Synthesis of antimicrobial surfaces by inverted glancing angle deposition (I-GLAD)

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Abstract

This research focuses on the synthesis and characterization of bio-inspired artificial antimicrobial surfaces using Inverted Glancing Angle Deposition (I-GLAD). The antimicrobial surfaces studied in this research are surfaces that are covered with nanoscale protrusions, which are observed in nature such as cicada wings and dragonfly wings. These nanoscale protrusions, mostly nanopillars and nanocones, achieve antimicrobial by mechano-bactericidal: the bacteria are deformed by being punctured into the protrusions and eventually killed. Even though research groups have published papers on mechano-bactericidal surfaces, there are still some challenges in this research: 1) the synthesis, scaling-up and fine control of the artificial nanoscale protrusions are still challenging; 2) the mechano-bactericidal mechanism is not universal. The challenge of the synthesis comes from the fact that the three- dimensional (3D) protrusion features for puncturing the bacteria have to be much smaller than bacteria, as small as only a couple nanometers. The proper spacing of the protrusion features is also required to allow the deformation of the bacteria. However, the sub-100 nm, high aspect-ratio, 3D features are challenging to obtain through traditional nanofabrication methods, especially by top-down nanofabrication techniques.

Our research group proposed to use glancing angle deposition (GLAD) to recreate cicada-wing-mimicry antimicrobial surfaces. GLAD is a bottom-up process for achieving complex 3D nanofeatures. The use of seeds alters the distribution of the features, and hexagonally packed nanofeature arrays are recreated. However, the requirement of the nanosphere seeds adds complexity to the process: the preparation of a monolayer of nanospheres is challenging, and the area of the seeds can be limited if seeding is not properly conducted. In the current research, we discuss the possibility of synthesizing the mechano-bactericidal antimicrobial surfaces by GLAD without predetermined seeds. The design and control of the process for synthesizing the antimicrobial surfaces are addressed in the study. Multiple materials including Ge and Ti are used for creating nanoscale protrusions for uncovering the mechano-bactericidal mechanism. The characterization of the surfaces, including the morphology, the superhydrophobicity, and the effectiveness of the antimicrobial property against both Gram positive and Gram negative bacteria are presented.

Biography of Presenter

Dr. Chuang Qu is currently a research scientist in the department of Electrical and Computer Engineering at the University of Louisville for the Kentucky Multi-Scale

Manufacturing and Nano Integration Node (KY MMNIN). He received his Ph.D. in Mechanical Engineering from Missouri University and Science and Technology in 2019. His research focuses on advanced nanofabrication, thin films, additive manufacturing, bio-inspired surfaces and optics.