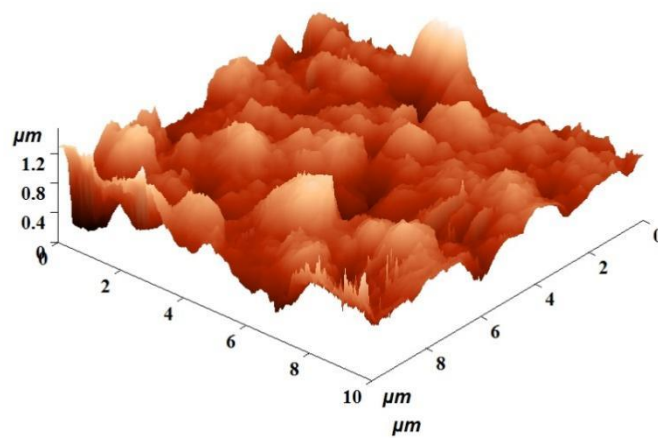


Fig 5.29 The 2Da AFM image of magnesium grade 1 Sample etched without water. The scan size is $10\mu\text{m} \times 10\mu\text{m}$.



***Fig 5.30 The 3Da AFM image of magnesium grade 1 Sample etched without water.
The scan size is 10μm× 10μm***



***Fig 5.31 The 3Da AFM image of magnesium grade 1 Sample etched without water.
The scan size is 10μm× 10μm***

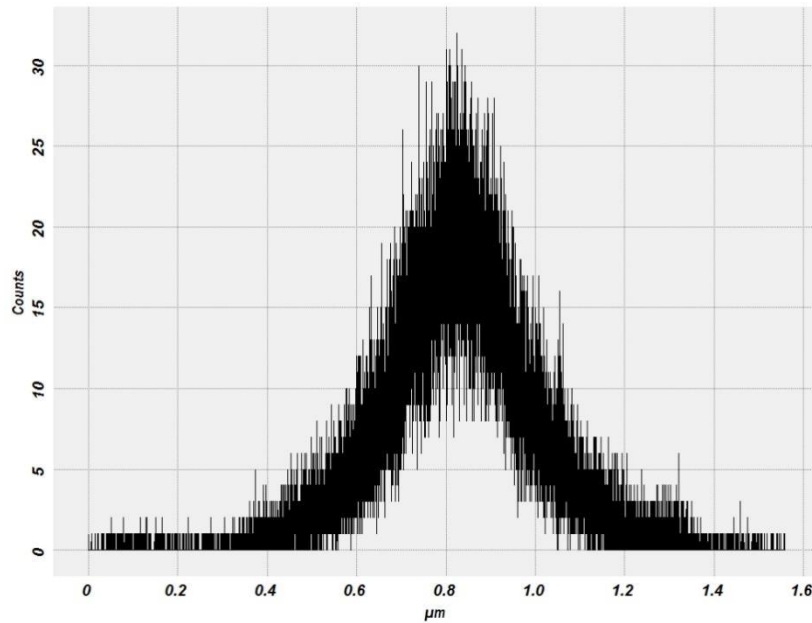


Fig 5.32 The Histogram AFM image of magnesium grade 1 Sample etched without water. The scan size is $10\mu\text{m} \times 10\mu\text{m}$.

