CLAIMS:

Claim 1. An article comprising a substrate and an anti-microbial coating, wherein the anti-microbial coating comprises at least one solvent-free black phosphorus flake.

Claim 2. An article according to claim 1 wherein the anti-microbial coating has a density that falls within a range of from 0.1 ng of black phosphorus per μm^2 of substrate to 1.0 ng of black phosphorus per μm^2 of substrate, preferably wherein the anti-microbial coating has a density that falls within a range of from 0.2 ng of black phosphorus per μm^2 of substrate to 0.6 ng of black phosphorus per μm^2 of substrate, even more preferably wherein the anti-microbial coating has a density of about 0.4 ng of black phosphorus per μm^2 of substrate.

Claim 3. An article according to claim 1 or 2 wherein the anti-microbial coating prevents the growth of, or kills, one or more bacterial species selected from the group consisting of: Escherichia coli, Pseudomonas aeruginosa, methicillin-resistant staphylococcus aureus (MRSA) (resistive species), Salmonella typhimurium, or Bacillus cereus or wherein the anti-microbial coating prevents the growth of, or kills, one or more fungal species selected from the group consisting of: Candida albicans, *Candida auris* (*C. auris*), sensitive Cryptococcus neoformans, fluconazole-resistant Cryptococcus neoformans, or Ampicillin-resistant Cryptococcus neoformans.

Claim 4. An article according to any one of claims 1 to 3, wherein the at least one black phosphorus flake has an average thickness that falls within a range of from 10 nm to 120 nm, preferably wherein the at least one black phosphorus flake has an average thickness that falls within a range of from 15 nm to 90 nm.

Claim 5. An article according to any one of claims 1 to 4, wherein the at least one black phosphorus flake is produced from a black phosphorus crystal by

mechanical exfoliation, preferably wherein the mechanical exfoliation is conducted in a solvent-free environment.

Claim 6. An article according to any one of claims 1 to 5 wherein the at least one black phosphorus flake generates reactive oxygen species (ROS) that are active towards at least some types of micro-organisms and wherein the reactive oxygen species (ROS) are generated when the black phosphorus flake is exposed to atmospheric oxygen, preferably wherein the reactive oxygen species (ROS) are generated under ambient conditions.

Claim 7. An article according to claim 6, wherein the reactive oxygen species are selected from the group consisting of a singlet oxygen radical ($^1O_2$), a hydroxy radical (OH·), a superoxide radical ($O_2^{\bullet-}$) and hydrogen peroxide (H_2O_2).

Claim 8. An article according to any one of claims 1 to 7, wherein the article is an implant, a medical instrument, a bioscaffold, or a woven or non-woven textile.

Claim 9 An article according to any one of claims 1 to 8, wherein the substrate is selected from the group consisting of: a metal, an alloy, a polymer, a textile, a glass, a ceramic, or any combination thereof, wherein if the substrate is metal the metal is selected from the group consisting of titanium, gold, stainless steel, aluminium, copper, or any combination thereof.

Claim 10. A method of producing an article having an anti-microbial coating, comprising:

providing a substrate;

depositing at least one black phosphorus flake onto a surface of the substrate in the absence of solvent.

Claim 11. A method according to claim 10, wherein the anti-microbial coating has a density that falls within a range of from 0.1 ng of black phosphorus per μm^2 of substrate to 1.0 ng of black phosphorus per μm^2 of substrate, preferably wherein the anti-microbial coating has a density that falls within a range of from 0.2 ng of black phosphorus per μm^2 of substrate to 0.6 ng of black phosphorus per μm^2 of substrate, even more preferably wherein the anti-microbial coating has a density of about 0.4 ng of black phosphorus per μm^2 of substrate.

Claim 12. A method according to any one of claims 10 to 11, wherein the at least one black phosphorus flake has an average thickness that falls within a range of from 10 nm to 120 nm, preferably wherein the at least one black phosphorus flake has an average thickness that falls within a range of from 15 nm to 90 nm.

Claim 13. A method according to any one of claims 10 to 12, wherein the at least one black phosphorus flake is produced from a black phosphorus crystal by mechanical exfoliation, preferably wherein the mechanical exfoliation is conducted in a solvent-free environment.

Claim 14. A method according to any one of claims 10 to 13, wherein the at least one black phosphorus flake is deposited onto a surface of the substrate by contacting the substrate surface with an applicator having at least one black phosphorus flake in contact with a surface thereof.

Claim 15. A method according to any one of claims 10 to 14, wherein the substrate is selected from the group consisting of: a metal, an alloy, a polymer, a textile, a glass, a ceramic, or any combination thereof, wherein if the substrate is metal the metal is selected from the group consisting of titanium, gold, stainless steel, aluminium, copper, or any combination thereof.

Claim 16. An article produced according to the method of any one of claims 10 to 15.

Claim 17. Use of at least one solvent-free black phosphorus flake in the manufacture of an anti-microbial coating for a substrate.

Claim 18. A method of producing at least one solvent-free black phosphorus flake with anti-microbial activity, comprising:

contacting a black phosphorus crystal with an applicator having an adhesive surface to cause the applicator to adhere to a surface of the black phosphorus crystal; and

removing the applicator from the surface of the black phosphorous crystal, thereby mechanically exfoliating at least one black phosphorous flake from the black phosphorous crystal.

Claim 19. An anti-microbial coating, comprising:

at least one black phosphorus flake produced in the absence of solvent.