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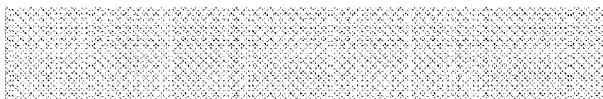


FIG. 1

(57) Abstract: The present disclosure relates to an antimicrobial thin film layer that may include a metallic material. The antimicrobial thin film layer may have a VLT of at least about 60%. The antimicrobial thin film layer may further have a MRSA anti-microbial rating of at least about 75%, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant Staphylococcus aureus (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.



THIN FILM LAYERS AND COMPOSITE STRUCTURES FOR VIRUS CONTROL

TECHNICAL FIELD

The present disclosure relates to thin film layers having antimicrobial properties and composite structures that include such thin film layer having antimicrobial properties.

BACKGROUND ART

Various microorganisms can cause sicknesses and the spread of these sicknesses often occurs due to the microorganisms' ability to survive on a surface for extended periods of time. Accordingly, thin film layers that can be applied to surfaces, in particular, surfaces located in medical buildings or on medical equipment, and which have anti-microbial properties would be desirable.

SUMMARY

According to a first aspect, an antimicrobial thin film layer may include a metallic material. The antimicrobial thin film layer may have a VLT of at least about 60%. The antimicrobial thin film layer may further have a MRSA anti-microbial rating of at least about 75%, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant *Staphylococcus aureus* (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

According to another aspect, a composite structure may include a substrate and an antimicrobial thin film layer overlying a surface of the substrate. The antimicrobial thin film layer may further have a MRSA anti-microbial rating of at least about 75%, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant *Staphylococcus aureus* (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

According to yet another aspect, a face shield may include a substrate and an antimicrobial thin film layer overlying a surface of the substrate. The antimicrobial thin film layer may further have a MRSA anti-microbial rating of at least about 75%, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant *Staphylococcus aureus* (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

According to still another aspect, an antimicrobial thin film layer may include a metallic material. The antimicrobial thin film layer may have a VLT of at least about 60%. The antimicrobial thin film layer may further have an *E. coli* anti-microbial rating of at least about 75%, where the *E. coli* anti-microbial rating is defined as the percent reduction of

Escherichia coli (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

According to another aspect, a composite structure may include a substrate and an antimicrobial thin film layer overlying a surface of the substrate. The antimicrobial thin film layer may further have an *E. coli* anti-microbial rating of at least about 75%, where the *E. coli* anti-microbial rating is defined as the percent reduction of Escherichia coli (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

According to yet another aspect, a face shield may include a substrate and an antimicrobial thin film layer overlying a surface of the substrate. The antimicrobial thin film layer may further have an *E. coli* anti-microbial rating of at least about 75%, where the *E. coli* anti-microbial rating is defined as the percent reduction of Escherichia coli (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

According to another aspect, a method of forming an antimicrobial thin film layer may include depositing a metallic material on a surface to form the antimicrobial thin film layer. The antimicrobial thin film layer may include a metallic material. The antimicrobial thin film layer may have a VLT of at least about 60%. The antimicrobial thin film layer may further have a MRSA anti-microbial rating of at least about 75%, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant Staphylococcus aureus (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

According to another aspect, a method of forming a composite structure may include providing a substrate and depositing a metallic material on a surface of the substrate to form an antimicrobial thin film layer overlying the surface of the substrate. The antimicrobial thin film layer may further have a MRSA anti-microbial rating of at least about 75%, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant Staphylococcus aureus (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

According to another aspect, a method of forming a face shield may include providing a substrate and depositing a metallic material on a surface of the substrate to form an antimicrobial thin film layer overlying the surface of the substrate. The antimicrobial thin film layer may further have a MRSA anti-microbial rating of at least about 75%, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant

Staphylococcus aureus (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

According to another aspect, a method of forming an antimicrobial thin film layer may include depositing a metallic material on a surface to form the antimicrobial thin film layer. The antimicrobial thin film layer may include a metallic material. The antimicrobial thin film layer may have a VLT of at least about 60%. The antimicrobial thin film layer may further have an *E. coli* anti-microbial rating of at least about 75%, where the *E. coli* anti-microbial rating is defined as the percent reduction of Escherichia coli (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

According to another aspect, a method of forming a composite structure may include providing a substrate and depositing a metallic material on a surface of the substrate to form an antimicrobial thin film layer overlying the surface of the substrate. The antimicrobial thin film layer may further have an *E. coli* anti-microbial rating of at least about 75%, where the *E. coli* anti-microbial rating is defined as the percent reduction of Escherichia coli (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

According to another aspect, a method of forming a face shield may include providing a substrate and depositing a metallic material on a surface of the substrate to form an antimicrobial thin film layer overlying the surface of the substrate. The antimicrobial thin film layer may further have an *E. coli* anti-microbial rating of at least about 75%, where the *E. coli* anti-microbial rating is defined as the percent reduction of Escherichia coli (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments are illustrated by way of example and are not limited to the accompanying figures.

FIG. 1 includes an illustration showing a diagram of an antimicrobial thin film layer according to embodiments described herein;

FIG. 2 includes an illustration showing a diagram of a composite structure according to embodiments described herein;

FIG. 3 includes an illustration showing a diagram of a face shield according to embodiments described herein;

FIG. 4 includes a flow chart showing a method for forming an antimicrobial thin film layer according to embodiments described herein;

FIG. 5 includes a flow chart showing a method for forming a composite structure according to embodiments described herein; and

5 FIG. 6 includes a flow chart showing a method for forming a face shield according to embodiments described herein.

Skilled artisans appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

10 The following discussion will focus on specific implementations and embodiments of the teachings. The detailed description is provided to assist in describing certain embodiments and should not be interpreted as a limitation on the scope or applicability of the disclosure or teachings. It will be appreciated that other embodiments can be used based on the disclosure and teachings as provided herein.

15 The terms “comprises,” “comprising,” “includes,” “including,” “has,” “having” or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a method, article, or apparatus that comprises a list of features is not necessarily limited only to those features but may include other features not expressly listed or inherent to such method, article, or apparatus. Further, unless expressly stated to the contrary, “or” refers to an
20 inclusive-or and not to an exclusive-or. For example, a condition A or B is satisfied by any one of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

Also, the use of “a” or “an” is employed to describe elements and components described herein. This is done merely for convenience and to give a general sense of the
25 scope of the invention. This description should be read to include one, at least one, or the singular as also including the plural, or vice versa, unless it is clear that it is meant otherwise. For example, when a single item is described herein, more than one item may be used in place of a single item. Similarly, where more than one item is described herein, a single item may be substituted for that more than one item.

30 Embodiments described herein are generally directed to an antimicrobial thin film layer. According to particular embodiments, the antimicrobial thin film layer may include a metallic material and may have a VLT of at least about 60%.

For purposes of illustration, FIG. 1 shows an antimicrobial thin film layer 100 according to embodiments described herein.

According to certain embodiments, the antimicrobial thin film layer 100 may have a particular VLT as measured according to ASTM D1003. For example, the antimicrobial thin film layer 100 may have a VLT of at least about 60%, such as, at least about 65% or at least about 70% or at least about 75% or at least about 80% or at least about 85% or at least about 90% or even at least about 95%. It will be appreciated that the VLT of the antimicrobial thin film layer 100 may be within a range between any of the values noted above. It will be further appreciated that the VLT of the antimicrobial thin film layer 100 may be any value between any of the values noted above.

According to still other embodiments, the antimicrobial thin film layer 100 may have a particular MRSA anti-microbial rating, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant *Staphylococcus aureus* (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196. For example, the antimicrobial thin film layer 100 may have an MRSA antimicrobial rating of at least about 75%, such as, at least about 77% or at least about 79% or at least about 81% or at least about 83% or at least about 85% or at least about 87% or at least about 89% or at least about 91% or at least about 93% or at least about 95% or at least about 97%. It will be appreciated that the MRSA antimicrobial rating of the antimicrobial thin film layer 100 may be within a range between any of the values noted above. It will be further appreciated that the MRSA antimicrobial rating of the antimicrobial thin film layer 100 may be any value between any of the values noted above.

