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Highly Biocidal Transparent Vacuum Deposited Coatings for Touch Surfaces to help in the Fight against COVID 19 and Healthcare Associated Infections (HCAI)

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A novel human coronavirus that is now named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2 - formerly called HCoV-19) emerged in Wuhan, China, in late 2019 and is now causing the COVID19 pandemic. National security is under duress due to this emergency with little hope of eradicating the problem in the short-term. Until widespread vaccination, there is a strategic need to invest in technological solutions to reduce and slow the impact of the pandemic. The SARS-CoV-2 virus can be present on plastic and glass surfaces for several days.

Fig. 1 – Microbial cultures from hand contact.

Once a hand has touched a contaminated surface, hand washing reduces the probability of infection by removing the virus. Gloves reduce the chance of contagion if changed frequently, although the virus will be transferred by a gloved hand to the next surface. Once travel restrictions are relaxed, the chance of spread from surfaces will increase as the population begins to move around again. Vacuum coating has a solution that can be used to greatly reduce the spread from common touch surfaces. Vacuum based nanostructured films can be highly biocidal and are hence self-sanitising. These films have a viral and microbial killing effectiveness above conventional cleaning methods. The killing action is continuous, hence it will have a positive impact to reduce the probability of cross-contamination from surfaces.

This paper presents a solution against infections derived from touch surfaces by using a nanotechnology coating based adhesive pad to protect the public from cross contamination. The coating development has been focused on flexible and transparent substrates and coatings which could be easily upscaled using Roll-to-Roll production techniques. Different biochemical and biological tests have been performed to quantify the biocidal activity.

Introduction

The 2019 SARS-CoV-2 outbreak responsible for COVID19 epidemic has presented an unprecedented high velocity of virus spread. While the ss + RNA enveloped virus can be destroyed by hand washing with appropriate disinfectants, surfaces, screens, and mobile phones, once touched can re-contaminate the user and pose a biothreat risk for infection spread globally. They can contribute to the decease crossing borders especially as they are omnipresent in modern transport and human-to-human social contact scenarios. Screens and other surfaces can also contribute to the contamination and genesis of additional secondary fomites (doorknobs, airport self-check-in stations, bus rails, ATM monitors, lift buttons, etc). Evidence from a Wenzhou shopping mall in China indicates that Fomite transmission on surfaces fueled the outbreak [1]. Such indirect transmission is a result of the virus being present on surfaces with which an infected individual has interacted. A study by the University of Nebraska Medical School treating patients from the Diamond Princess Cruise Ship, showed 72.4% of surfaces near to patients were positive for the viral RNA and 77.8% of cell phones were contaminated [2].

Recent evidence in a letter published in the New England Journal of Medicine on 17th March 2020 [3] finds that the stability of the virus SARS-CoV-2 is "similar to that of SARS-CoV-1 under the experimental circumstances tested." The new coronavirus was found to be viable up to 72 hours after being placed on stainless steel and plastic. It was viable up to four hours after being placed on copper, and up to 24 hours after being put on cardboard. On copper, no viable SARS-CoV-2 was measured after 4 hours and importantly, the decay of the virus is exponential. Hence the dose of SARS-CoV-2 that is likely to be received from a biocidal surface is much lower than comparable materials and this is important information for pandemic mitigation efforts. Previous work by Keevil at Southampton University [4] in the UK has also shown that a relatively low concentration of enveloped respiratory viruses may retain infectivity on common hard surfaces for longer than previously thought (5 days) and copper surfaces were shown to disable a high proportion of coronavirus within 5 minutes and entirely within 30 minutes.

All forms of surfaces present a contagion risk whether it be from a viral or microbial source, but the widespread use of touch screens in healthcare and community settings is a possible 'Trojan Horse' contributing to the transmission of microbial infections in epidemics and pandemics [5].

Touchscreen technology is seen as 'safer' than face to face contact. Supermarket self-checkouts are a good example, with a constant flow of use and interaction from both staff and customers. Another is a doctor's surgery, where sick people are all asked to touch the same surface in a steady flow.

Viral contamination will certainly remain present on a touchscreen for hours and days if not removed by cleaning. There is an urgent for a smart means to self-sanitise the surface to reduce the contagion risk. The desirability of this approach is also backed-up by the inability of conventional cleaning methods to effectively sanitise surfaces. This is evident from the high levels of Healthcare Associated Infections (HCAI) as well as studies of contamination on surfaces found within medical settings [6].

This paper presents a solution against infections derived from touch surfaces by using a nanotechnology vacuum-deposited coated adhesive pad to protect the public from cross-contamination. The coating development has been focused on flexible and transparent substrates and coatings which could be easily upscaled using Roll-to-Roll production techniques. Different biochemical and biological tests have been performed to quantify the biocidal activity.

Before the COVID19 pandemic, Healthcare-Associated Infections (HCAI) were the prime focus for self-sanitising surface technology developments. HCAI poses a serious risk to patients as they can result in significant harm to those infected.

The estimated HCAI incidence rate in the USA (2014) was 4.5%, corresponding to 9.3 infections per 1000 patient-days and 1.7 million affected patients[6]. The European Centre for Disease Prevention and Control (ECDC) estimated that 4,131,000 patients are affected by approximately 4,544,100 episodes of HCAI every year in Europe [6].

