In view of the foregoing, and given the ramifications of accurately analyzing selected analytes in test samples, there remains a need for improvements in the application of the reagent layer on test elements.

Systems, apparatuses, techniques and processes for applying a wet film to a substrate using a slot die are provided. In one embodiment, the air pressure around at least a portion of the discharge end of the slot die is adjustable in order to control the width and thickness of the wet film being applied to the substrate. Among other things, this technique allows the coating gap between the discharge end of the slot die and the substrate to be increased, which results in reduced wet film deformities, such as streaking, caused by debris trapped between the slot die and the substrate. Increased coating gaps also reduce the impact that variations in the substrate thickness have on the coating process. In addition, the ability to control the width and thickness of the wet film also increases thickness uniformity along the substrate which, in the case of the substrate being used to form test elements for measuring the presence and/or concentrations of selected analytes in test samples, results in greater lot to lot consistency and accuracy in the test elements.

In one embodiment, a method for applying a wet film to a substrate includes applying a coating material from a discharge end of a slot die onto a moving web of the substrate to form the wet film on the substrate. The wet film includes a width and a thickness relative to the substrate. The method also includes applying a vacuum force adjacent the discharge end of the slot die and adjusting the vacuum force in real-time while applying the coating material to control the width and thickness of the wet film.

In another embodiment, the method further includes sensing the width of the wet film, and adjusting the vacuum force is performed in response to determining the width corresponds to a value other than a predetermined value.

In another embodiment the predetermined value is about 5 millimeters.

In another embodiment the predetermined value is about 7 millimeters.

In another embodiment the predetermined value is between about 4.7 millimeters and about 5.3 millimeters.

In another embodiment the predetermined value is between about 6.7 millimeters and about 7.5 millimeters.

In another embodiment the substrate is formed of a polymer material on which a plurality of electrode patterns may be positioned.

In another embodiment the method further includes applying the coating material from the discharge end of the slot die over the electrode patterns to form the wet film on the electrode patterns.

In another embodiment applying the vacuum force includes positioning a vacuum box adjacent the discharge end of the slot die. The vacuum box includes a pair of vacuum outlets positioned opposite one another and upstream from the wet film.

In another embodiment the method further includes maintaining a constant coating gap between the slot die and the moving web.

In another embodiment the coating gap is between about 40 μm and about 450 μm.

In another embodiment the coating material includes a reagent for producing an optical or electrochemical signal in the presence of a test analyte.

In another embodiment the test analyte is glucose and the reagent includes at least one of an enzyme, co-enzyme and co-factor.

In another refinement, the thickness of the wet film is between about 40 μm and about 100 μm.

In another refinement, the method further includes drying the wet film to provide a dried layer of the coating material on the substrate. The dried layer of the coating material includes a dried thickness between about 3 μm and about 20 μm.

In another refinement, applying the vacuum force creates a pressure differential between an upstream side of the discharge end and a downstream side of the discharge end.

In a further embodiment, an apparatus for applying a wet film to a substrate includes a slot die positionable adjacent to the substrate and including a discharge end from which a coating material is dischargeable onto the substrate to form the wet film. The apparatus also includes an air pressure regulation system operable to control width and thickness of the wet film relative to the substrate by adjusting air pressure adjacent the discharge end of the slot die as the coating material is discharged onto the substrate.

In one embodiment the air pressure regulation system includes an enclosure at least partially surrounding the discharge end of said slot die, and a vacuum source coupled with the enclosure.

In another embodiment the apparatus further includes a sensor configured to determine the width of the wet stripe and provide a corresponding sensor signal representative of the width. The apparatus also includes a controller responsive to the sensor signal to adjust an amount of vacuum applied by the vacuum source to the enclosure when the sensor signal is representative of a width that corresponds to a value other than a predetermined value.

In another embodiment the predetermined value is between about 4.7 millimeters and about 5.3 millimeters.

In another embodiment the predetermined value is between about 6.7 millimeters and about 7.5 millimeters.

In another embodiment the vacuum source is coupled with the enclosure at a location upstream from the wet film.

In another embodiment the enclosure includes a pair of vacuum outlets positioned opposite one another.

In another embodiment the apparatus further includes a moving web of the substrate with the web being formed of a polymer material on which a plurality of electrode patterns may be positioned. The slot die is positionable over the electrode patterns such that the coating material is dischargeable from the discharge end to form the wet film on the electrode patterns.

In another embodiment a coating gap in the range of about 40 μm to about 450 μm extends between the discharge end of the slot die and the substrate.

In another embodiment the apparatus further includes a roller system operable to move a web of the substrate relative to the slot die.