According to yet other embodiments, the antimicrobial thin film layer 100 may have an *E. coli* anti-microbial rating, where the *E. coli* anti-microbial rating is defined as the percent reduction of *Escherichia coli* (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196. For example, the antimicrobial thin film layer 100 may have an *E. coli* antimicrobial rating of at least about 75%, such as, at least about 77% or at least about 79% or at least about 81% or at least about 83% or at least about 85% or at least about 87% or at least about 89% or at least about 91% or at least about 93% or at least about 95% or at least about 97%. It will be appreciated that the *E. coli* antimicrobial rating of the antimicrobial thin film layer 100 may be within a range between any of the values noted above. It will be further appreciated that the *E. coli* antimicrobial rating of the antimicrobial thin film layer 100 may be any value between any of the values noted above.

According to yet other embodiments, the antimicrobial thin film layer 100 may have a particular average thickness. For example, the antimicrobial thin film layer 100 may have an

average thickness of not greater than about 15 nm, such as, not greater than about 14 nm or not greater than about 13 nm or not greater than about 12 nm or not greater than about 11 nm or not greater than about 10 nm or not greater than about 9 nm or not greater than about 8 nm or not greater than about 7 nm or not greater than about 6 nm or even not greater than about 5 nm. According to yet other embodiments, the antimicrobial thin film layer 100 may have an average thickness of at least about 0.1 nm or at least about 0.2 nm or at least about 0.3 nm or at least about 0.4 nm or at least about 0.5 nm or at least about 0.6 nm or at least about 0.7 nm or at least about 0.8 nm or at least about 0.9 nm or at least about 1 nm or at least about 2 nm or at least about 3 nm or even at least about 4 nm. It will be appreciated that the average thickness of the antimicrobial thin film layer 100 may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the average thickness of the antimicrobial thin film layer 100 may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the metallic material of the antimicrobial thin film layer 100 may include copper, silver, gold, platinum, nickel, zinc, iron, chrome, any combination thereof, any alloy thereof, any oxide thereof, or any metal oxide thereof.

According to still other embodiments, the metallic material of the antimicrobial thin film layer 100 may consist essentially of copper, silver, gold, platinum, nickel, zinc, iron, chrome, any combination thereof, any alloy thereof, any oxide thereof, or any metal oxide thereof.

According to still other embodiments, the antimicrobial thin film layer 100 may be a copper layer, a silver layer, a gold layer, an iron layer, a chrome layer, a platinum layer, any combination thereof, any alloy thereof, any oxide layer thereof, or any metal oxide layer thereof.

According to yet other embodiments, the antimicrobial thin film layer 100 may be a sputtered metallic layer.

According to yet other embodiments, the antimicrobial thin film layer 100 may be a continuous metallic layer. According to still other embodiments, the antimicrobial thin film layer 100 may be a non-continuous metallic layer.

According to still other embodiments, the antimicrobial thin film layer 100 may include multiple metallic layers. For example, the antimicrobial thin film layer 100 may include at least about 2 metallic layers, such as, at least about 3 metallic layers or at least about 4 metallic layers or at least about 5 metallic layers or at least about 6 metallic layers or at least about 7 metallic layers or at least about 8 metallic layers or at least about 9 metallic layers or even at least about 10 metallic layers. It will be appreciated that any of the multiple

metallic layers may have any of the characteristics described herein with regarding to a metallic layer.

Turning to an alternative embodiment, a composite structure may include a substrate, and an antimicrobial thin film layer overlying a surface of the substrate. According to particular embodiments, the antimicrobial thin film layer may include a metallic material and may have a VLT of at least about 60%.

For purposes of illustration, FIG. 2 shows a composite structure 200. According to certain embodiments, the composite structure 200 may include a substrate 210 and an antimicrobial thin film layer 220 overlying a surface of the substrate 210.

According to certain embodiments, the antimicrobial thin film layer 220 may have a particular VLT as measured according to ASTM D1003. For example, the antimicrobial thin film layer 220 may have a VLT of at least about 60%, such as, at least about 65% or at least about 70% or at least about 75% or at least about 80% or at least about 85% or at least about 90% or even at least about 95%. It will be appreciated that the VLT of the antimicrobial thin film layer 220 may be within a range between any of the values noted above. It will be further appreciated that the VLT of the antimicrobial thin film layer 220 may be any value between any of the values noted above.

According to still other embodiments, the antimicrobial thin film layer 220 may have a particular MRSA anti-microbial rating, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant *Staphylococcus aureus* (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196. For example, the antimicrobial thin film layer 220 may have an MRSA antimicrobial rating of at least about 75%, such as, at least about 77% or at least about 79% or at least about 81% or at least about 83% or at least about 85% or at least about 87% or at least about 89% or at least about 91% or at least about 93% or at least about 95% or at least about 97%. It will be appreciated that the MRSA antimicrobial rating of the antimicrobial thin film layer 220 may be within a range between any of the values noted above. It will be further appreciated that the MRSA antimicrobial rating of the antimicrobial thin film layer 220 may be any value between any of the values noted above.

According to yet other embodiments, the antimicrobial thin film layer 220 may have an *E. coli* anti-microbial rating, where the *E. coli* anti-microbial rating is defined as the percent reduction of *Escherichia coli* (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196. For example, the antimicrobial thin film layer 220 may have an *E. coli* antimicrobial rating of at

least about 75%, such as, at least about 77% or at least about 79% or at least about 81% or at least about 83% or at least about 85% or at least about 87% or at least about 89% or at least about 91% or at least about 93% or at least about 95% or at least about 97%. It will be appreciated that the *E. coli* antimicrobial rating of the antimicrobial thin film layer 220 may be within a range between any of the values noted above. It will be further appreciated that the *E. coli* antimicrobial rating of the antimicrobial thin film layer 220 may be any value between any of the values noted above.

According to yet other embodiments, the antimicrobial thin film layer 220 may have a particular average thickness. For example, the antimicrobial thin film layer 220 may have an average thickness of not greater than about 15 nm, such as, not greater than about 14 nm or not greater than about 13 nm or not greater than about 12 nm or not greater than about 11 nm or not greater than about 10 nm or not greater than about 9 nm or not greater than about 8 nm or not greater than about 7 nm or not greater than about 6 nm or even not greater than about 5 nm. According to yet other embodiments, the antimicrobial thin film layer 220 may have an average thickness of at least about 0.1 nm or at least about 0.2 nm or at least about 0.3 nm or at least about 0.4 nm or at least about 0.5 nm or at least about 0.6 nm or at least about 0.7 nm or at least about 0.8 nm or at least about 0.9 nm or at least about 1 nm or at least about 2 nm or at least about 3 nm or even at least about 4 nm. It will be appreciated that the average thickness of the antimicrobial thin film layer 220 may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the average thickness of the antimicrobial thin film layer 220 may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the metallic material of the antimicrobial thin film layer 220 may include copper, silver, gold, platinum, nickel, zinc, iron, chrome, any combination thereof, any alloy thereof, any oxide thereof, or any metal oxide thereof.

According to still other embodiments, the metallic material of the antimicrobial thin film layer 220 may consist essentially of copper, silver, gold, platinum, nickel, zinc, iron, chrome, any combination thereof, any alloy thereof, any oxide thereof, or any metal oxide thereof.

According to still other embodiments, the antimicrobial thin film layer 220 may be a copper layer, a silver layer, a gold layer, an iron layer, a chrome layer, a platinum layer, any combination thereof, any alloy thereof, any oxide layer thereof, or any metal oxide layer thereof.

According to yet other embodiments, the antimicrobial thin film layer 220 may be a sputtered metallic layer.

According to yet other embodiments, the antimicrobial thin film layer 220 may be a continuous metallic layer. According to still other embodiments, the antimicrobial thin film layer 220 may be a non-continuous metallic layer.

According to still other embodiments, the antimicrobial thin film layer 220 may include multiple metallic layers. For example, the antimicrobial thin film layer 220 may include at least about 2 metallic layers, such as, at least about 3 metallic layers or at least about 4 metallic layers or at least about 5 metallic layers or at least about 6 metallic layers or at least about 7 metallic layers or at least about 8 metallic layers or at least about 9 metallic layers or even at least about 10 metallic layers. It will be appreciated that any of the multiple metallic layers may have any of the characteristics described herein with regarding to a metallic layer.

