Claims

1. A method for determining the size of particles, the method comprising the steps of,

(a) providing a substrate which has a non-metallic surface having particles on said non-metallic surface; and defining a minimum size of particles whose size is to be determined;

(b) depositing a layer of metal on the non-metallic surface of the substrate and said particles which are on said non-metallic surface of the substrate, so that each of said particles is provided with a respective single layer of metal and an area of the said non-metallic surface which is without particles is provided with a layer of metal, wherein, for each particle there is a gap between the layer of metal on that particle and the layer of metal on said non-metallic surface and wherein the non-metallic surface of the substrate is inorganic and the thickness of the layer of metal deposited on the non-metallic inorganic surface of the substrate and the thickness of the layer of metal deposited on said particles is in the range 20nm-80nm;

(c) illuminating said layers of metal on said particles and said layer of metal on said non-metallic surface of the substrate with electromagnetic rays, so that said electromagnetic rays are scattered by the layers of metal on said particles to produce respectively scattered electromagnetic rays; or illuminating said layers of metal on said particles and said layer of metal on said non-metallic surface of the substrate, so that at least a portion of said electromagnetic rays are absorbed by layers of metal on said particles and another portion of said electromagnetic rays are reflected by said layer of metal on said non-metallic surface of the substrate to produce reflected electromagnetic rays;

(d) receiving the scattered electromagnetic rays at an array of photodiodes; or receiving the said reflected electromagnetic rays at an array of photodiodes;

(e) forming an image which comprises pixels, wherein each pixel in the image corresponds to a respective photodiode in said array, wherein the colour of each pixel in said image corresponds to the intensity and/or frequency of the electromagnetic rays which photodiode corresponding to that pixel received;

(f) processing said formed image to determine the size of the particles; wherein the layer of metal comprises silver and the thickness of the layer of metal deposited on the non-metallic surface of the substrate and the thickness of the layer of

metal deposited on said particles, is larger than said defined minimum size of particles whose size is to be determined.

2. A method according to claim 1, wherein the method comprises the steps of,

(a) providing a substrate which has a non-metallic surface having particles on said non-metallic surface;

(b) depositing a layer of metal on the non-metallic surface of the substrate and said particles which are on said non-metallic surface of the substrate, so that each of said particles is provided with a respective single layer of metal and an area of the said non-metallic surface which is without particles is provided with a layer of metal, wherein, for each particle there is a gap between the layer of metal on that particle and the layer of metal on said non-metallic surface;

(c) illuminating said layers of metal on said particles and said layer of metal on said non-metallic surface of the substrate with electromagnetic rays, so that said electromagnetic rays are scattered by layers of metal on said particles to produce respectively scattered electromagnetic rays;

(d) receiving the scattered electromagnetic rays at an array of photodiodes;

(e) forming a dark field image which comprises pixels, wherein each pixel in the image corresponds to a respective photodiode in said array, wherein the colour of each pixel in said image corresponds to the intensity and/or frequency of the scattered light which photodiode corresponding to that pixel received;

(f) processing said dark field image to determine the size of the particles.

3. A method according to any one of the preceding claims wherein step (a) comprises providing a substrate which has a non-metallic surface, wherein the non-metallic surface comprises at least one or more of, silicon, SiO_2 (glass), quartz, gallium arsenide, Si_3N_4, TiO_2, HfO_2, ZnSe, ZnS, ZrO_2, Nb_2O_5, $LaTiO_3$, To_2O_5, LiF, MgF_2, Na_3AlF_6, a photoresist, a corrosion inhibitor layer or an adhesion promoter layer.

4. A method according to any one of the preceding claims wherein the layer of metal deposited on the non-metallic surface of the substrate and the layer of metal deposited on said particles, comprises at least one of: W, Co, Ag, Au, Al, Cu.

5. A method according to any one of the preceding claims wherein the non-metallic surface of the substrate is inorganic, and wherein the thickness of the layer of metal deposited on the non-metallic surface of the substrate and the thickness of the layer of metal deposited on said particles, is in the range 10nm-150nm.

6. A method according to any one of the preceding claims wherein the non-metallic surface of the substrate is organic, and wherein the thickness of the layer of metal deposited on the non-metallic surface of the substrate and the thickness of the layer of metal deposited on said particles, is in the range 20nm-160nm.

7. A method according to any one of the preceding claims wherein the step (b) comprises depositing a layer of metal on the non-metallic surface of the substrate and a layer of metal on said particles, at a deposition rate in the range 0.2 Angstroms/second - 50 Angstroms/second.

8. A method according to any one of the preceding claims wherein the layer of metal deposited on the non-metallic surface of the substrate and the layer of metal deposited on said particles comprises silver (Ag); and the thickness of the layer of metal deposited on the non-metallic surface of the substrate and the thickness of the layer of metal deposited on said particles, is in the range 40nm-70nm; and the step (b) comprises depositing the layer of metal on the non-metallic surface of the substrate and the layer of metal on said particles, at a deposition rate in the range 0.8 Angstroms/second - 5 Angstroms/second.