The Agency for Health care Research and Quality reported that HCAIs are the most common complications of hospital care and one of the top 10 leading causes of death in the USA [7].

Reducing healthcare-associated infections (HCAIs) remains a key indicator for most developed countries when measuring public safety and quality of care.

The main objective of this work is the creation by vacuum coating of highly biocidal surfaces that will rapidly kill viral and microbial strains.

Copper as a Biocidal Material

Copper materials have been used since ancient times for their antimicrobial properties, and modern science has demonstrat-ed how incredibly effective the surface is in terms of bacterial and viral killing. Technology-based upon bulk copper materi-als are now available that can minimise the survival of germs on surfaces, the main barrier is cost and convenience. Studies have shown that copper surfaces for instance have a log 3 (99.9%) effectiveness in killing microbes as metal ions are highly efficient in this regard. This is superior to rigorous chemical cleaning. The cost however of manufacturing and replacing fixtures and fittings with copper components has prevented widespread uptake despite clear evidence of benefits.

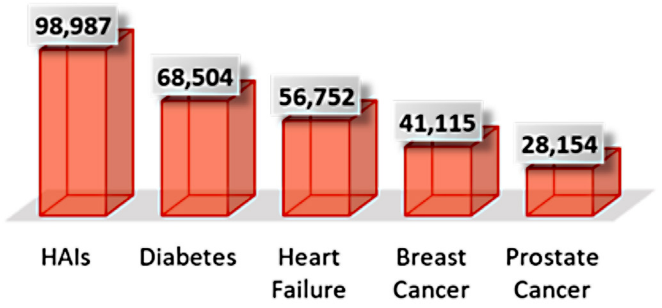

Fig. 2 – Leading of death causes in USA [7].

The background to creating biocidal coatings is based upon two strands of wider research. The first is the use of metallic surfaces as effective antimicrobial agents. The second is the role of the nano-scale topography of a surface to provide an-timicrobial performance. Extensive work on Ag, Cu, Ti, Zn materials has illustrated their use as antimicrobial agents. Likewise work on nanostructured surfaces and nano-particles has yielded good results for antimicrobial performance. Nanostructuring of surfaces alone can produce environments that effectively kill microbes on a LOG 2 to 4 scale (99 to 99.99%). If this nano-structuring is combined with optimum metal ion leaching effect, metallic based nanostructured mate-rials have the potential to provide highly effective antimicro-bial and consequently antiviral surfaces.

Vacuum deposition is used industrially to deposit thin layers of virtually any material type onto all forms of surface. Certain vacuum-deposited based layers can combine several biocidal actions; the presence of ionic metals, and the creation of a nano topography that promotes chemical and electrical activity between features [8]. Prior work by Gencoa has shown that these combined effects are required to produce the highest levels of antimicrobial effectiveness [9,10]. Under the correct deposition conditions, a range of metals can be combined with a hard ma-

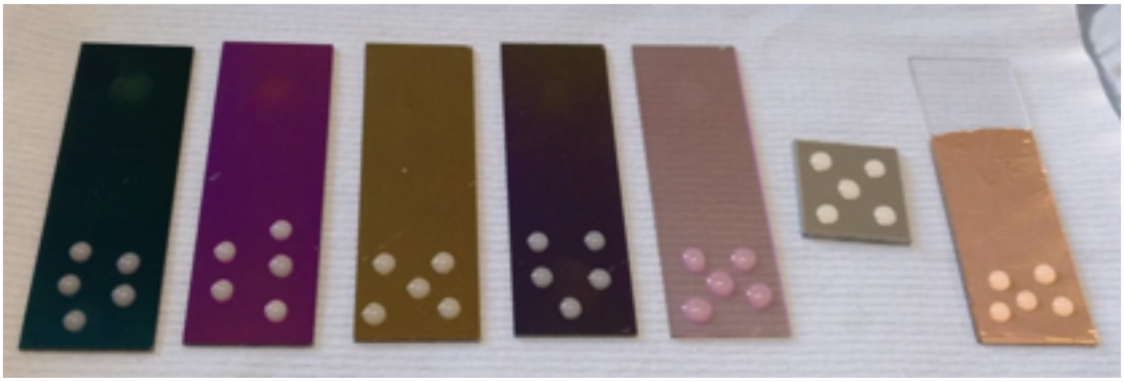

Fig. 3 – Biocidal activity testing of various sputter deposited vacuum coatings.

trix to result in a microbial kill rate of LOG6 (99.9999%) within minutes. These layers perform as well in terms of antimicrobial performance as the best nano-clustered silver surfaces.

Gencoa has created coatings with varying degrees of complexity directly onto 3D objects. Such coatings can be tailored to provide, extreme hardness, low friction, different colour hues, or even transparency. So vacuum deposition provides the coating 'armory' to create the critical coating microstructure required to enhance the biocidal performance of these materials.

To more rapidly exploit the technology and impact the battle against the Sars-Cov-2 virus, the recent focus is to create 30-100nm thickness layers based upon copper on-top of a thin plastic web which can then be adhered onto a touch surface. The choice of copper-based layers is a 'safe' approach since copper and a wide range of its alloys are the only materials approved by the US FDA to make public claims of antimicrobial activity. All other materials including silver have failed to gain approval. Copper is a lower cost material than silver and can be sputtered at high rates compared to other metals.

