PROCESS FOR DEPOSITING DRY POWDER PARTICLES ONTO A SUBSTRATE AND ADHESIVELY BONDING THE PARTICLES TO THE SUBSTRATE

Background

Particles are often disposed on substrates for a variety of purposes, for example as spacers, to produce retroreflective articles, to produce abrasive articles, to produce scratch and sniff articles, and so on.

Summary

In broad summary, herein are methods for using a hollow, rotating stencil roll to deposit flowable dry powder particles onto a moving substrate and to adhesively bond the particles to a pressure-sensitive adhesive surface of the substrate.

In one example, a method for adhesively bonding flowable dry powder particles to a moving substrate is provided. The method includes:

dispersing flowable dry powder particles onto a major radially inner surface of a hollow, rotating stencil roll,

contacting a pressure-sensitive adhesive major surface of a moving substrate with a major radially outer surface of the hollow, rotating stencil roll and temporarily adhesively attaching the pressure-sensitive adhesive major surface of the moving substrate to the major radially outer surface of the hollow, rotating stencil roll;

as the substrate rotates with the stencil roll, allowing at least some flowable dry powder particles to pass through at least some apertures in the stencil roll so as to contact the pressure-sensitive adhesive major surface of the moving substrate and to be adhesively bonded thereto; and, allowing at least some flowable dry powder particles that have not adhesively bonded to the pressure-sensitive adhesive surface of the moving substrate to tumble freely along the major radially inner surface of the stencil roll as the stencil roll rotates;

and,

detaching the pressure-sensitive adhesive surface of the moving substrate from the outer surface of the hollow, rotating stencil roll so as to produce a substrate comprising an array of flowable dry powder particles attached to the pressure-sensitive adhesive major surface thereof,

wherein the flowable dry powder particles consist of inorganic particles.

These and other aspects will be apparent from the detailed description below. In no event, however, should this broad summary be construed to limit the claimable subject matter, whether such subject matter is presented in claims in the application as initially filed or in claims that are amended or otherwise presented in prosecution.

Brief Description of the Drawings

Fig. 1 is a side schematic cross sectional view of an exemplary apparatus and process that can be used to deposit flowable dry powder particles onto a moving substrate.

Fig. 2 is a side schematic cross sectional view of another exemplary apparatus and process that can be used to deposit flowable dry powder particles onto a moving substrate.

Fig. 3 is a side perspective view of an exemplary stencil shell of a stencil roll.

Fig. 4 is a perspective, isolated view of a portion of an exemplary stencil shell with apertures comprising sub-apertures.

Fig. 5 is a perspective, isolated view of a portion of another exemplary stencil shell with apertures comprising sub-apertures.

Fig. 6 is a top view of an exemplary substrate with flowable dry particles attached thereto, the dry powder particles being present on the substrate as a nested array.

Fig. 7 is a side schematic cross sectional view of an exemplary substrate with flowable dry powder particles adhesively bonded thereto.

Like reference numbers in the various figures indicate like elements. Some elements may be present in identical or equivalent multiples; in such cases only one or more representative elements may be designated by a reference number but it will be understood that such reference numbers apply to all such identical elements. Unless otherwise indicated, all figures and drawings in this document are not to scale and are chosen for the purpose of illustrating different embodiments of the invention. In particular the dimensions of the various components are depicted in illustrative terms only, and no relationship between the dimensions of the various components should be inferred from the drawings, unless so

What is claimed is:

1. A method for adhesively bonding flowable dry powder particles to a moving substrate, the method comprising:

dispersing flowable dry powder particles onto a major radially inner surface of a hollow, rotating stencil roll,

contacting a pressure-sensitive adhesive major surface of a moving substrate with a major radially outer surface of the hollow, rotating stencil roll and temporarily adhesively attaching the pressure-sensitive adhesive major surface of the moving substrate to the major radially outer surface of the hollow, rotating stencil roll;

as the substrate rotates with the stencil roll, allowing at least some flowable dry powder particles to pass through at least some apertures in the stencil roll so as to contact the pressure-sensitive adhesive major surface of the moving substrate and to be adhesively bonded thereto; and, allowing at least some flowable dry powder particles that have not adhesively bonded to the pressure-sensitive adhesive surface of the moving substrate to tumble freely along the major radially inner surface of the stencil roll as the stencil roll rotates;

and,

detaching the pressure-sensitive adhesive surface of the moving substrate from the outer surface of the hollow, rotating stencil roll so as to produce a substrate comprising an array of flowable dry powder particles attached to the pressure-sensitive adhesive major surface thereof,

wherein the flowable dry powder particles consist of inorganic particles.