9. A method according to any one of the preceding claims wherein the electromagnetic rays have a wavelength in the range 180nm-750nm.

10. A method according to any one of the preceding claims wherein the step of processing said formed image to determine the size of the particles, comprises (i) inputting the image to a predefined model; wherein the predefined model defines different combinations of predefined image characteristics and a predefined particle

size being associated with each of the different combinations of predefined image characteristics;

(ii) extracting characteristics from said image; and identifying a combination of predefined image characteristics which matches said extracted characteristics; and

(iii) outputting the predefined particle size which are associated with said identified combinations of predefined image characteristics which matched said extracted characteristics, wherein the outputted predefined particle size corresponds to the size of a particle which is shown in the image.

11. A method according to claim 10 wherein, either, said image formed in step (e) is an image corresponding to only a part of the whole surface area of the substrate, and steps (i)-(iii) are repeated for each of a plurality of images until images for whole surface area of the substrate have been processed or until images for a selected portion of the surface area of the substrate have been processed ; or, wherein said image formed in step (e) is an single image corresponding to the whole surface area of the substrate, and steps (i)-(iii) are carried out a single time for said single image, or, said image formed in step (e) is an single image corresponding to a selected portion of the surface area of the substrate, and steps (i)-(iii) are carried out a single time for said single image.

12. A method according to any one of the preceding claims comprising using said formed image to estimate the location of a particle on said non-metallic surface.

13. A method according to claim 12 further comprising the steps of,

moving a Raman laser source to above the location of a particle;

illuminating the layer of metal at the location of the particle, with a Raman laser emitted by the Raman laser source, wherein said Raman laser is scattered by said layer of metal to produce scattered light, and wherein the scattered light comprises both Raman scattered light and also Rayleigh scattered light;

receiving said scattered light at an objective lens;

filtering out the Rayleigh scattered light from the from the received scattered light and passing only the Raman scattered light through said objective lens;

using an optical dispersion grating to disperse the Raman scattered

light into different frequencies;

receiving the dispersed Raman scattered light into a linear photodiode having a plurality of pixels, wherein each pixel is associated with a predefined different light frequency;

determining a photon count per pixel, wherein the photon count per pixel corresponds to a light intensity for certain frequency;

plotting the acquired photon count per frequency to form a Raman spectra.

14. A method according to claim 13 further comprising the step of using the Raman spectra to characterize the material of the particles.

15. A method according to any one of the preceding claims wherein said deposited a layer of metal comprises grains of a plurality of different sizes; and wherein the average size of all the grains of the layer of metal is in the range 10nm-100nm.

16. A method according to any one of the preceding claims wherein physical vapor deposition is used to deposit said layer of metal on the non-metallic surface of the substrate and said particles, so that each of said particles is provided with a respective layer of metal and an area of the said non-metallic surface which is without particles is provided with a layer of metal, wherein, for each particle there is a gap between the layer of metal on that particle and the layer of metal on said metallic surface.

17. An assembly, which is operable to execute the method according to any one of the preceding claims comprising,

a station comprising means for depositing a layer of metal on said non-metallic surface and said particles on said non-metallic surface of the substrate, so that each of said particles is provided with a respective metallic layer and an area of the said non-metallic surface which is without particles is provided with a metallic layer, wherein, for each particle there is a gap between the metallic layer on the particle and the metallic layer on said non-metallic surface, and wherein the non-metallic surface of the substrate is inorganic and the thickness of the layer of metal deposited on the non-metallic inorganic surface of the substrate and the thickness of the layer of metal

deposited on said particles is in the range 20nm-80nm, and wherein the layer of metal comprises silver and the thickness of the layer of metal deposited on the non-metallic surface of the substrate and the thickness of the layer of metal deposited on said particles, is larger than a defined minimum size of particles whose size is to be determined;

a station comprising means for illuminating said layers of metal on said particles and metallic surface with electromagnetic rays, so that said electromagnetic rays are scattered by layers of metal on said particles to produce respectively scattered electromagnetic rays; or illuminating said layers of metal on said particles and non-metallic surface with electromagnetic rays, so that at least a portion of said electromagnetic rays are absorbed by layers of metal on said particles and another portion of said electromagnetic rays are reflected by the metallic layer provided on the non-metallic surface on the substrate to produce reflected electromagnetic rays ;

a station comprising an array of photodiodes which can receive the scattered electromagnetic rays at an array of photodiodes; or which can receive said reflected electromagnetic rays;

a station comprising means for forming an image which comprises pixels, wherein each pixel in the image corresponds to a respective photodiode in said array, wherein the colour of each pixel in said image corresponds to the intensity and/or frequency of the electromagnetic rays which photodiode corresponding to that pixel received;

a station comprising means for processing said formed image to determine the size of the particles.