In a practical sense, the concept is a copper version of an aluminium metallised 'snack' packet, although oversimplified, it is a close analogy. Importantly, it is a very low-cost manufacturing process and suitable surfaces can simply be covered by the adhesive film in order to afford months and years of protection, hence avoiding costly hardware changes. Flat surfaces are easily protected as are simple geometry 3D shapes. More complicated shapes can be protected by heat-shrinkable coated plastic, or have a PVD coating applied directly. There are two market requirements of equal importance; touch surfaces and touch screens. Hence, both opaque and transparent forms of coating on plastic are needed to protect the existing built environment. Opaque forms are more readily produced as they can be simple copper or copper alloy films. Transparent forms present more of a challenge and new form is presented here that has great potential for exploitation.

EXPERIMENTAL & RESULTS

Cleaning Process & Coating Deposition

A Physical Vapor Deposition (PVD) method was used in order to produce the different coatings on surfaces; as described generically in reference [11]. The PVD unit to create the layers comprised of a vacuum vessel (1600 L/s turbopump), 2 off Gencoa magnetron sputtering sources, and 1 off Gencoa linear ion source. During coating, the substrates were rotated in front of the plasma sources. The substrates were attached to a suitable substrate holder.

Various metallic, glass, and plastic substrates have been used for the work. Small glass slides are a convenient substrate for testing purposes and have been widely used. One important point of note is that different glass slides have different topography due to atmospheric corrosion that gives the possibility to accumulate soluble crystalline initiators on the glass surface. The surface profile is influenced by the topography of the substrate. To ensure reproducibility, the "memory" from the glass substrate should be removed otherwise data will be distorted which presents great difficulty for coating development.

Additional direct evidence of an ever-changing reaction of glass surfaces is shown by AFM of thin metallic coating on top of two different glass substrates (Fig. 4). Significant differences arise from the topography of the glass and explains changes in surface activity with environmental conditions. Investigations by Prof. Dr.-Ing Edda Rädlein from the University of Ilmenau has shown the surface condition of the glass varies widely with defects such as delamination, dendrites, and droplets commonly present.

To avoid topography variation interference with measurements, the glass surfaces have been treated by vacuum-based plasma treatment (ion beam) and the corresponding biocidal performance has been measured [10].

This has demonstrated that ion source cleaning of the substrate prior to coating, removes the biocidal effect from original glass topography, obtaining a clear and reproducible start point for new coatings. Plastic substrates however do not have such a pronounced surface 'memory' and are hence more stable from this point of view.

The main surface preparation prior to coating deposition was achieved via a Gencoa IM300 ion source for 5 minutes (2 kV × 100 mA) with a mixture rate of (70Ar : 30O2) in order to remove the organic compounds from the surface and 30 minutes with just Ar gas at 2 kV × 50 mA erasing any memory effect over an effective linear zone of 300 mm of etching.

The main (bulk) coating was produced from a 100 mm × 300 mm target using a Gencoa SW100300HY magnetron sputter cathode. The target material for these studies was pure copper or copper alloy, however, a very wide range of materials have been used in the past.

The transparent coatings were produced using Reactive Magnetron Sputtering. The reactive process was controlled via a Speedflo™ feedback controller using an Optix sensor as the input signal [12,13]. The main sputtering gas was Ar with reactive gas additions. Speedflo™ was used to adjust the copper spectrum signal from a spectrophotometer, in order to control optical properties of the thin film. The copper value was selected from

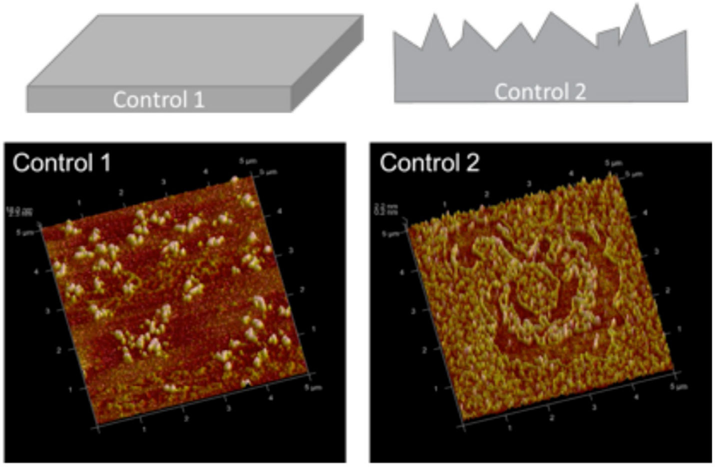

Fig. 4 – AFM on coated (less than 5nm metallic coating) glass slide contact mode. Control 1 smooth topography, control 2 strong topography.

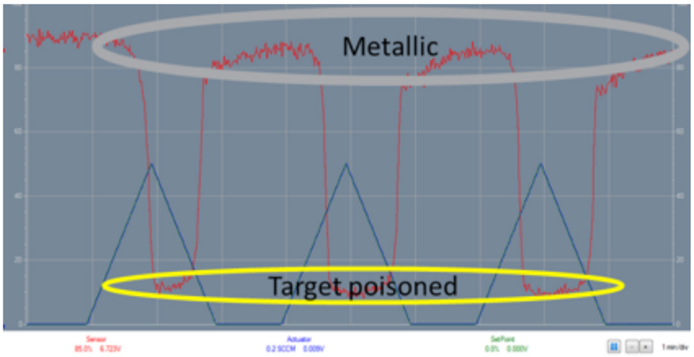

Fig. 5 – Speedflo ™ display with hysteresis of a metal oxygen system reaction.