According to certain embodiments, the substrate 210 may have a particular VLT as measured according to ASTM D1003. For example, the substrate 210 may have a VLT of at least about 60%, such as, at least about 65% or at least about 70% or at least about 75% or at least about 80% or at least about 85% or at least about 90% or even at least about 95%. It will be appreciated that the VLT of the substrate 210 may be within a range between any of the values noted above. It will be further appreciated that the VLT of the substrate 210 may be any value between any of the values noted above.

According to yet other embodiments, the substrate 210 may include a particular material. For example, the substrate 210 may include a polyethylene terephthalate (PET) material, a polycarbonate material, an acrylic material, a plastic material, or a glass material. According to still other embodiments, the substrate 210 may consist of a polyethylene terephthalate (PET) material, a polycarbonate material, an acrylic material, a plastic material, or a glass material.

According to still other embodiments, the substrate 210 may have a particular average thickness. For example, the substrate 210 may have an average thickness of not greater than about 1.0 mm, such as, not greater than about 0.9 mm or not greater than about 0.8 mm or not greater than about 0.7 mm or not greater than about 0.6 mm or even not greater than about 0.5 mm. According to yet other embodiments, the substrate 220 may have an average thickness of at least about 0.001 mm or at least about 0.005 mm or at least about 0.01 mm or at least about 0.05 mm or at least about 0.1 mm or at least about 0.2 mm or at least about 0.3 mm or at least about 0.4 mm. It will be appreciated that the substrate 210 may be within a range between any of the minimum and maximum values noted above. It will be further

appreciated that the average thickness of the substrate 210 may be any value between any of the minimum and maximum values noted above.

According to certain embodiments, the composite structure 200 may have a particular VLT as measured according to ASTM D1003. For example, the composite structure 200 may have a VLT of at least about 60%, such as, at least about 65% or at least about 70% or at least about 75% or at least about 80% or at least about 85% or at least about 90% or even at least about 95%. It will be appreciated that the VLT of the composite structure 200 may be within a range between any of the values noted above. It will be further appreciated that the VLT of the composite structure 200 may be any value between any of the values noted above.

According to still other embodiments, the composite structure 200 may have a particular average thickness. For example, the composite structure 200 may have an average thickness of not greater than about 1.0 mm, such as, not greater than about 0.9 mm or not greater than about 0.8 mm or not greater than about 0.7 mm or not greater than about 0.6 mm or even not greater than about 0.5 mm. According to yet other embodiments, the composite structure 200 may have an average thickness of at least about 0.001 mm or at least about 0.005 mm or at least about 0.01 mm or at least about 0.05 mm or at least about 0.1 mm or at least about 0.2 mm or at least about 0.3 mm or at least about 0.4 mm. It will be appreciated that the average thickness of the composite structure 200 may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the average thickness of the composite structure 200 may be any value between any of the minimum and maximum values noted above.

Turning to yet another alternative embodiment, a face shield may include a substrate, and an antimicrobial thin film layer overlying a surface of the substrate. According to particular embodiments, the antimicrobial thin film layer may include a metallic material and may have a VLT of at least about 60%.

For purposes of illustration, FIG. 3 shows a face shield 300. According to certain embodiments, the face shield 300 may include a substrate (not shown) and an antimicrobial thin film layer 320 overlying a surface of the substrate.

According to certain embodiments, the antimicrobial thin film layer 320 may have a particular VLT as measured according to ASTM D1003. For example, the antimicrobial thin film layer 320 may have a VLT of at least about 60%, such as, at least about 65% or at least about 70% or at least about 75% or at least about 80% or at least about 85% or at least about 90% or even at least about 95%. It will be appreciated that the VLT of the antimicrobial thin

film layer 320 may be within a range between any of the values noted above. It will be further appreciated that the VLT of the antimicrobial thin film layer 320 may be any value between any of the values noted above.

According to still other embodiments, the antimicrobial thin film layer 320 may have a particular MRSA anti-microbial rating, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant *Staphylococcus aureus* (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196. For example, the antimicrobial thin film layer 320 may have an MRSA antimicrobial rating of at least about 75%, such as, at least about 77% or at least about 79% or at least about 81% or at least about 83% or at least about 85% or at least about 87% or at least about 89% or at least about 91% or at least about 93% or at least about 95% or at least about 97%. It will be appreciated that the MRSA antimicrobial rating of the antimicrobial thin film layer 320 may be within a range between any of the values noted above. It will be further appreciated that the MRSA antimicrobial rating of the antimicrobial thin film layer 320 may be any value between any of the values noted above.

According to yet other embodiments, the antimicrobial thin film layer 320 may have an *E. coli* anti-microbial rating, where the *E. coli* anti-microbial rating is defined as the percent reduction of *Escherichia coli* (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196. For example, the antimicrobial thin film layer 320 may have an *E. coli* antimicrobial rating of at least about 75%, such as, at least about 77% or at least about 79% or at least about 81% or at least about 83% or at least about 85% or at least about 87% or at least about 89% or at least about 91% or at least about 93% or at least about 95% or at least about 97%. It will be appreciated that the *E. coli* antimicrobial rating of the antimicrobial thin film layer 320 may be within a range between any of the values noted above. It will be further appreciated that the *E. coli* antimicrobial rating of the antimicrobial thin film layer 320 may be any value between any of the values noted above.

According to yet other embodiments, the antimicrobial thin film layer 320 may have a particular average thickness. For example, the antimicrobial thin film layer 320 may have an average thickness of not greater than about 15 nm, such as, not greater than about 14 nm or not greater than about 13 nm or not greater than about 12 nm or not greater than about 11 nm or not greater than about 10 nm or not greater than about 9 nm or not greater than about 8 nm or not greater than about 7 nm or not greater than about 6 nm or even not greater than about 5 nm. According to yet other embodiments, the antimicrobial thin film layer 320 may have an

average thickness of at least about 0.1 nm or at least about 0.2 nm or at least about 0.3 nm or at least about 0.4 nm or at least about 0.5 nm or at least about 0.6 nm or at least about 0.7 nm or at least about 0.8 nm or at least about 0.9 nm or at least about 1 nm or at least about 2 nm or at least about 3 nm or even at least about 4 nm. It will be appreciated that the average thickness of the antimicrobial thin film layer 320 may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the average thickness of the antimicrobial thin film layer 320 may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the metallic material of the antimicrobial thin film layer 320 may include copper, silver, gold, platinum, nickel, zinc, iron, chrome, any combination thereof, any alloy thereof, any oxide thereof, or any metal oxide thereof.

According to still other embodiments, the metallic material of the antimicrobial thin film layer 320 may consist essentially of copper, silver, gold, platinum, nickel, zinc, iron, chrome, any combination thereof, any alloy thereof, any oxide thereof, or any metal oxide thereof.

According to still other embodiments, the antimicrobial thin film layer 320 may be a copper layer, a silver layer, a gold layer, an iron layer, a chrome layer, a platinum layer, any combination thereof, any alloy thereof, any oxide layer thereof, or any metal oxide layer thereof.

According to yet other embodiments, the antimicrobial thin film layer 320 may be a sputtered metallic layer.

According to yet other embodiments, the antimicrobial thin film layer 320 may be a continuous metallic layer. According to still other embodiments, the antimicrobial thin film layer 320 may be a non-continuous metallic layer.

According to still other embodiments, the antimicrobial thin film layer 320 may include multiple metallic layers. For example, the antimicrobial thin film layer 320 may include at least about 2 metallic layers, such as, at least about 3 metallic layers or at least about 4 metallic layers or at least about 5 metallic layers or at least about 6 metallic layers or at least about 7 metallic layers or at least about 8 metallic layers or at least about 9 metallic layers or even at least about 10 metallic layers. It will be appreciated that any of the multiple metallic layers may have any of the characteristics described herein with regarding to a metallic layer.

According to certain embodiments, the substrate may have a particular VLT as measured according to ASTM D1003. For example, the substrate may have a VLT of at least about 60%, such as, at least about 65% or at least about 70% or at least about 75% or at least

about 80% or at least about 85% or at least about 90% or even at least about 95%. It will be appreciated that the VLT of the substrate may be within a range between any of the values noted above. It will be further appreciated that the VLT of the substrate may be any value between any of the values noted above.