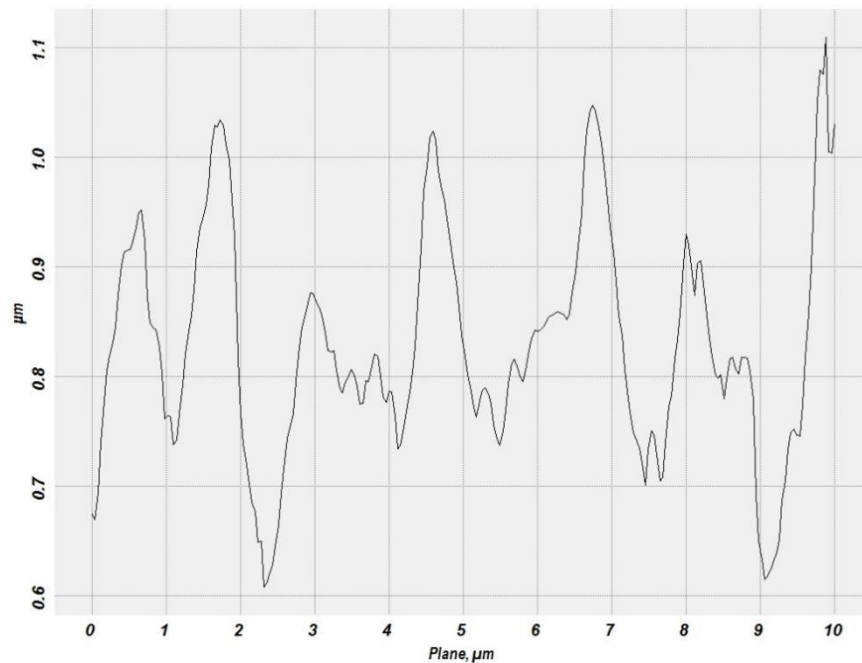


Fig 5.33 The X section@1140nm line profile AFM image of magnesium grade 1 Sample etched without water. The scan size is $10\mu\text{m} \times 10\mu\text{m}$.

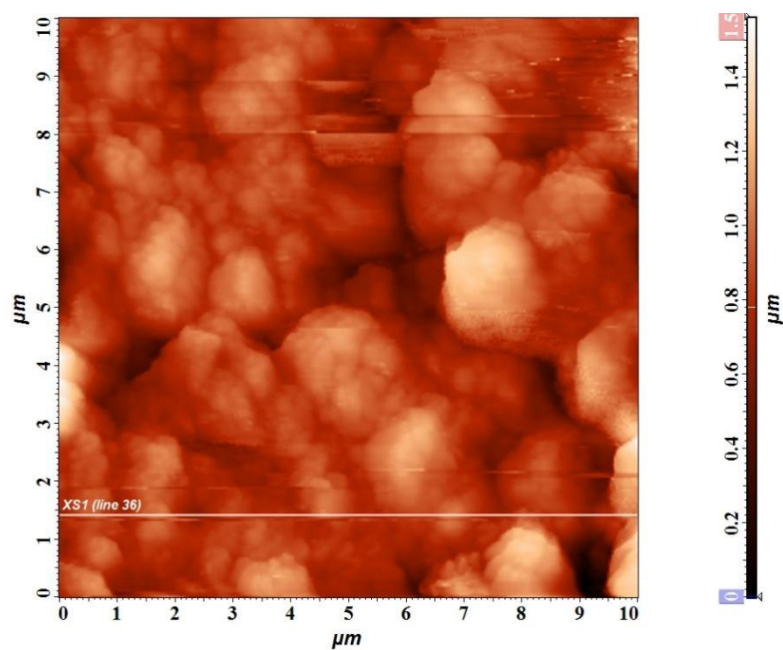


Fig 5.34 The X section@1140nm AFM image of magnesium grade 1 Sample etched without water. The scan size is 10µm× 10µm.

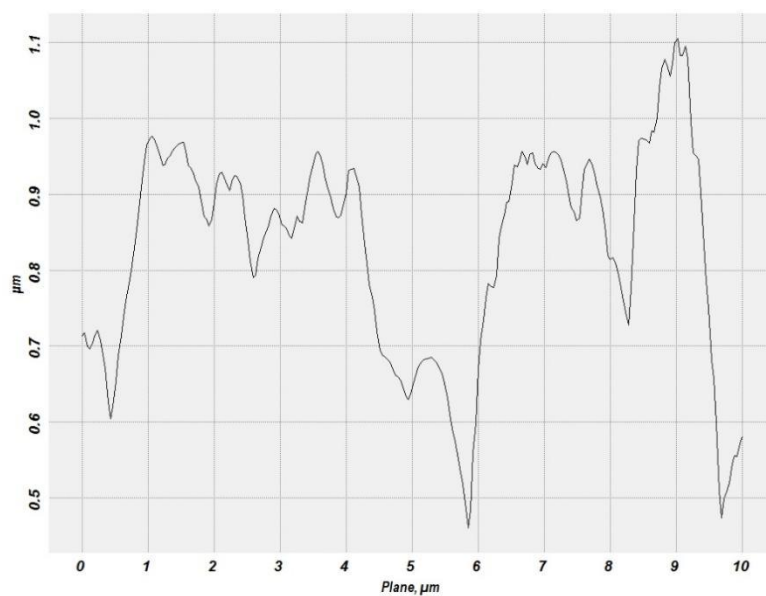


Fig 5.35 The X section@3550nm line profile AFM image of magnesium grade 1 Sample etched without water. The scan size is 10µm× 10µm.