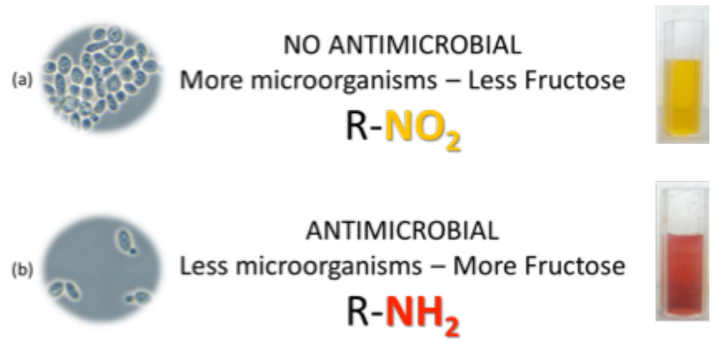

Fig. 6 – Antimicrobial effectiveness related with colony forming unit (cfu) and colorimetric solution absorbance; (**a**) reducing sugar (fructose) is consumed by microorganisms alive on no antimicrobial surface (DNS-yellow solution); (**b**) The low amount of microorganism 3,5-dinitrosalicylic acid is reduced to 3-amino-5-nitrosalicylic acid (red solution) due to the presence of fructose in the solution.

the hysteresis behaviour of the reactive system linked to the desired transparency and other layer properties, see Fig. 5.

Red line (metal signal from metallic mode at 90% sensor to target poisoned mode at 10% sensor), blue line (oxygen setpoint 0-50% of 100 sccm mass flow).

Biochemical Method for Assessment of Biocidal Activity of Vacuum Deposited Coatings

One of the main aims of this and prior research [11,12], was related to using a biochemical method that could provide reliable biocidal results for the different PVD coating types. With that in mind, a simple test for the evaluation of biocidal performance was developed that can rank different coating types for bioactivity within 1-3 days. This is a powerful means of speeding up coating development as results are rapidly available to experiment with the coating properties.

The method was based on the titration of a reducing sugar, such as fructose, which is metabolized by a suitable microbe such as yeast. The microbe needs to be representative of a bacteria responding to the same type of oxidative stresses that would produce bacteria kill. It was found that the yeast Saccharomyces Cerevisiae was a suitable choice for the test - even though it is not a bacteria itself.

This quick test used a colorimetric reaction called the Miller reaction (Fig. 6) [14]. The oxidation of the ketone functional group present in the reducing sugar, fructose, in this case, will favor the reduction of NO_2 group of 3,5-dinitrosacylic acid (yellow) to NH_2 resulting in 3 amino, 5-nitro salicylic acid (red color solution). The color change can be quantitatively assessed and a titration of the non-consumed fructose can be measured. A suitable yeast (Saccharomyces Cerevisiae) was used as a representative microbe.

A method was also required to multiply the remaining bacteria that survived the exposure to the biocidal surface. Once the microbes are allowed to grow from their decimated numbers to a suitable scale, these solutions could be used for the consumption of a known amount of fructose within a range that is easily measurable. An appropriate data analysis and treatment are needed to produce a suitable scale that would reflect the biocidal activity of a given surface. The method was tested and calibrated against several antimicrobial standards and a biological test based on the Japanese Industrial Standard JIS Z 2801:2000 [15].

For the biochemical test, a solution of 555 mg of Saccharomyces Cerevisiae in 20 ml of deionized water was prepared. From this solution, a volume of 0.125ml was added (as 5 x 25µl drops) on top of each test coupon. Each test coupon was enclosed on an individual isolation polypropylene cubicle box 45 mm x 30 mm x 20 mm, to prevent excessive solution evaporation and contamination of the surface. The coupon and yeast solution was left to react for 0.1 to 4 hours at room temperature under UV light (work distance of 35cm substrate/light sources, 380nm with 160W and 400nm with 1200mW light sources) and in darkness (Fig. 4). After the contact test, 10 ml of deionized water was added into each drop to dilute the solution which has been in contact with the test sample. From each of the box's mixture, a 2 ml aliquot was taken and added into a test tube. To each one of these test tubes 2mL of a 24mM fructose solution was added, followed by 1ml of 65mM (NH4)2HPO4 (growth factor). The alive microorganisms were able to grow and form colonies in the solution at the same time as they would consume the fructose. The growth was maintained for up to 3 days at room temperature. References with no yeast and yeast without test samples were also included to obtain a benchmark for 100% and 0% death of microbes.

After the 3 days growth 1ml of each solution was taken and placed into a 5ml cuvette (12.5 × 12.5 × 45 mm cuvette). To this growth extract, 1ml of 22mM DNS (3,5-dinitrosalicylic acid) and 1ml of saturated NaOH in water were added. The cuvette was placed in darkness at room temperature and allowed to react for 48 hours. After that time each cuvette was measured using a UV/VIS spectrometer. The absorbance as 575nm was measured using a UV-Vis spectrophotometer (Ocean Optics USB4000). This absorbance is directly proportional to the amount of remaining (unconsumed) reducing sugar [16]. The original solution with no yeast would have a strong red intense color and would represent the 100% on the Miller scale. The sample with yeast and no biocidal effect represents 0% in the scale as they would consume all fructose leaving a yellow color on the Miller's reaction. For each test, the absorbance at 575nm was placed with reference to the 0-100% scale.