5 According to yet other embodiments, the substrate may include a particular material. For example, the substrate may include a polyethylene terephthalate (PET) material, a polycarbonate material, an acrylic material, a plastic material, or a glass material. According to still other embodiments, the substrate may consist of a polyethylene terephthalate (PET) material, a polycarbonate material, an acrylic material, a plastic material, or a glass material.

10 According to still other embodiments, the substrate may have a particular average thickness. For example, the substrate may have an average thickness of not greater than about 1.0 mm, such as, not greater than about 0.9 mm or not greater than about 0.8 mm or not greater than about 0.7 mm or not greater than about 0.6 mm or even not greater than about 0.5 mm. According to yet other embodiments, the substrate may have an average thickness
15 of at least about 0.001 mm or at least about 0.005 mm or at least about 0.01 mm or at least about 0.05 mm or at least about 0.1mm or at least about 0.2 mm or at least about 0.3 mm or at least about 0.4 mm. It will be appreciated that the substrate may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the average thickness of the substrate may be any value between any of the minimum and
20 maximum values noted above.

 According to certain embodiments, the face shield 300 may have a particular VLT as measured according to ASTM D1003. For example, the face shield 300 may have a VLT of at least about 60%, such as, at least about 65% or at least about 70% or at least about 75% or at least about 80% or at least about 85% or at least about 90% or even at least about 95%. It
25 will be appreciated that the VLT of the face shield 300 may be within a range between any of the values noted above. It will be further appreciated that the VLT of the face shield 300 may be any value between any of the values noted above.

 According to still other embodiments, the face shield 300 may have a particular average thickness. For example, the face shield 300 may have an average thickness of not
30 greater than about 1.0 mm, such as, not greater than about 0.9 mm or not greater than about 0.8 mm or not greater than about 0.7 mm or not greater than about 0.6 mm or even not greater than about 0.5 mm. According to yet other embodiments, the face shield 300 may have an average thickness of at least about 0.001 mm or at least about 0.005 mm or at least about 0.01 mm or at least about 0.05 mm or at least about 0.1mm or at least about 0.2 mm or at least

about 0.3 mm or at least about 0.4 mm. It will be appreciated that the average thickness of the face shield 300 may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the average thickness of the face shield 300 may be any value between any of the minimum and maximum values noted above.

5 It will be appreciated that and embodiments described herein with regard to an antimicrobial thin film layer, a composite structure or a face shield may include additional layers. For example, an antimicrobial thin film layer, a composite structure or a face shield may include an adhesive layer. According to still other embodiments, an antimicrobial thin film layer, a composite structure or a face shield may include a liner.

10 Turning to still another alternative embodiment, a method of forming a composite structure may include depositing a metallic material on a surface to form the antimicrobial thin film layer.

For purposes of illustration, FIG. 4 includes a flow chart showing a method 400 for forming an antimicrobial thin film layer. According to certain embodiments, the method 400
15 may include a first step 410 of depositing a metallic material on a surface to form an antimicrobial thin film layer.

It will be appreciated that the antimicrobial thin film layer formed according to method 400 may include any of the characteristics or properties of the any embodiment of an antimicrobial thin film layer described herein.

20 According to certain embodiments, the first step 410 of depositing the metallic material on the surface to form an antimicrobial thin film layer may include any know deposition method that can form the metallic layer as described herein. According to certain embodiments, depositing the metallic material may include a chemical deposition technique, a physical deposition technique, a sputtering deposition technique, an evaporation deposition
25 technique, or a SolGel deposition technique.

Turning to yet another alternative embodiment, a method of forming a composite structure may include providing a substrate and depositing a metallic material on a surface of the substrate to form an antimicrobial thin film layer overlying the surface of the substrate.

For purposes of illustration, FIG. 5 includes a flow chart showing a method 500 for
30 forming a composite structure. According to certain embodiments, the method 500 may include a first step 510 of providing a substrate, and a second step 520 of depositing a metallic material on a surface of the substrate to form an antimicrobial thin film layer overlying the surface of the substrate.

It will be appreciated that the substrate, antimicrobial thin film layer and composite structure formed according to method 500 may include any of the characteristics or properties of the any embodiment of an antimicrobial thin film layer described herein.

According to certain embodiments, the second step 520 of depositing the metallic material on the surface of the substrate may include any know deposition method that can form the metallic layer as described herein. According to certain embodiments, depositing the metallic material may include a chemical deposition technique, a physical deposition technique, a sputtering deposition technique, an evaporation deposition technique, or a SolGel deposition technique.

Turning to another alternative embodiment, a method of forming a face shield may include providing a substrate and depositing a metallic material on a surface of the substrate to form an antimicrobial thin film layer overlying the surface of the substrate.

For purposes of illustration, FIG. 6 includes a flow chart showing a method 600 for forming a composite structure. According to certain embodiments, the method 600 may include a first step 610 of providing a substrate, and a second step 620 of depositing a metallic material on a surface of the substrate to form an antimicrobial thin film layer overlying the surface of the substrate.

It will be appreciated that the substrate, antimicrobial thin film layer and face shield formed according to method 600 may include any of the characteristics or properties of the any embodiment of an antimicrobial thin film layer described herein.

According to certain embodiments, the second step 620 of depositing the metallic material on the surface of the substrate may include any know deposition method that can form the metallic layer as described herein. According to certain embodiments, depositing the metallic material may include a chemical deposition technique, a physical deposition technique, a sputtering deposition technique, an evaporation deposition technique, or a SolGel deposition technique.

Many different aspects and embodiments are possible. Some of those aspects and embodiments are described herein. After reading this specification, skilled artisans will appreciate that those aspects and embodiments are only illustrative and do not limit the scope of the present invention. Embodiments may be in accordance with any one or more of the embodiments as listed below.

Embodiment 1. An antimicrobial thin film layer comprising a metallic material, wherein the antimicrobial thin film layer has a VLT of at least about 60%, and wherein the antimicrobial thin film layer has a MRSA anti-microbial rating of at least about 75%, where

the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant *Staphylococcus aureus* (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

Embodiment 2. An antimicrobial thin film layer comprising a metallic material, wherein the antimicrobial thin film layer has a VLT of at least about 60%, and wherein the antimicrobial thin film layer has an *E. coli* anti-microbial rating of at least about 75%, where the *E. coli* anti-microbial rating is defined as the percent reduction of *Escherichia coli* (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

Embodiment 3. A composite structure comprising: a substrate, and an antimicrobial thin film layer overlying a surface of the substrate, wherein the antimicrobial thin film layer comprises a metallic material, wherein the composite structure has a VLT of at least about 60%, and wherein the antimicrobial thin film layer has a MRSA anti-microbial rating of at least about 75%, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant *Staphylococcus aureus* (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

Embodiment 4. A composite structure comprising: a substrate, and an antimicrobial thin film layer overlying a surface of the substrate, wherein the antimicrobial thin film layer comprises a metallic material, wherein the composite structure has a VLT of at least about 60%, and wherein the antimicrobial thin film layer has an *E. coli* anti-microbial rating of at least about 75%, where the *E. coli* anti-microbial rating is defined as the percent reduction of *Escherichia coli* (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

Embodiment 5. A face shield comprising: a substrate, and an antimicrobial thin film layer overlying a surface of the substrate, wherein the antimicrobial thin film layer comprises a metallic material, wherein the composite structure has a VLT of at least about 60%, and wherein the antimicrobial thin film layer has a MRSA anti-microbial rating of at least about 75%, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant *Staphylococcus aureus* (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

Embodiment 6. A face shield comprising: a substrate, and an antimicrobial thin film layer overlying a surface of the substrate, wherein the antimicrobial thin film layer comprises a metallic material, wherein the composite structure has a VLT of at least about 60%, and wherein the antimicrobial thin film layer has an *E. coli* anti-microbial rating of at least about

75%, where the *E. coli* anti-microbial rating is defined as the percent reduction of Escherichia coli (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

5 Embodiment 7. The antimicrobial thin film layer, composite structure or face shield of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the antimicrobial thin film layer has a MRSA anti-microbial rating of at least about 75%, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant Staphylococcus aureus (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196 or at least about 77% or at least about 79% or at least about 81% or at least about 83% or at least about 85% or at least about 87% or at least about 89% or at least about 91% or at least about 93% or at least about 95% or at least about 97%.