In another embodiment the apparatus further includes a reservoir containing a quantity of the coating material, and the coating material includes a reagent for producing an optical or electrochemical signal in the presence of a test analyte.

In another embodiment the test analyte is glucose and the reagent includes at least one of an enzyme, co-enzyme and co-factor.

Inthe present disclosure, a method for applying a wet film to a substrate includes applying a coating material from a discharge end of a slot die onto the substrate to form the wet film on the substrate; controlling a thickness of the wet film relative to the substrate by adjusting a pressure differential existing between an upstream side of the slot die and a downstream side of the slot die; and maintaining a constant coating gap between the discharge end of the slot die and the substrate while controlling the thickness of the wet film.

In one aspect of the present disclosure, there is provided a method for applying a wet film (15) to a substrate (18) comprising: applying a coating material (12) from a discharge end (35) of a slot die onto said substrate (18) to form said wet film (15) on said substrate (18); controlling a thickness of said wet film (15) relative to said substrate (18) by adjusting a pressure differential existing between an upstream side of said slot die and a downstream side of said slot die; and maintaining a constant coating gap between said discharge end (35) of said slot die and said substrate (18) while controlling the thickness of the wet film (15), wherein said coating material (12) includes a reagent for producing an optical or electrochemical signal in the presence of a test analyte

In one embodiment adjusting the pressure differential includes changing an amount of vacuum applied adjacent to the upstream side of the discharge end of the slot die.

In another embodiment adjusting the pressure differential is performed in response to determining that a width of said wet film (15) corresponds to a value other than a predetermined value.

In another embodiment the predetermined value is between about 2.5 millimeters and 7.5 millimeters.

In another embodiment, the method further includes maintaining a constant flow rate of the coating material through the slot die while controlling the thickness of the wet film.

In another embodiment, the method further includes moving said substrate (18) relative to the slot die, and maintaining a constant rate of movement of said substrate (18) relative to the slot die while controlling the thickness of said wet film (15).

In another embodiment the coating gap is between about 40 μm and about 450 μm.

In another embodiment the coating material includes a reagent for producing an optical or electrochemical signal in the presence of a test analyte.

Another embodiment of the present disclosure is a unique technique for forming test elements useful for measuring the presence and/or concentrations of selected analytes in test samples. Other embodiments include unique methods, systems, devices, kits, assemblies, equipment, and/or apparatus related to slot die coating processes, including those used to apply a reagent material to a test element.

Further aspects, embodiments, forms, features, benefits, objects, and advantages shall become apparent from the detailed description and figures provided herewith.

FIG. 1 is a diagrammatic illustration of a slot die coating apparatus.

FIG. 2 is an enlarged, side plan view of a slot die assembly of the apparatus of FIG. 1.

FIG. 3 is a front, plan view of the slot die assembly illustrated in FIG. 2 rotated ninety degrees relative to the view of FIG. 2.

FIG. 4 is an enlarged, diagrammatic illustration of an operation for applying a coating material to a substrate with the slot die coating apparatus illustrated in FIG. 1.

FIG. 5 is a diagrammatic illustration of a vacuum supply system configured to be coupled with the slot die assembly of FIG. 2.

FIG. 6 is a side plan view of a substrate material on which a wet film has been formed.

FIG. 7 is a diagrammatic illustration of a system for controlling operation of the slot die coating apparatus of FIG. 1 and vacuum supply system of FIG. 6.

FIGS. 8-9 are graphical illustrations of the thickness profile of a layer of reagent material across its width.

## CLAIMS

1. A method for applying a wet film (15) to a substrate (18), comprising:

applying a coating material (12) from a discharge end (35) of a slot die onto said substrate (18) to form said wet film (15) on said substrate (18);

controlling a thickness of said wet film (15) relative to said substrate (18) by adjusting a pressure differential existing between an upstream side of said slot die and a downstream side of said slot die; and

maintaining a constant coating gap between said discharge end (35) of said slot die and said substrate (18) while controlling said thickness of said wet film (15), wherein said coating material (12) includes a reagent for producing an optical or electrochemical signal in the presence of a test analyte.

2. The method of claim 1, wherein adjusting said pressure differential includes changing an amount of vacuum applied adjacent to said upstream side of said slot die.

3. The method of claim 1 or 2, wherein adjusting said pressure differential is performed in response to determining that a width of said wet film (15) corresponds to a value other than a predetermined value.

4. The method of claim 1, 2, or 3, which further includes moving said substrate (18) relative to said slot die, and maintaining a constant rate of movement of said substrate (18) relative to said slot die while controlling said thickness of said wet film (15).

5. The method of any one of claims 1 to 4, which further includes maintaining a constant flow rate of said coating material (12) through said slot die while controlling said thickness of said wet film (15).