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(54) Title: COATING AND CURING APPARATUS AND METHODS

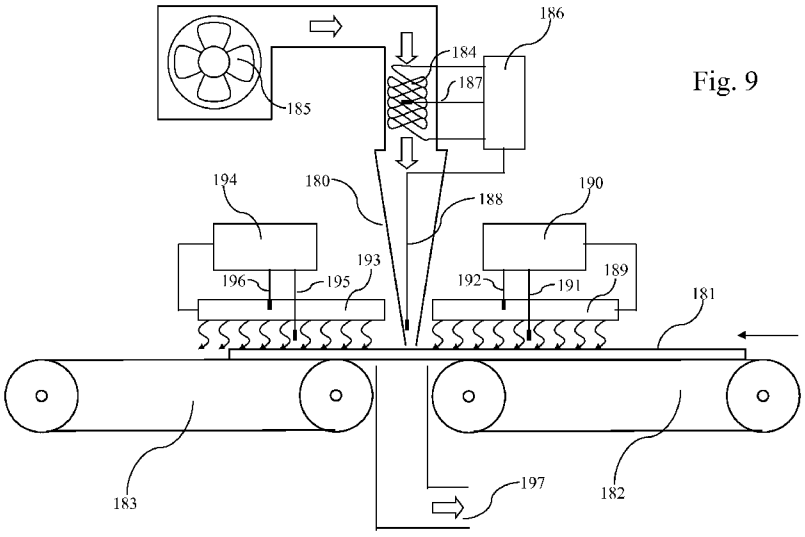

Fig. 9

(57) Abstract: Disclosed are coating apparatus including flow coating and roll-coating that may be used for uniform sol-gel coating of substrates such as glass, solar panels, windows or part of an electronic display. Also disclosed are methods for substrate preparation, flow coating and roll coating. Lastly systems and methods for skin curing sol-gel coatings deposited onto the surface of glass substrates using a high temperature air-knife are disclosed.

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AMENDED CLAIMS
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1. A coating and curing apparatus, comprising:

a conveyor system of a combination roll coating and curing facility, wherein the combination roll coating and curing facility comprises at least one roll coating facility followed by at least one curing facility, the at least one roll coating facility comprising a doctor roller and an application roller, and wherein the conveyor system is adapted to transport a substantially flat substrate first through the roll coating facility and afterwards through the curing facility;

a source of a sol-gel coating for use in the combination roll coating and curing facility, the source comprising space for a reservoir of the sol-gel coating material between the doctor roller and the application roller of the roll coating facility, the reservoir in fluid communication with the doctor roller and the application roller;

a processor that controls a process parameter of the at least one roll coating facility; and

an air knife of the at least one curing facility, wherein the air knife is adapted to direct a heated air stream to a portion of the flat substrate as it is transported through the at least one curing facility,

wherein the at least one roll coating facility is adapted to coat the substantially flat substrate with a continuous film of sol gel coating material and wherein the air knife is adapted to cure the continuous sol gel coating material while an interior of the substantially flat substrate remains at a temperature substantially lower than a temperature of air from the air knife.

2. The apparatus of claim 1, wherein the conveyor system is configured for coating a solar module.

3. The apparatus of claim 1 further comprising an electrical element disposed within the heated air stream to heat the air flowing through the air knife.

4. The apparatus of claim 1, wherein the air is heated to a temperature between about 300 °C and 1000 °C.

5. The apparatus of claim 1 further comprising a fan in the heated air stream that directs air through an electrical element heater to the air-knife.

6. The apparatus of claim 1, further comprising an electronic controller that controls a temperature of the heated air stream based on readings from at least one temperature sensor located in the heated air stream.

7. The apparatus of claim 1, further comprising an exhaust to remove heated air from the apparatus.

8. The apparatus of claim 1, further comprising a flat plate attached to the leading edge of the air-knife, wherein the flat plate is adapted to form a pre-heat chamber with the top surface of the substantially flat substrate.

9. The apparatus of claim 1, further comprising an infra-red emitter disposed along the conveyor system as part of the curing facility and prior to the air knife, wherein the infra-red emitter is adapted to heat the substantially flat substrate to a temperature of between 25 °C to 200 °C.

10. The apparatus of claim 1, further comprising an infra-red emitter disposed along the conveyor system subsequent to the air knife, wherein the infra-red emitter is adapted to maintain the flat substrate at a temperature of between 120 °C to 400 °C.

11. The apparatus of claim 1, wherein the process parameters comprise at least one of: i. a doctor roller spacing; ii. pressure to an application roller, the application roller spacing or pressure taken with respect to the substantially flat substrate; a speed at which the substantially flat substrate is conveyed by the conveyor system; and in the case of reverse roll-coating, a difference in speed between the substantially flat substrate and the application surface of the application roller.

12. The apparatus of claim 1, wherein the processor further controls a process parameter of the curing facility.

13. The apparatus of claim 1, wherein a plurality of roll coating facilities and curing facilities are arranged sequentially.

14. The apparatus of claim 1, wherein the air-temperature exiting the air knife is between 500 °C to 750 °C.

15. The apparatus of claim 1, wherein the conveyor system through the processor, is configured to convey the substantially flat substrate at a speed between 0.25cm/s and 3.5cm/s.

16. The apparatus of claim 1, wherein the curing facility is configured to maintain a surface of the substantially flat substrate between 150 °C to 600 °C while an inner temperature does not exceed 100 °C -120 °C.