15 Embodiment 8. The antimicrobial thin film layer, composite structure or face shield of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the antimicrobial thin film layer has an *E. coli* anti-microbial rating of at least about 75%, where the *E. coli* anti-microbial rating is defined as the percent reduction of Escherichia coli (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196 or at least about 77% or at least about 79% or at least about 81% or at least about 83% or at least about 85% or at least about 87% or at least about 89% or at least about 91% or at least about 93% or at least about 95% or at least about 97%.

20 Embodiment 9. The antimicrobial thin film layer, composite structure or face shield of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the antimicrobial thin film layer has a VLT of at least about 60% or at least about 65% or at least about 70% or at least about 75% or at least about 80% or at least about 85% or at least about 90% or at least about 95%.

25 Embodiment 10. The antimicrobial thin film layer, composite structure or face shield of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the composite structure has a VLT of at least about 60% or at least about 65% or at least about 70% or at least about 75% or at least about 80% or at least about 85% or at least about 90% or at least about 95%.

30 Embodiment 11. The antimicrobial thin film layer, composite structure or face shield of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the face shield has a VLT of at least about 60% or at least about 65% or at least about 70% or at least about 75% or at least about 80% or at least about 85% or at least about 90% or at least about 95%.

Embodiment 12. The antimicrobial thin film layer, composite structure or face shield of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the antimicrobial thin film layer has an average thickness of not greater than about 15 nm or not greater than about 14 nm or not

greater than about 13 nm or not greater than about 12 nm or not greater than about 11 nm or not greater than about 10 nm or not greater than about 9 nm or not greater than about 8 nm or not greater than about 7 nm or not greater than about 6 nm or not greater than about 5 nm.

Embodiment 13. The antimicrobial thin film layer, composite structure or face shield
5 of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the antimicrobial thin film layer has an average thickness of at least about 0.1 nm.

Embodiment 14. The antimicrobial thin film layer, composite structure or face shield
of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the metallic material comprises
copper, silver, gold, platinum, nickel, zinc, iron, chrome, any combination thereof, any alloy
10 thereof, any oxide thereof, or any metal oxide thereof.

Embodiment 15. The antimicrobial thin film layer, composite structure or face shield
of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the antimicrobial thin film layer is a
copper layer, a silver layer, a gold layer, an iron layer, a chrome layer, a platinum layer, any
combination thereof, any alloy thereof, any oxide layer thereof, or any metal oxide layer
15 thereof.

Embodiment 16. The antimicrobial thin film layer, composite structure or face shield
of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the antimicrobial thin film layer is a
sputtered metallic layer.

Embodiment 17. The antimicrobial thin film layer, composite structure or face shield
20 of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the antimicrobial thin film layer is a
continuous metallic layer.

Embodiment 18. The antimicrobial thin film layer, composite structure or face shield
of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the substrate comprises a
polyethylene terephthalate (PET) material, a polycarbonate material, an acrylic material, a
25 plastic material, a glass material.

Embodiment 19. The antimicrobial thin film layer, composite structure or face shield
of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the substrate comprises an average
thickness of not greater than about 1.0 mm or not greater than about 0.9 mm or not greater
than about 0.8 mm or not greater than about 0.7 mm or not greater than about 0.6 mm or not
30 greater than about 0.5 mm.

Embodiment 20. The antimicrobial thin film layer, composite structure or face shield
of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the substrate comprises an average
thickness of at least about 0.001 mm or at least about 0.005 mm or at least about 0.01 mm or

at least about 0.05 mm or at least about 0.1mm or at least about 0.2 mm or at least about 0.3 mm or at least about 0.4 mm.

Embodiment 21. The antimicrobial thin film layer, composite structure or face shield of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the composite structure comprises an average thickness of not greater than about 1.0 mm or not greater than about 0.9 mm or not greater than about 0.8 mm or not greater than about 0.7 mm or not greater than about 0.6 mm or not greater than about 0.5 mm.

Embodiment 22. The antimicrobial thin film layer, composite structure or face shield of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the composite structure comprises an average thickness of at least about 0.001 mm or at least about 0.005 mm or at least about 0.01 mm or at least about 0.05 mm or at least about 0.1mm or at least about 0.2 mm or at least about 0.3 mm or at least about 0.4 mm.

Embodiment 23. The antimicrobial thin film layer, composite structure or face shield of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the face shield comprises an average thickness of not greater than about 1.0 mm or not greater than about 0.9 mm or not greater than about 0.8 mm or not greater than about 0.7 mm or not greater than about 0.6 mm or not greater than about 0.5 mm.

Embodiment 24. The antimicrobial thin film layer, composite structure or face shield of any one of embodiments 1, 2, 3, 4, 5, and 6, wherein the face shield comprises an average thickness of at least about 0.001 mm or at least about 0.005 mm or at least about 0.01 mm or at least about 0.05 mm or at least about 0.1mm or at least about 0.2 mm or at least about 0.3 mm or at least about 0.4 mm.

Embodiment 25. A method of forming an antimicrobial thin film layer, wherein the method comprises depositing a metallic material on a surface to form the antimicrobial thin film layer, wherein the antimicrobial thin film layer has a VLT of at least about 60%, and wherein the antimicrobial thin film layer has a MRSA anti-microbial rating of at least about 75%, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant *Staphylococcus aureus* (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

Embodiment 26. A method of forming an antimicrobial thin film layer, wherein the method comprises depositing a metallic material on a surface to form the antimicrobial thin film layer, wherein the antimicrobial thin film layer has a VLT of at least about 60%, and wherein the antimicrobial thin film layer has an *E. coli* anti-microbial rating of at least about 75%, where the *E. coli* anti-microbial rating is defined as the percent reduction of *Escherichia*

coli (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

Embodiment 27. A method of forming a composite structure, wherein the method comprises: providing a substrate, and depositing a metallic material on a surface of the substrate to form an antimicrobial thin film layer overlying the surface of the substrate, wherein the antimicrobial thin film layer comprises a metallic material, wherein the composite structure has a VLT of at least about 60%, and wherein the antimicrobial thin film layer has a MRSA anti-microbial rating of at least about 75%, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant *Staphylococcus aureus* (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

Embodiment 28. A method of forming a composite structure, wherein the method comprises: providing a substrate, and depositing a metallic material on a surface of the substrate to form an antimicrobial thin film layer overlying the surface of the substrate, wherein the antimicrobial thin film layer comprises a metallic material, wherein the composite structure has a VLT of at least about 60%, and wherein the antimicrobial thin film layer has an *E. coli* anti-microbial rating of at least about 75%, where the *E. coli* anti-microbial rating is defined as the percent reduction of *Escherichia coli* (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

Embodiment 29. A method of forming a face shield, wherein the method comprises: providing a substrate, and depositing a metallic material on a surface of the substrate to form an antimicrobial thin film layer overlying the surface of the substrate, wherein the antimicrobial thin film layer comprises a metallic material, wherein the composite structure has a VLT of at least about 60%, and wherein the antimicrobial thin film layer has a MRSA anti-microbial rating of at least about 75%, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant *Staphylococcus aureus* (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

Embodiment 30. A method of forming a face shield, wherein the method comprises: providing a substrate, and depositing a metallic material on a surface of the substrate to form an antimicrobial thin film layer overlying the surface of the substrate, wherein the antimicrobial thin film layer comprises a metallic material, wherein the composite structure has a VLT of at least about 60%, and wherein the antimicrobial thin film layer has an *E. coli*

anti-microbial rating of at least about 75%, where the *E. coli* anti-microbial rating is defined as the percent reduction of Escherichia coli (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

Embodiment 31. The method of any one of embodiments 25, 26, 27, 28, 29, and 30, wherein the antimicrobial thin film layer has a MRSA anti-microbial rating of at least about 75%, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant Staphylococcus aureus (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196 or at least about 77% or at least about 79% or at least about 81% or at least about 83% or at least about 85% or at least about 87% or at least about 89% or at least about 91% or at least about 93% or at least about 95% or at least about 97%.