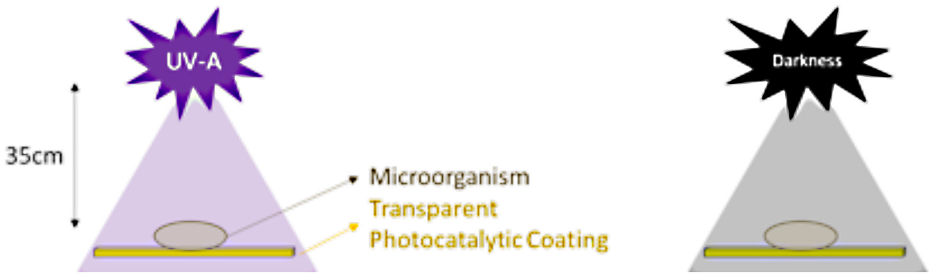

Fig. 7 – Reaction of 0.125ml microbes with a possible antimicrobial transparent photocatalytic coating sample, under 35 cm distance of UV light and in darkness.

Results

The absorbance at 575 nm is measured by UV-Vis spectrophotometer in reference to the 0-100% of the Miller's reaction scale gives a directly proportional value to the amount of reducing sugar [14], hence a related logarithmic value regarding the yeast viable colony forming units (cfu) as the viable microbes are responsible for the sugar solution depletion.

This method developed by Gencoa has created a simple scale for biocidal surface efficacy by normalizing blank (maximum of cfu/mL) to 0% biocidal effect and a solution with zero microorganism (minimum of cfu/mL) up to 100% kill effectiveness.

Different coatings have been deposited and tested to compare their suitability as transparent biocidal layers. Titanium dioxide is a well-known bioactive coating type that is activated by UV light to produce a photocatalytic effect. TiO_2 based materials have been created with various alloy additions and compared to zinc oxide-based layers, see Fig. 8. The activation by UV light directly onto the sample confirms that such TiO_2 based layers are highly biocidal giving a log 6 or 99.9999% kill effect. (Fig. 8).

Whilst titanium oxide-based coatings are highly effective, the reliance upon UV light is a strong negative as this wavelength of light is not present in internal areas of buildings. As shown in Fig. 9, the absence of UV light renders the same films completely inactive. Hence, experiments based upon transparent forms of copper compounds were conducted to identify a formula that could provide biocidal activity without the need for daylight.

Fig. 10 shows a range of results conducted in darkness with a 1 hour contact time for the yeast solution. This compares different forms of sputtered copper with a transparent copper compound. The results show that highly biocidal copper based sputtered films can be created with a high degree of transparency and do not required UV light activation. These transparent layers are as bioactive as optimised sputtered copper, and hence are extremely effective. Pure sputtered copper films require the correct structure to be active. It is apparent that very smooth copper surfaces are not biocidal. This is a surprising result and has been reproduced a number of times. Copper ions are toxic, but the effective release of copper ions from a sputtered surface is also dependant upon other factors. Copper deposited with the right energy conditions on a silicon wafer forms a continuous film with little growth structure – essentially featureless. These coating types do not display the mechanisms required to produce bioactivity. However, the very smooth surfaces can be 'activated' by chemical etching or ion surface treatment to create some surface variations that drive the mechanisms needed for bioactivity. This

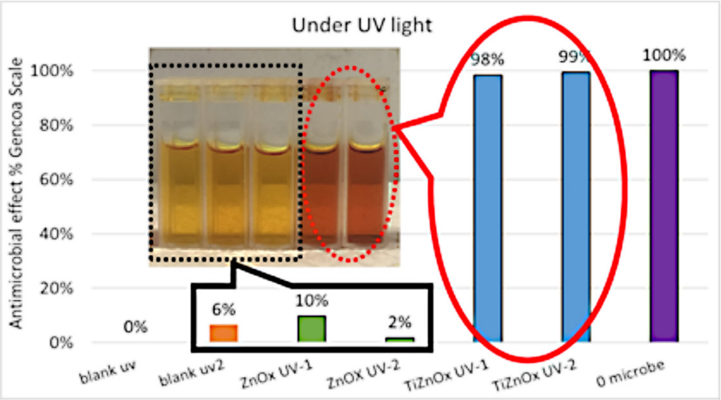

Fig. 8 – The kill effectiveness of zinc and titanium oxide-based materials by biochemical est after UV light reaction for 4h. Blank samples (maximum of cfu/mL) and ZnOx samples with yellow solution. ZnOx coating have the lowest biocidal effect (less than Log 1, or 90% kill effect). This is compared with red solution coming from the log 6 (99.9999% kill effect) TiZnOx coatings developed, such as the active zero microbe (minimum of cfu/mL) to 100% kill effectiveness.

