Surface modification of biomedical devices is a key strategy for enhancing biocompatibility and bioactivity without affecting bulk material properties. This thesis explores the development of a three-dimensional (3D) micro-architected zinc (Zn) coating for implant applications, leveraging zinc's emerging role as a next-generation biodegradable material with the potential to support bone regeneration.

A template-assisted electrodeposition approach is employed to fabricate the 3D Zn structures. The process begins with the optimization of high-resolution 3D microprinting of photocurable resin templates, guided by CAD design and systematic parameter studies. These templates are subsequently filled with zinc via electrodeposition to form microstructured coatings with controlled geometry.

Mechanical properties are evaluated using in situ micropillar compression testing, enabling insight into structure–property relationships. Compared to conventional fabrication methods such as Focused Ion Beam (FIB) milling, this approach allows the production of standalone micropillars without inducing structural damage. Final metallic architectures are obtained by removing the polymer template through plasma etching.

The results demonstrate the potential of template-assisted electrodeposition as a versatile method for designing Zn-based microstructures, offering improved pathways for tissue integration, enhanced healing, and reduced infection risk in biomedical implant applications.