Embodiment 32. The method of any one of embodiments 25, 26, 27, 28, 29, and 30, wherein the antimicrobial thin film layer has an *E. coli* anti-microbial rating of at least about 75%, where the *E. coli* anti-microbial rating is defined as the percent reduction of Escherichia coli (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196 or at least about 77% or at least about 79% or at least about 81% or at least about 83% or at least about 85% or at least about 87% or at least about 89% or at least about 91% or at least about 93% or at least about 95% or at least about 97%.

Embodiment 33. The method of any one of embodiments 25, 26, 27, 28, 29, and 30, wherein depositing the metallic material comprises a chemical deposition technique, a physical deposition technique, a sputtering deposition technique, an evaporation deposition technique, or a SolGel deposition technique.

Embodiment 34. The method of any one of embodiments 25, 26, 27, 28, 29, and 30, wherein the antimicrobial thin film layer has a VLT of at least about 60% or at least about 65% or at least about 70% or at least about 75% or at least about 80% or at least about 85% or at least about 90% or at least about 95%.

Embodiment 35. The method of any one of embodiments 25, 26, 27, 28, 29, and 30, wherein the composite structure has a VLT of at least about 60% or at least about 65% or at least about 70% or at least about 75% or at least about 80% or at least about 85% or at least about 90% or at least about 95%.

Embodiment 36. The method of any one of embodiments 25, 26, 27, 28, 29, and 30, wherein the face shield has a VLT of at least about 60% or at least about 65% or at least

about 70% or at least about 75% or at least about 80% or at least about 85% or at least about 90% or at least about 95%.

Embodiment 37. The method of any one of embodiments 25, 26, 27, 28, 29, and 30, wherein the antimicrobial thin film layer has an average thickness of not greater than about
5 15 nm or not greater than about 14 nm or not greater than about 13 nm or not greater than about 12 nm or not greater than about 11 nm or not greater than about 10 nm or not greater than about 9 nm or not greater than about 8 nm or not greater than about 7 nm or not greater than about 6 nm or not greater than about 5 nm.

Embodiment 38. The method of any one of embodiments 25, 26, 27, 28, 29, and 30,
10 wherein the antimicrobial thin film layer has an average thickness of at least about 0.1 nm.

Embodiment 39. The method of any one of embodiments 25, 26, 27, 28, 29, and 30, wherein the metallic material comprises copper, silver, gold, platinum, iron, chrome, any combination thereof, any alloy thereof, any oxide thereof or any metal oxide thereof.

Embodiment 40. The method of any one of embodiments 25, 26, 27, 28, 29, and 30,
15 wherein the antimicrobial thin film layer is a copper layer, a silver layer, a gold layer, an iron layer, a chrome layer, a platinum layer, any combination thereof, any alloy thereof, any oxide layer thereof, or any metal oxide layer thereof.

Embodiment 41. The method of any one of embodiments 25, 26, 27, 28, 29, and 30, wherein the antimicrobial thin film layer is a sputtered metallic layer.

Embodiment 42. The method of any one of embodiments 25, 26, 27, 28, 29, and 30,
20 wherein the antimicrobial thin film layer is a continuous metallic layer.

Embodiment 43. The method of any one of embodiments 25, 26, 27, 28, 29, and 30, wherein the substrate comprises a polyethylene terephthalate (PET) material, a polycarbonate material, an acrylic material, a plastic material, or a glass material.

Embodiment 44. The method of any one of embodiments 25, 26, 27, 28, 29, and 30, wherein the substrate comprises an average thickness of not greater than about 1.0 mm or not greater than about 0.9 mm or not greater than about 0.8 mm or not greater than about 0.7 mm or not greater than about 0.6 mm or not greater than about 0.5 mm.

Embodiment 45. The method of any one of embodiments 25, 26, 27, 28, 29, and 30,
30 wherein the substrate comprises an average thickness of at least about 0.001 mm or at least about 0.005 mm or at least about 0.01 mm or at least about 0.05 mm or at least about 0.1 mm or at least about 0.2 mm or at least about 0.3 mm or at least about 0.4 mm.

Embodiment 46. The method of any one of embodiments 25, 26, 27, 28, 29, and 30, wherein the composite structure comprises an average thickness of not greater than about 1.0

mm or not greater than about 0.9 mm or not greater than about 0.8 mm or not greater than about 0.7 mm or not greater than about 0.6 mm or not greater than about 0.5 mm.

Embodiment 47. The method of any one of embodiments 25, 26, 27, 28, 29, and 30, wherein the composite structure comprises an average thickness of at least about 0.001 mm or at least about 0.005 mm or at least about 0.01 mm or at least about 0.05 mm or at least about 0.1 mm or at least about 0.2 mm or at least about 0.3 mm or at least about 0.4 mm.

Embodiment 48. The method of any one of embodiments 25, 26, 27, 28, 29, and 30, wherein the face shield comprises an average thickness of not greater than about 1.0 mm or not greater than about 0.9 mm or not greater than about 0.8 mm or not greater than about 0.7 mm or not greater than about 0.6 mm or not greater than about 0.5 mm.

Embodiment 49. The method of any one of embodiments 25, 26, 27, 28, 29, and 30, wherein the face shield comprises an average thickness of at least about 0.001 mm or at least about 0.005 mm or at least about 0.01 mm or at least about 0.05 mm or at least about 0.1 mm or at least about 0.2 mm or at least about 0.3 mm or at least about 0.4 mm.

Note that not all of the activities described above in the general description or the examples are required, that a portion of a specific activity may not be required, and that one or more further activities may be performed in addition to those described. Still further, the order in which activities are listed is not necessarily the order in which they are performed.

Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments. However, the benefits, advantages, solutions to problems, and any feature(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature of any or all the claims.

The specification and illustrations of the embodiments described herein are intended to provide a general understanding of the structure of the various embodiments. The specification and illustrations are not intended to serve as an exhaustive and comprehensive description of all of the elements and features of apparatus and systems that use the structures or methods described herein. Separate embodiments may also be provided in combination in a single embodiment, and conversely, various features that are, for brevity, described in the context of a single embodiment, may also be provided separately or in any subcombination. Further, reference to values stated in ranges includes each and every value within that range. Many other embodiments may be apparent to skilled artisans only after reading this specification. Other embodiments may be used and derived from the disclosure, such that a structural substitution, logical substitution, or another change may be made without departing

from the scope of the disclosure. Accordingly, the disclosure is to be regarded as illustrative rather than restrictive.

WHAT IS CLAIMED IS:

1. An antimicrobial thin film layer comprising a metallic material,
wherein the antimicrobial thin film layer has a VLT of at least about 60%, and
wherein the antimicrobial thin film layer has a MRSA anti-microbial rating of at least about 75%, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant *Staphylococcus aureus* (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.
2. A composite structure comprising:
a substrate, and
an antimicrobial thin film layer overlying a surface of the substrate,
wherein the antimicrobial thin film layer comprises a metallic material,
wherein the composite structure has a VLT of at least about 60%, and
wherein the antimicrobial thin film layer has a MRSA anti-microbial rating of at least about 75%, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant *Staphylococcus aureus* (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.
3. The antimicrobial thin film layer, or composite structure of any one of claims 1, and 2, wherein the antimicrobial thin film layer has an *E. coli* anti-microbial rating of at least about 75%, where the *E. coli* anti-microbial rating is defined as the percent reduction of *Escherichia coli* (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.
4. The antimicrobial thin film layer, or composite structure of any one of claims 1, and 2, wherein the antimicrobial thin film layer has a VLT of at least about 60%.
5. The antimicrobial thin film layer, or composite structure of any one of claims 1, and 2, wherein the antimicrobial thin film layer has an average thickness of not greater than about 15 nm.
6. The antimicrobial thin film layer, or composite structure of any one of claims 1, and 2, wherein the metallic material comprises copper, silver, gold, platinum, nickel, zinc, iron, chrome, any combination thereof, any alloy thereof, any oxide thereof, or any metal oxide thereof.
7. The antimicrobial thin film layer, or composite structure of any one of claims 1, and 2, wherein the antimicrobial thin film layer is a copper layer, a silver layer, a gold layer,

an iron layer, a chrome layer, a platinum layer, any combination thereof, any alloy thereof, any oxide layer thereof, or any metal oxide layer thereof.