2. The method of claim 1 wherein the flowable dry powder particles that tumble freely along the major radially inner surface of the stencil roll as the stencil roll rotates, form a rolling bank as the stencil roll rotates.

3. The method of claim 1 wherein the stencil roll further comprises at least one particle-contacting member that at least closely abuts the major radially inner surface of the rotating stencil roll but is not attached to the stencil roll so as to rotate congruently therewith, which member assists in dislodging flowable dry powder particles from the major radially inner surface of the stencil roll so that the particles can tumble freely along the major radially inner surface of the stencil roll.

4. The method of claim 3 wherein the particle-contacting member is in the form of at least one brush that comprises bristles that contact the major radially inner surface of the stencil roll, wherein the brush is mounted at an angular distance, along the direction of rotation of the stencil roll, of from 30 degrees to 100 degrees from a gravitationally lowest point of the stencil roll.

5. The method of claim 1 wherein the major radially outer surface of the stencil roll is a release surface.

6. The method of claim 1 wherein at least selected apertures of the stencil roll are configured so that flowable dry powder particles can pass through each selected aperture only one at a time, so that for each complete rotation of the stencil roll, only one flowable dry particle is passed through each selected aperture to be attached to the pressure-sensitive adhesive major surface of the substrate.

7. The method of claim 1 wherein at least selected apertures of the stencil roll are configured so that multiple dry powder particles can pass through each selected aperture at a time, so that for each complete rotation of the stencil roll, multiple flowable dry powder particles are passed through each selected aperture to be attached to the pressure-sensitive adhesive major surface of the substrate.

8. The method of claim 1 wherein at least selected apertures of the stencil roll each comprise a plurality of sub-apertures, at least selected sub-apertures being sized so as to allow at least one flowable dry powder particle to pass therethrough at a time, so that the method causes a plurality of flowable dry powder particles to be attached to the pressure-sensitive adhesive major surface of the substrate, as a nested array.

9. The method of claim 1 wherein the stencil roll comprises a stencil shell that comprises a plurality of apertures extending therethrough, and wherein the apertures exhibit a radial length, on average, of from 20 μm to 4 mm.

10. The method of claim 9 wherein the stencil shell is a cylindrical screen-printing screen with a hardened screen-printing emulsion patterned thereon, wherein the hardened emulsion comprises interior edges that define areas of the screen-printing screen that do not have hardened emulsion thereon, which areas of the screen-printing screen that do not have hardened emulsion thereon provide apertures of the stencil shell.

11. The method of claim 1 wherein the pressure-sensitive adhesive major surface of the substrate is detached from the major radially outer surface of the stencil roll, at a location that is angularly within plus or minus 40 degrees from a gravitationally highest point of the stencil roll.

12. The method of claim 1 wherein the apparatus comprises a backing roll that abuts the stencil roll to form a nip, and wherein the pressure-sensitive adhesive major surface of the substrate is detached from

the major radially outer surface of the stencil roll, at a location that is angularly within plus or minus 40 degrees from the nip.

13. The method of claim 1 wherein the apparatus comprises a backing roll that abuts the stencil roll to form a nip, and wherein the pressure-sensitive adhesive major surface of the substrate is detached from the major radially outer surface of the stencil roll, at a location that is at least 90 degrees angularly from the nip along the direction of rotation of the stencil roll.

14. The method of claim 1 wherein the dispensing of the flowable dry powder particles onto the radially inner major surface of the stencil roll comprises gravity-dropping the flowable dry powder particles onto the radially inner major surface of the stencil roll.

15. The method of claim 14 wherein the gravity-dropping comprises allowing additional flowable dry powder particles to gravity-drop onto a loose mass of flowable dry powder particles located at least in a lowermost angular portion of the interior of the rotating stencil roll.

16. The method of claim 1 wherein the flowable dry powder particles comprise partially reflective glass beads.

17. The method of claim 1 wherein the flowable dry powder particles are present as a polydisperse mixture with a particle size coefficient of variation of at least about 100%.

18. The method of claim 1 wherein less than about 10 % by number of the flowable dry powder particles are attached to areas of the pressure-sensitive adhesive major surface of the substrate that had come into contact with the radially outer major surface of the stencil roll.

19. The method of claim 1 wherein the substrate comprises a backing with a layer of pressure-sensitive adhesive disposed on a major surface thereof.

20. The method of claim 1 wherein the stencil roll comprises a stencil shell comprising a plurality of apertures and wherein the apertures exhibit a diameter, on average, of from 20 μm to 4 mm.