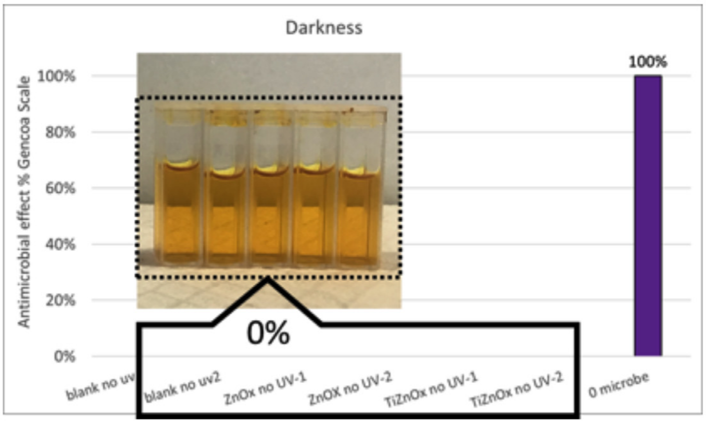

Fig. 9 – Negative solution in antimicrobial efficiency of ZnOx and TiZnOx samples showed by biochemical Gencoa test after in darkness for 4h.

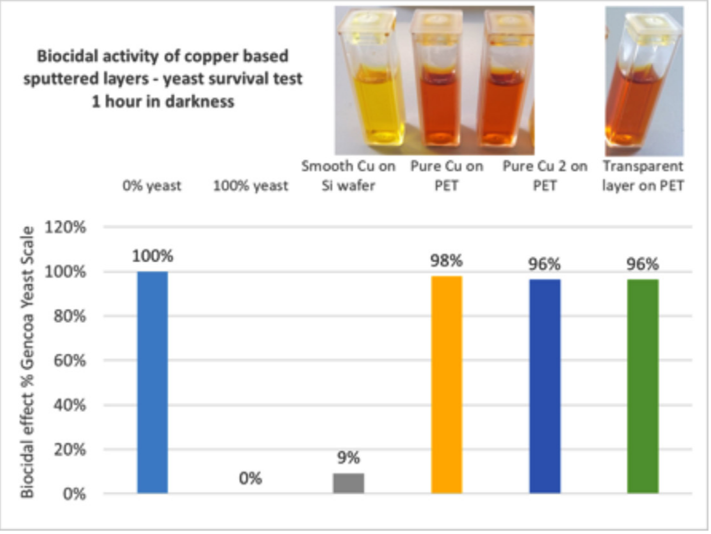

Fig. 10 – Comparison of a biocidal performance of different sputtered copper based materials after 1 hour yeast solution contact duration in darkness.

has been demonstrated by tests on commercial copper adhesive tapes. Initially these surfaces are not active, however with 'ageing' they can develop surface oxides and the surfaces begin to be biocidal. In this respect, the newly exposed 'clean' copper tape is less desirable than the more 'dirty' looking oxidised form. It would appear that smooth surfaces in a uniform electrical state are not effective. Some disturbance to this uniform surface is required to drive a reaction to disturb microorganisms and cause cell death.

Discussion

Vacuum coating has the ability to create growth features on the nanometer scale from a wide range of material types. The growth features enhance the biocidal performance of vacuum deposited materials when compared to a surface made by conventional methods. Copper is a well known biocidal surface, and thermomechanical produced copper materials are not as effective as a vacuum-deposited copper. This is true for sputtered and evaporated vacuum-deposited copper which routinely have a LOG 5 or 6 kill rate compared to LOG 3 for conventional copper surfaces. Also, too 'perfect' a copper surface is not as effective as a rougher or oxidised surface.

The growth features of a vacuum deposited layer will have some degree of 'separation' to their neighbours, and this separation, whilst not necessarily always physical, will provide a subtle difference in electrochemistry. Once the features are bridged by an organic body, it creates a highly effective mechanism to disturb and kill the microbe or virus. Whilst there are also surface area differences between smooth and rougher copper sputtered layers, this does not alone explain why pure copper transitions from very low to highly biocidal as the nanotopography changes.

Fig. 12 illustrates different sputtered surface coatings with varying separation between features. All these layers provide high levels of biocidal activity, and only the left image contains some copper elements. Not all material types can create the