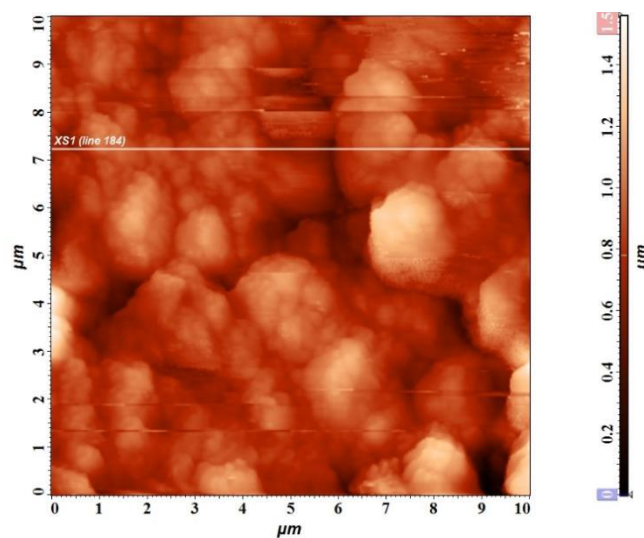


Fig 5.36 The X section@3550nm AFM image of magnesium grade 1 Sample etched without water. The scan size is 10 μ m $\times$ 10 μ m.

Roughness analysis	
Amount of sampling	65536
Max	1538.86 nm
Min	0 nm
Peak-to-peak, Sy	1538.86 nm
Ten point height, Sz	766.26 nm
Average	738.035 nm
Average Roughness, Sa	108.381 nm
Root Mean Square, Sq	146.838 nm
Second moment	566257
Surface skewness, Ssk	-0.395141
Coefficient of kurtosis, Ska	2.41848
Entropy	12.2675

Table 5.4 AFM Roughness Analysis of Sample (1)

REFERENCES

1. Laser surface modification of aluminium and magnesium alloys, J. C. Betts
2. Pure magnesium laser surface modification using Nd:YAG laser, H. Pereira
3. Laser Surface Modification of Mg-Gd-Ca Alloy for Corrosion Resistance and Biocompatibility Enhancement. Chengpeng Ma
4. Influence of laser surface melting on the properties of MB26 and AZ80 magnesium alloys. Yuhang Li
5. Surface modification of biomedical Mg-Ca and Mg-Zn-Ca alloys using selective laser melting: Corrosion behaviour, microhardness and biocompatibility
6. Laser Surface Engineering of Magnesium Alloys, ASHISH SINGH
7. Evaporation of colloidal droplets from aluminum–magnesium alloy surfaces after laser-texturing and mechanical processing, K.A. Batishcheva ^{*}, G.V. Kuznetsov, E.G. Orlova, Yu.N. Vympina
8. Studies on surface morphology of under liquid laser ablated magnesium alloy, V.K. BupeshRaja ^{a,1}, Gururaj Parande ^{b,2}, D. Ramachandran ^{c,3}, Ajay Shivsharan Reddy ^{a,4}, Manoj Gupta ^{b,5}, Pushkaraj D. Sonawane
9. Investigation of Wettability Properties of Laser Surface Modified Rare Earth Mg Alloy. Khadka Indiraa, ^{b, *}, Castagne Sylviea, ^b, Wang Zhongkea, ^c, Zheng Hongyua, ^c
10. Laser surface modification of AZ31B Mg alloy for bio-wettability, Yee-Hsien Ho, Hitesh D Vora and Narendra B Dahotre
11. McBride ED. Absorbable metal in bone surgery. J Am Med Assoc 1938;111(27):2464–7.
12. Verbrugge J. Le Matériel Mé'tallique Re'sorbable En Chirurgie Osseuse. La Press Med 1934;23:460–5