8. The antimicrobial thin film layer, or composite structure of any one of claims 1, and 2, wherein the antimicrobial thin film layer is a sputtered metallic layer.

9. The antimicrobial thin film layer, or composite structure of any one of claims 1, and 2, wherein the antimicrobial thin film layer is a continuous metallic layer.

10. The antimicrobial thin film layer, or composite structure of any one of claims 1, and 2, wherein the substrate comprises a polyethylene terephthalate (PET) material, a polycarbonate material, an acrylic material, a plastic material, a glass material.

11. The antimicrobial thin film layer, or composite structure of any one of claims 1, and 2, wherein the substrate comprises an average thickness of not greater than about 1.0 mm.

12. A method of forming an antimicrobial thin film layer, wherein the method comprises depositing a metallic material on a surface to form the antimicrobial thin film layer,

wherein the antimicrobial thin film layer has a VLT of at least about 60%, and

wherein the antimicrobial thin film layer has a MRSA anti-microbial rating of at least about 75%, where the MRSA anti-microbial rating is defined as the percent reduction of methicillin-resistant *Staphylococcus aureus* (MRSA) activity from an initial inoculation of MRSA on the surface of the anti-microbial layer after 24 hours as measured using ISO22196.

13. The method of claim 12, wherein the antimicrobial thin film layer has an *E. coli* anti-microbial rating of at least about 75%, where the *E. coli* anti-microbial rating is defined as the percent reduction of *Escherichia coli* (*E. coli*) activity from an initial inoculation of *E. coli* on the surface of the anti-microbial layer after 24 hours as measured using ISO22196 or at least about 77% or at least about 79% or at least about 81% or at least about 83% or at least about 85% or at least about 87% or at least about 89% or at least about 91% or at least about 93% or at least about 95% or at least about 97%.

14. The method of claim 12, wherein depositing the metallic material comprises a chemical deposition technique, a physical deposition technique, a sputtering deposition technique, an evaporation deposition technique, or a SolGel deposition technique.

