# ABSTRACT

The main focus of this research is to develop a functional surface which can protect biomedical implants and devices from bacterial attack and the surface should be capable of restricting bacterium to form colonies. Bacterial infections are being generally treated by providing antibiotics, but a serious problem occurs when biofilm diminishes the effectiveness of antibiotics. The surface of Grade-5 Ti6Al4V alloy and polydimethylsiloxane (PDMS) surfaces were modified using different micro-nano fabrication techniques to inhibit the attachment of bacterial cells. The influence of different shapes and sizes of micro-nano structures and surface wettability on the attachment bacterial cell have been investigated.

A nanosecond pulsed laser was used to fabricate pit structures on Ti6Al4V alloy followed by annealing at different duration. Thermal annealing was adopted to reduce the transition time from hydrophilic to superhydrophobic surface generation. The 40 µm spacing of pit structures annealed at 300 ℃ for 120 min. exhibited the maximum contact angle of $162° \pm 2°$. The superhydrophobic surface restricts the initial attachment of *E. coli* and *S. aureus* which could help in delaying the formation of biofilm compared to (contact angle $63° \pm 3°$) plain Ti6Al4V surfaces.

Thermal dewetting is an easy and cost-effective approach to fabricate nanoparticles on a larger area for making bactericidal surfaces. This method was then applied to Ti6Al4V metallic surfaces to test its antibacterial property. The silver thin film of 15 nm on Ti6Al4V substrate when annealed at 750 °C for 15 min has shown the excellent antibacterial property. The controlled release of silver ions was ensured so that the excess leaching of $Ag^+$ should not damage tissue cells. The $Ag^+$ and physical contact between polygonal particles available on the Ti6Al4V surface resists the colony formation of *Escherichia coli (E. coli), Staphylococcus aureus (S. aureus), Salmonella typhi (S. typhi), and* Methicillin-resistant *Staphylococcus* *aureus (MRSA)* by disrupting its membrane which results in the death of bacterias. This method significantly enhances the antibacterial property of the modified bone plate implant by 96% against the aforementioned four bacteria without hindering the growth of fibroblast cells. Further, polystyrene film embedded with AgNPs was fabricated using a DC sputter coating followed by thermal dewetting and soft molding in order to make bactericidal polymer surfaces. The AgNPs induced modified polymer surface through a new approach is found to be highly effective against *E. coli* and *S. aureus* whereas plain polystyrene film is highly prone to the growth of bacterial cells.

Different types of nanostructures were fabricated on PDMS using soft lithography techniques and tested for surface wettability to minimize the surface area for bacterial attachment. It was found that the tendency of the formation of biofilm is negligible on a triangular structured surface. Moreover, the high aspect ratio micro-pillar of specific size has shown significant bacterial resistance against *E. coli* (68.21%) and *S. aureus* (64.31%) along with high drug resistance *S. typhi* (55.81%) and *MRSA* (60.01%) in LB media whereas, in urine, ~ 82% of all four bacteria were successfully inhibited. Theoretically, it is confirmed that the dimension of the proposed micropillar pattern satisfies the stability condition for the Cassie-Baxter model. This method of making high aspect ratio structures can be employed for catheters that do not change the original chemical composition of the polymer. The ability of the proposed structured surface to inhibit the attachment of a wide range of bacterial cells is remarkable without any use of a bactericidal agent. Last, the indigenous hot embossing set-up was developed for making micro-nano structures on a larger area. The developed set-up overcomes the limitations of available fabrication techniques which can make nanostructures to a very small area (500 µm × 500 µm).

**Keywords:** Micro-nanostructured surfaces, Functional surfaces, Antibacterial surfaces, Laser texturing, DC sputter coating, Thermal dewetting, Electron beam lithography