13. Witte F, Kaese V, Haferkamp H, Switzer E, Meyer-Lindenberg A, Wirth CJ, et al. In vivo corrosion of four magnesium alloys and the associated bone response. *Biomaterials* 2005;26(17):3557–63.
14. Williams DF. Effects of the environment on materials. *Biomed Eng* 1971;6:106–13.
15. ASTM B 275-90: Standard Practice for Codification of Certain
16. Nonferrous Metals and Alloys, Cast and Wrought. *Annual Book of ASTM Standards*. Philadelphia, Pennsylvania, USA: American Society for Testing and Materials; 1990
17. DIN 50918: Elektrochemische Korrosionsuntersuchungen. Deutsche Normen. Berlin: Beuth Verlag; 1978. p. 1–6.
18. Beckmann F. Microtomography using synchrotron radiation as a user experiment at beamlines BW2 and BW5 of HASYLAB at DESY. *Proc SPIE* 2002;4503:34–41
19. Scharnweber D. Degradation. In: Helson JA, Breme HJ, editors *Metals as biomaterials*. 4th ed. New York: Wiley; 1998. p. 101–51
20. Seyfarth H. Problem of implantation of foreign bodies. *Arch Orthop Unfallchir* 1956;48(3):254–69
21. Sridhar TM. Electrochemic deposition of hydroxyapatite coatings and corrosion aspects of metallic implants. *Corr Rev* 2002;20:255–93
22. Khan MA, Williams RL, Williams DF. The corrosion behaviour of Ti–6Al–4V, Ti–6Al–7Nb and Ti–13Nb–13Zr in protein solutions. *Biomaterials* 1999;20(7):631–7.
23. D. Beeman, J. Silverman, R. Lynds, M.R. Anderson, *Phys.Rev. B* 870 (1984)30.
24. H.K. Mao, R.J. Hemerly, *Nature* 721 (1991) 351

25. M. Yoshikawa, Y. Mori, M. Maegawa, Appl. Phys. Lett. 3114 (1993) 62.

PLAGIARISM REPORT

SJ SAINATH G AKASHWARAN final report ..final.pdf

ORIGINALITY REPORT

18%

- | | | |
|----------|---|-----------------------|
| 1 | en.wikipedia.org
<small>Internet</small> | 419 words – 5% |
| <hr/> | | |
| 2 | Manoj Gupta, Nai Mui Ling Sharon. "Magnesium, Magnesium Alloys, and Magnesium Composites", Wiley, 2011
<small>Crossref</small> | 223 words – 3% |
| <hr/> | | |
| 3 | V.K. BupeshRaja, Gururaj Parande, D. Ramachandran, Ajay Shivsharan Reddy, Manoj Gupta, Pushkaraj D. Sonawane. "Studies on surface morphology of under liquid laser ablated magnesium alloy", Materials Today: Proceedings, 2021
<small>Crossref</small> | 179 words – 2% |
| <hr/> | | |
| 4 | Umanath Karuppusamy, Devika D, Rashia Begum S. "Experimental investigation of machinability and geometrical behavior of Titanium Alloy (Ti-6Al-4V) using Abrasive Waterjet Circular cut using Response Surface Methodology-Desirability approach", Research Square Platform LLC, 2021
<small>Crossref Posted Content</small> | 175 words – 2% |
| <hr/> | | |
| 5 | sist.sathyabama.ac.in
<small>Internet</small> | 166 words – 2% |
| <hr/> | | |
| 6 | H. Pereira, O. Carvalho, G. Miranda, F. S. Silva. "Pure magnesium laser surface modification using | 109 words – 1% |

CONFERENCE CERTIFICATE



**CHENNAI
INSTITUTE OF
TECHNOLOGY**
Transforming Lives

Certificate No: **ICAMT2022_235**

**CHENNAI
INSTITUTE OF TECHNOLOGY**
Sarathy Nagar, Kundrathur, Chennai - 600069.

ICAMT 2022
International Conference on Advances in Manufacturing Technology

Certificate

This is to certify that
AKASHWARAN.G

from
**SATHYABAMA INSTITUTE OF SCIENCE AND
TECHNOLOGY, CHENNAI**

has participated in the **International Conference on
Advances in Manufacturing Technology - ICAMT 2022**
organised by Department of Mechanical Engineering,
Chennai Institute of Technology on 25th & 26th Mar, 2022



Organizing Secretary



Principal

CONFERENCE CERTIFICATE



**CHENNAI
INSTITUTE OF
TECHNOLOGY**
Advancing the Frontiers of Knowledge

Certificate No: **ICAMT2022_236**

**CHENNAI
INSTITUTE OF TECHNOLOGY**
Sarathy Nagar, Kundrathur, Chennai - 600069.

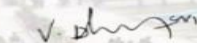
ICAMT 2022
International Conference on Advances in Manufacturing Technology

Certificate

This is to certify that
SAINATH.S.J

from
**SATHYABAMA INSTITUTE OF SCIENCE AND
TECHNOLOGY, CHENNAI**

has participated in the **International Conference on
Advances in Manufacturing Technology - ICAMT 2022**
organised by Department of Mechanical Engineering,
Chennai Institute of Technology on 25th & 26th Mar, 2022



Organizing Secretary



Principal