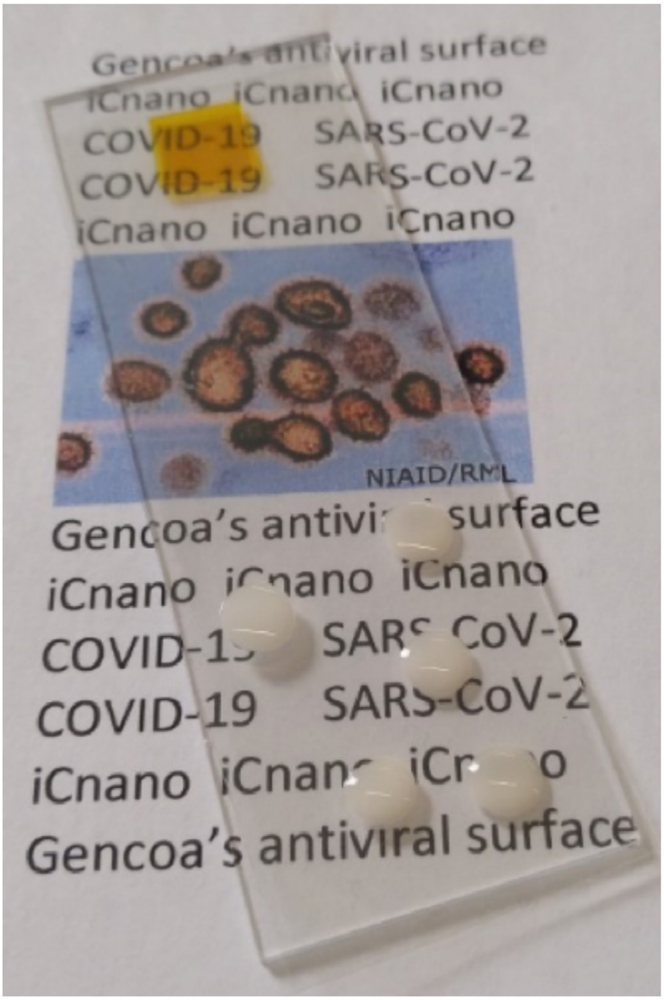

Fig. 11 – Copper based transparent compound - highly biocidal coating on glass.

same activity – some are clearly more effective than others. Hence, the role of metal ion leaching, toxicity, and reactive oxygen species generation will determine the effectiveness of any final coating structure. In the future, there will be a need for a large armory of biocidal coating material types for different application areas – for example where high hardness or a particular colour finish is required.

There are two main characteristics that produce an effective biocidal coating: The chemical nature of the surface (the coating material) and the topography of the surface (growth structure).

Regarding the chemical nature of the material, it is known that copper can interact with lipids, causing their peroxidation and opening of holes in the cell membranes, thereby compromising the integrity of cells [16].

One additional factor for the biocidal efficiency of coatings is related to topography. The most efficient biocidal coatings benefit from coating features which enhance the oxidative electrocatalytic process [17] (see Fig. 13).

The generation of reactive oxygen species is widely cited as an important mechanism for surface bioactivity. Driving this reaction requires different surface features to promote

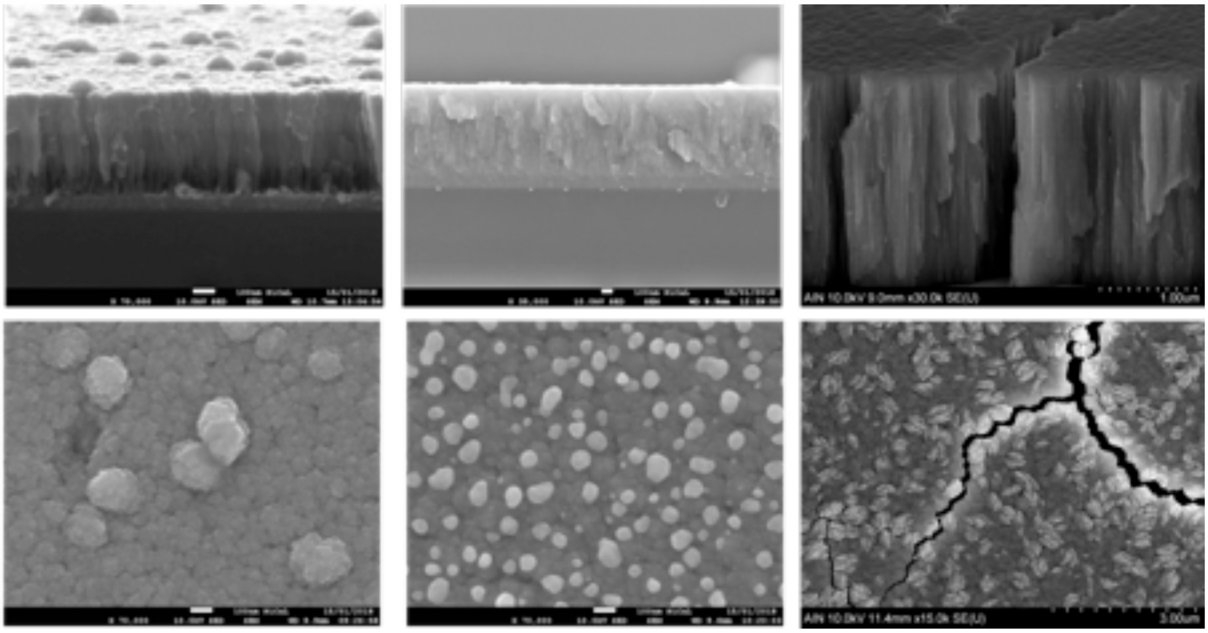

Fig. 12 – Nanorough sputtered coating structure examples with high levels of bioactivity.

electrical potential differences which are bridged by the microorganism. By creating a coating that has distinct growth structures is an important aspect of any biocidal vacuum deposited layer. These nanofeatures set this route apart from other means of manufacturing surfaces.

Another strength of vacuum coating is the ability to reduce the amount of active ingredient, and hence the cost. Vacuum coating thickness levels vary from a few nanometers to a few microns. For biocidal coatings, a few tens of nanometers are required. Even thin alternative materials such as copper tape requires 35 microns of metal. Other dip or spray coating processes likewise are tens or 100's of microns thick. Hence vacuum coating will always 'win' the economic race to minimise material usage.

