# ABSTRACT

The need for long-lasting metallic implants is increasing as the number of aged people suffering from degenerative bone diseases increases resulting in revision surgeries. Metallic implants make up almost 70% to 80% of the implants used to replace damaged bones. Despite their tremendous strength, metallic implants have extremely high Young's modulus when compared to the bone which leads to stress-shielding effect. Pores are incorporated in the implant structures to reduce the density and hence the modulus, but reduces the strength which in turn reduces the longevity of the bone.

This study aims to improve the compressive strength of the porous Ti6Al4V structures and maintain Young’s modulus closer or equal to human bone modulus to avoid stress-shielding effect. The possibilities of combining the bio-inert and biodegradable materials for implant applications are explored. Ti6Al4V offers excellent corrosion resistance making it a bio-inert material. But, Mg is a biodegradable material that degrades in the biological environment. Porous Ti6Al4V structures are fabricated with different pore sizes and strut sizes resulting in specific porosity, using Electron Beam Melting (EBM), an additive manufacturing (AM) technique. They are subsequently infiltrated with pure magnesium (Mg). The strength of the porous Ti6Al4V structures increases by 1.5 times after Mg infiltration, and their Young's modulus ranges between 4–6 GPa, which is similar to the trabecular bone modulus of 10 GPa. Being a biodegradable material, Mg will corrode which will affect the strength of the Ti6Al4V/Mg structures. Thus, it is imperative to study their strength retention properties based on corrosion studies. Mg infiltrated Ti6Al4V samples are immersed in kokubos’ simulated body fluid (SBF) at various time intervals. It is found that corrosion initiated at the interface region and the amount of Mg present in the sample influenced the corrosion rate.

The corroded samples were subjected to compression testing with and without the presence of Mg corrosion by-product to understand its influence on their strength retention. At the end of the $14^{th}$ day of immersion, among the corroded samples without the presence of corrosion products, samples with their primitive porous Ti6Al4V structure having lower porosity (60%) exhibited maximum compressive strength of 264 MPa and Young’s modulus of 3.8 GPa. The strut size also played a major role in determining the samples’ compressive properties. But, among the corroded samples with the presence of corrosion products, even after one month of immersion, the same sample whose porosity of the primitive porous structure of around 60% ended up with a maximum compressive strength of 311 MPa which is higher than the compressive strength of the cortical bone of 200 MPa. All the samples have Young's modulus between 4.3 and 5.3 GPa, which is similar to the trabecular bone modulus of 10 GPa. XRD results of the corroded samples showed the presence of biominerals like magnesium hydroxide and hydroxyapatite which forms the precursors of tissue formation.

The pore size of the Ti6Al4V structures played a major role in trapping the Mg corrosion products within them resulting in better strength retention. After a month, Ti6Al4V/Mg sample with Ti6Al4V structure having a lower pore size of 0.8 mm showed a 37 % reduction of compressive strength from its Mg infiltrated Ti6Al4V structure before immersion. This showed better strength retention when compared to other samples whose reduction of compressive strength ranges between 41 % and 56 %. Ultimately, the design of the primitive porous Ti6Al4V structure is responsible for having higher compressive properties, as well as in retaining them. These design features of the porous structures like pore and strut sizes are very well controlled by employing AM technique in fabricating these structures. Thus, Ti6Al4V/Mg structure, wherein porous Ti6Al4V is made using AM technique, can be employed as long-lasting metallic implants to replace the deceased human bone.