15. The method of claim 12, wherein the antimicrobial thin film layer has a VLT of at least about 60%.

1/6

100

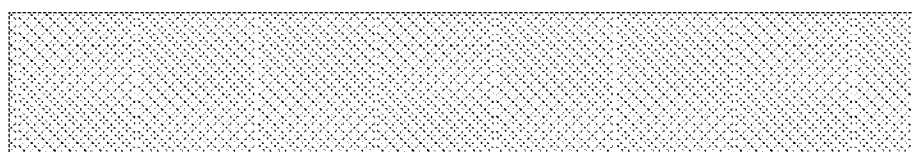


FIG. 1

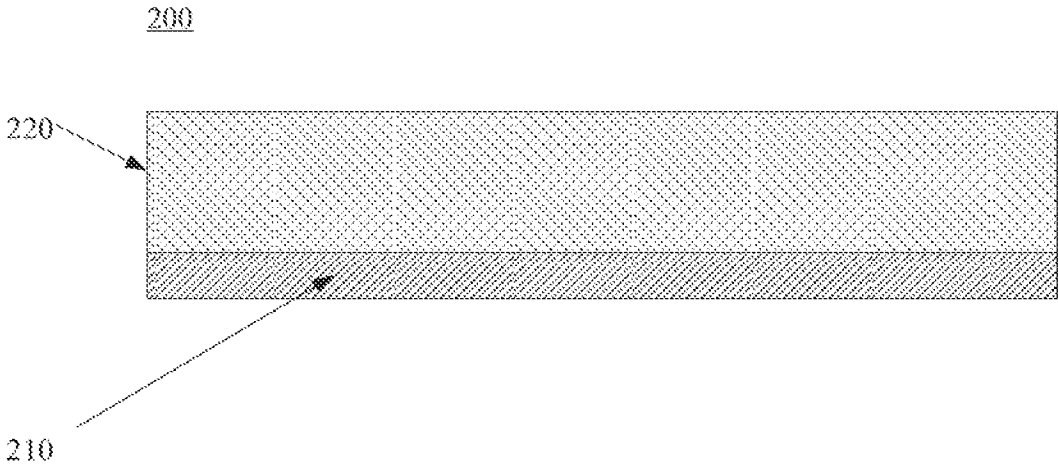


FIG. 2

300

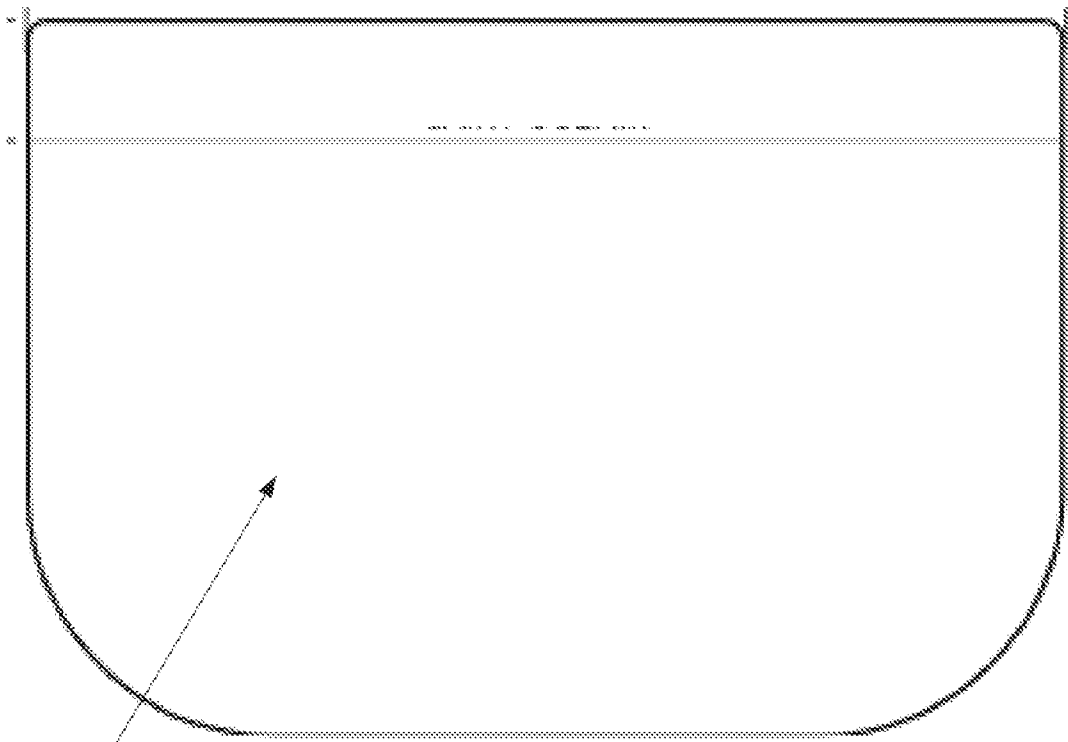


FIG. 3

320

4/6

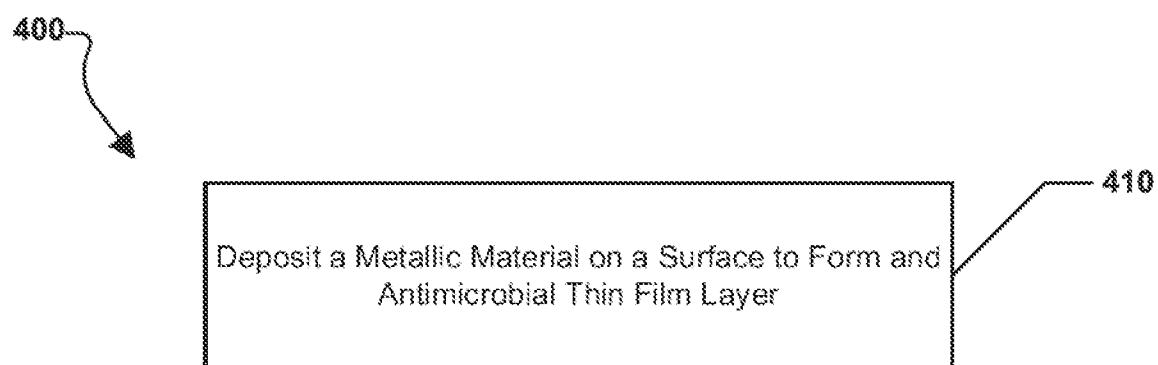
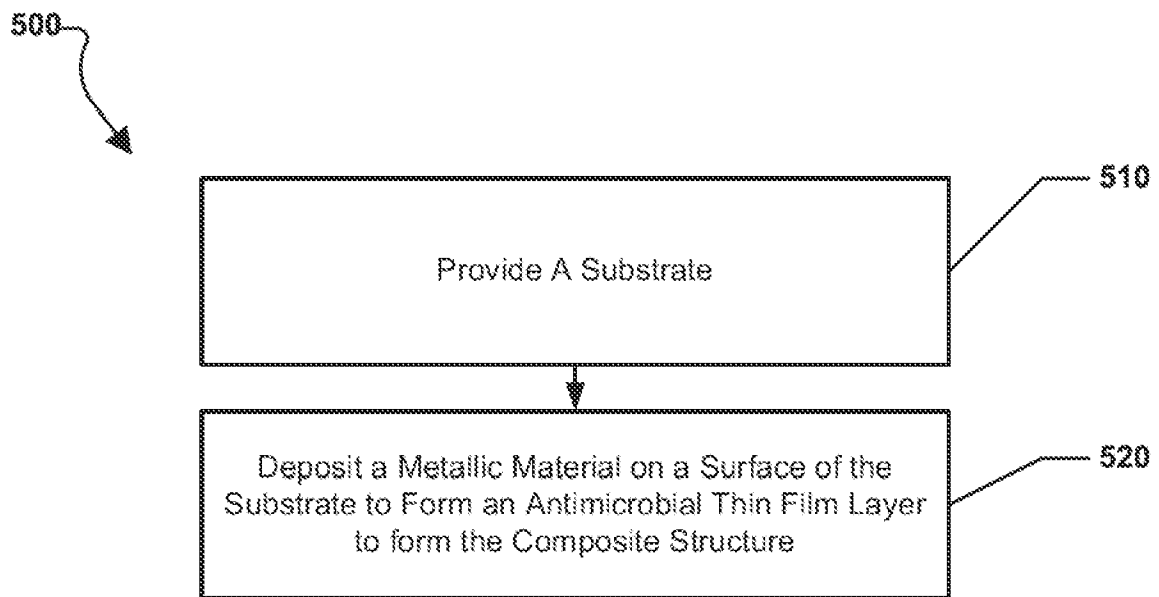
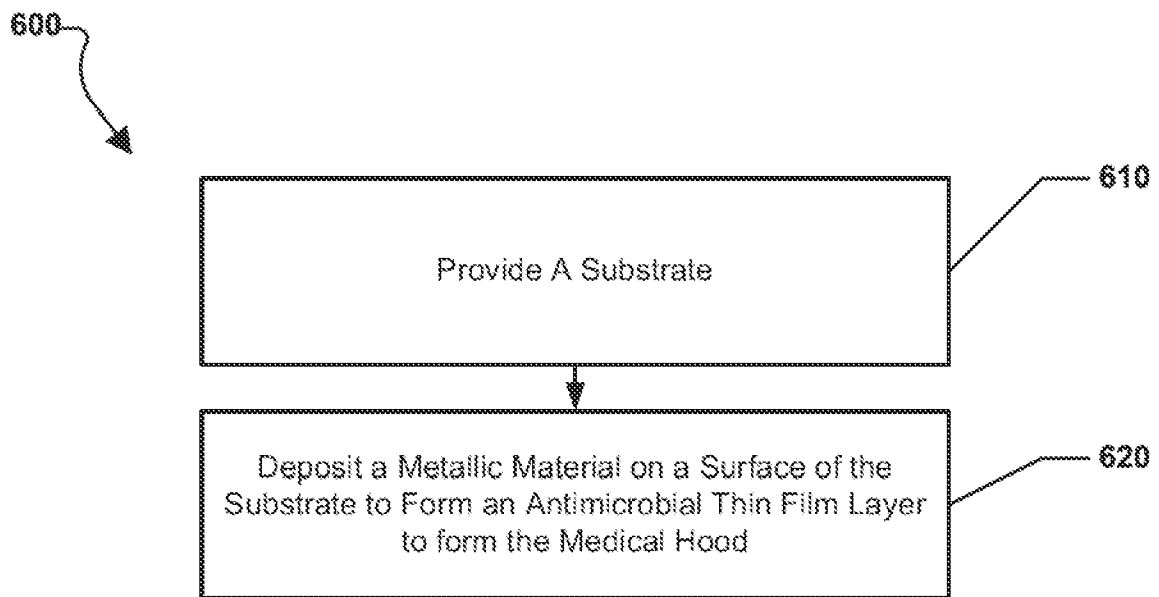


FIG. 4

5/6

**FIG. 5**

6/6

**FIG. 6**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2021/073045

A. CLASSIFICATION OF SUBJECT MATTER C08J 7/06(2006.01)i; C08J 5/18(2006.01)i; C08K 3/08(2006.01)i; C03C 17/06(2006.01)i; B32B 15/08(2006.01)i; B32B 17/06(2006.01)i According to International Patent Classification (IPC) or to both national classification and IPC																				
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) C08J 7/06(2006.01); A01N 25/08(2006.01); A01N 59/16(2006.01); A61L 15/46(2006.01); C08K 3/015(2018.01); C09D 5/00(2006.01) Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Korean utility models and applications for utility models Japanese utility models and applications for utility models Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) eKOMPASS(KIPO internal) & Keywords: antimicrobial, metal, deposition, visible light transmittance, staphylococcus aureus, escherichia coli																				
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>WO 2020-183204 A1 (PILKINGTON TECHNOLOGY MANAGEMENT LIMITED) 17 September 2020 (2020-09-17) claims 18-20; pages 1-42; tables 6c-13; figures 2, 8</td> <td>1-6,9,10,12-15</td> </tr> <tr> <td>Y</td> <td></td> <td>7,8,11</td> </tr> <tr> <td>Y</td> <td>SÁNCHEZ-VALDES, S. et al., "Silver nanoparticle deposition on hydrophilic multilayer film surface and its effect on antimicrobial activity", Journal of applied polymer science, 2012, Vol. 123, No. 5, pages 2643-2650 abstract; pages 2643-2647; table I</td> <td>7,8,11</td> </tr> <tr> <td>A</td> <td>US 2018-0093008 A1 (3M INNOVATIVE PROPERTIES COMPANY) 05 April 2018 (2018-04-05) the whole document</td> <td>1-15</td> </tr> <tr> <td>A</td> <td>KR 10-2020-0127065 A (LOTTE CHEMICAL CORP.) 10 November 2020 (2020-11-10) the whole document</td> <td>1-15</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	WO 2020-183204 A1 (PILKINGTON TECHNOLOGY MANAGEMENT LIMITED) 17 September 2020 (2020-09-17) claims 18-20; pages 1-42; tables 6c-13; figures 2, 8	1-6,9,10,12-15	Y		7,8,11	Y	SÁNCHEZ-VALDES, S. et al., "Silver nanoparticle deposition on hydrophilic multilayer film surface and its effect on antimicrobial activity", Journal of applied polymer science, 2012, Vol. 123, No. 5, pages 2643-2650 abstract; pages 2643-2647; table I	7,8,11	A	US 2018-0093008 A1 (3M INNOVATIVE PROPERTIES COMPANY) 05 April 2018 (2018-04-05) the whole document	1-15	A	KR 10-2020-0127065 A (LOTTE CHEMICAL CORP.) 10 November 2020 (2020-11-10) the whole document	1-15
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Date of the actual completion of the international search 14 April 2022		Date of mailing of the international search report 15 April 2022																		
Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon 35208, Republic of Korea Facsimile No. +82-42-481-8578		Authorized officer HEO, Joo Hyung Telephone No. +82-42-481-5373																		

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PCT/US2021/073045

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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