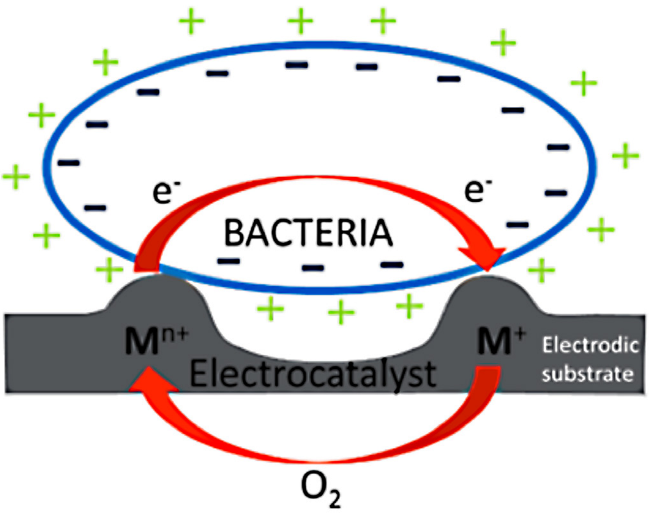

Fig. 13 – Mechanism of reactive oxygen generation between nanosized surface features in contact with a microorganism.

The use of a 'vacuum' environment adds cost compared to atmospheric processes, but this vacuum element is the key to creating and using very small amounts of materials on surfaces. As the vacuum coating industry is mature, very high speed and efficient processing routes are widely available. In particular, Roll-To-Roll coating of plastic is conducted at a large scale at tens to hundreds of meters per minute. Hence, by coating a plastic film with a biocidal layer, followed by an adhesive backing, a low-cost protective pad is created that can adhere to a touch surface. These pads create a self-sanitising effect that will rapidly kill microbes and viruses. This is ideal in the fight against COVID19 and HCAI, since the manual cleaning methods are not required and the technology acts 24/7. Hence the probability of decease contagion is greatly reduced.

Perhaps the biggest challenge of the modern era relates to touch screens. They are designed to encourage hand contact to the surfaces that multiple users will interact with continually. It's hard to imagine a worse scenario when trying to tackle contagion. Voice-activated screens will be a very effective solution. But how reliable will that technology be in public places with background noise and different accents? Touch screens are here to stay for the foreseeable future. As has been shown there is now a very effective vacuum coating solution to greatly reduce the risk of using such screens. The transparent film can adhere to existing screens to offer the same highly biocidal performance that vacuum-deposited copper can impart. As the layer activation is not light-dependent, it will have 24/7 operation and will last many months as they have good handwear resistance.

What are the downsides? Clearly if more plastic finds its way into the oceans, the public will have reservations about its eco-credentials. However, these are far from single-use items.

HIGHLY BIOCIDAL TRANSPARENT VACUUM DEPOSITED COATINGS FOR TOUCH SURFACES TO HELP IN THE FIGHT AGAINST COVID 19 AND HEALTHCARE ASSOCIATED INFECTIONS (HCAI)

Fig. 14 – Three different forms of copper based biocidal vacuum coatings on PET film: from the top, transparent, gold effect and pure copper.

At least 6 months of life is expected. There are a range of biodegradable plastic film options, which will be assessed to ensure they can impart the same stable biocidal action over extended periods. Such self-sanitising surfaces will greatly reduce the need for cleaning chemical use and disposal, which is a positive factor.

Biofouling will need to be addressed by routine cleaning weekly with an aqueous scrub. This will remove gross contamination and ensure the active surface is exposed.

The toxic effect of nanomaterials on humans is a concern in the health industry. Small <100nm Nanomaterials (particles) can cross biological membranes and access cells, tissues, and organs that larger-sized particles normally cannot. However, this coated form of nanotechnology is designed to remain intact within the bulk coating and avoid breakdown or release from the underlying substrate. This assumption will need to be verified to avoid concerns related to nanoparticle generation. However, on a scale of risks compared to the negative impact of COVID19 and HCAI, a rational approach would be encouraged to prevent regulatory barriers for adoption. Copper-based materials are however already FDA approved.

CONCLUSIONS

This work has successfully created highly biocidal sputtered coatings based upon copper. The sputtered copper performs better than conventional copper materials moving the bioactivity from LOG3 to LOG6. A reliable method for quantifying surfaces biocidal activity has been developed to accurately rank different layer types. Based on the rapid testing capability, it has been possible to create a new form of transparent coating that does not rely upon UV light for activation. The copper-based compound kills microbes and viruses at the same speed as sputtered copper, and will afford the same round the clock self-santising effect. The broad-spectrum biological killing capacity that these coatings provide combined with low cost of production should drive widespread adoption. Sputter PVD can create a 'super' surface of chemical delivery and morphology in a highly robust form with an attractive appearance.

The final piece of the puzzle remains unanswered – how quickly is the SARS-CoV-2 virus killed on these surfaces. It is estimated that the half-life will be less than 5 minutes but testing remains outstanding. All University labs are closed, hence the pool of available testing sites are very small, and needless to say, very busy. However, in the near future the results will be available.

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CONTRIBUTED
ORIGINAL ARTICLE

HIGHLY BIOCIDAL TRANSPARENT VACUUM DEPOSITED COATINGS FOR TOUCH SURFACES TO HELP IN THE FIGHT AGAINST COVID 19 AND HEALTHCARE ASSOCIATED INFECTIONS (HCAI)

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