Metal Antimicrobial Surfaces

Robert Douglas, Sam Chan, Craig Manning, David Bird.

Metals as antimicrobial materials

The anti-microbial properties of copper and other metals have been known for many years, killing both bacteria and viruses. Professor Bill Kevil's group at the University of Southampton demonstrated in 2021 that the SARsCoV-2 virus could be deactivated in as little as 1 minute on a copper surface, with repeatable results in only 10 minutes.

CPI's electronic-materials fabrication facility in the HealthTech-BU has almost 15 years' experience in depositing thin-films of metals for a variety of applications for device fabrication, including large-area substrates (Figure 3) and roll-to-to-roll materials. With the capability for testing the growth of microbes now also established within the BU, a £5k , 2-week long project was proposed to demonstrate CPI's capability to both deposit the metals of interest and test their efficacy as anti-microbial materials.

Metal deposition

CPI has a variety of physical and chemical vapour deposition process. Physical vapour deposition (PVD) gives the purest metals, and sputter-coating (Figures 1 and 2) is the PVD process with the greatest flexibility and highest deposition rates for the materials of interest, and so was chosen for this study.

Substrates were prepared by; adhering PET film to a glass-carrier; cleaning in surfactant solution (1% Decon-90 surfactant) with ultrasonics; baking to drive off any moisture at 70 °C for one hour; metallization (Figure 4) in a Moorefield Minilab sputter coater with Argon gas.

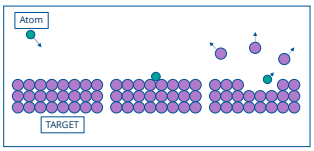

Figure 1: *The sputtering process*

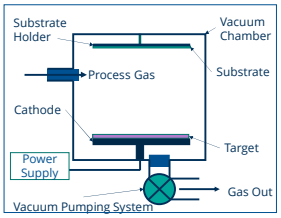

Figure 2: *Schematic of the sputtering system*

Figure 3: *Sputter tools up to 370mmx470mm.*

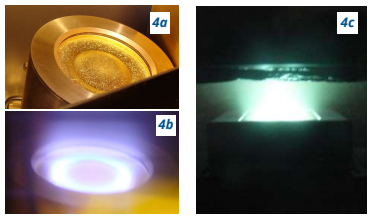

Figure 4: *Gold sputter target (4a); Argon plasma on a gold target (4b); Argon plasma on a copper target*

Metal selection

Copper was chosen as a known good anti-bacterial metal; silver was chosen due to its excellent deposition rate (2.8 atoms ejected per Argon atom *versus* Cu's 2.0) under standard conditions (500 eV Ar ions). Uncoated glass, plastic and thick copper foils were also chosen as reference materials. Metal oxides and nitrides were considered but not used here due to much slower deposition rates.

Patterning of the metal into conductive tracks was considered to enable chemical-free sterilization of the surfaces, however the test-fixture was too complex to implement with the microbial testing within this project.

Microbial assays

After the surfaces have been coated we assay how well bacteria survive on the surface. We use a method based on ISO 22196:2011 (Measurement of antibacterial activity on plastics and other non-porous surfaces).

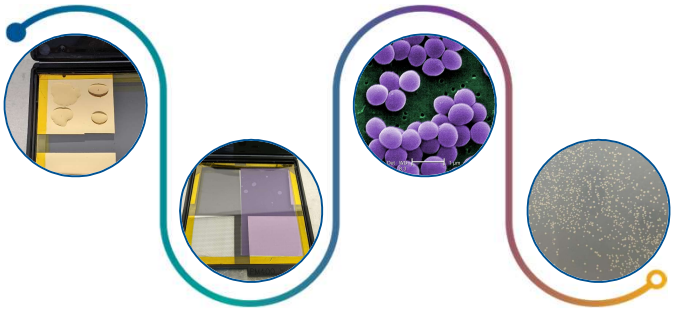

Figure 3: *Method schematic. Disinfectants are tested to remove and residual life without damaging the surface. Bacteria are seeded at a known density to the surface and covered. They are incubated at a controlled temperature, in this case for 24hrs. The bacteria are then washed off diluted and seeded to plates. After they have grown the number of colonies are counted.*

We used *Staphylococcus aureus* for our assay, it is the most pathogenic of the Staphylococci, and it can cause skin infections, pneumonia, endocarditis, and osteomyelitis. Antibiotic resistant strains such as Methicillin-resistant Staphylococcus aureus (MRSA) are becoming more prevalent especially in a healthcare setting and their control is a priority.

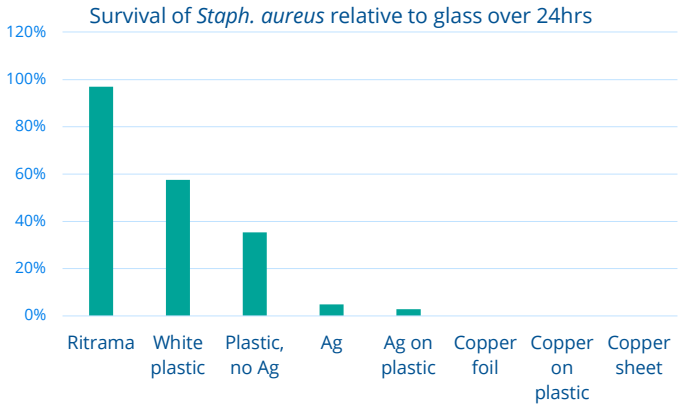

Figure 4: *Assay on a selection of metal and control surfaces based on ISO 22196:2011 Measurement of antibacterial activity on plastics and other non-porous surfaces method. We see a complete kill (7 log) on all the copper surfaces after 24hrs.*

Conclusions and Future Work

The sputtered copper films were as effective as the copper foil control, despite being 500x thinner. The silver was quite effective, but not as good as the copper.

The sputtered copper films were not very robust, with the test protocol degrading the films. Therefore, this deposition technique is not likely to be suitable for high-use touch points like door handles, but may be suitable for large-area surfaces such as walls, or materials that are used and disposed, such as bandages.

Future work would include: other organisms of interest; other metals of interest such as copper and silver alloys to reduce the cost; trialling wet and dry assay; long-term testing.