heating profile is produced along most of the specimen-bearing surface of the slide. The substantially uniform temperature profile has less than a 5° temperature variation across the specimen-bearing area of the slide. Additionally or alternatively, the conductive heater can be configured to produce a central low temperature heating zone along the support element and a peripheral high temperature heating zone along the support element. Additionally or alternatively, the conductive heater is positioned underneath the support element and defines an opening through which a convective flow is capable of passing to cool the support element.

The system for heating a specimen-bearing slide, in some embodiments, includes a convection cooling device coupled to the controller and configured to deliver a convective flow into the opening based on a signal from the controller. In certain embodiments, the convection cooling device includes at least one fan capable of producing the convective flow. In some embodiments, compressed air or motive air can be used.

The support element, in some embodiments, comprises stainless steel. In some embodiments, a portion of the support element between the support surface for carrying the slide and the conductive heater has a thermal conductivity equal to or less than about 20 W/m*K.

In view of the above, in accordance with a first aspect, there is provided a slide processing apparatus for processing a specimen carried by a slide, comprising: a staining module including a slide holder platen having a first sidewall, a second sidewall, and a slide receiving region between the first sidewall and the second sidewall, a slide positioned on the slide receiving region, the slide including a first edge and an opposing second edge, an opposable element disposed proximate to the slide and including a first edge portion and an opposing second edge portion, and an opposable actuator for holding the opposable element, wherein the opposable element ~~to~~ forms a capillary gap between the opposable element and the slide, the first edge portion of the opposable element being closer to the first sidewall than the first edge of the slide,

and the second edge portion of the opposable element being closer to the second sidewall than the second edge of the slide, characterized in that a width WG1 of a first gap between the first edge portion of the opposable element and the first sidewall is smaller than the distance D1 between the first edge portion of the opposable element to the first edge of the slide, and a width WG2 of a second gap between the second edge portion of the opposable element to the second sidewall is smaller than the distance D2 between the second edge portion of the opposable element to the second edge of the slide.

In accordance with a second aspect, there is provided a system for processing a specimen carried by a slide, comprising: a specimen processing station including ~~an opposable actuator,~~ a slide processing apparatus for processing a specimen carried by a slide of the first aspect, wherein a slide holder platen ~~including~~ includes a slide support region, the slide holder platen being configured to heat a liquid on a slide at the slide support region while ~~an~~ the opposable element held by the opposable actuator contacts and moves the liquid along the slide, and a replenishment device configured to deliver a supplemental liquid between the opposable element and the slide; and a controller programmed to control the specimen processing station such that the replenishment device delivers the supplemental liquid at a replenishing rate to compensate for evaporative losses of the liquid., wherein the controller is programmed to control the specimen processing station to move the opposable element while the opposable element engages the liquid on the slide while an evaporation rate of the liquid is kept equal to or less than about 100 µL per minute.

~~In accordance with a third aspect, there is provided a method of processing a biological specimen carried by a slide, comprising: heating a liquid on a slide held by a slide holder; rolling an opposable element that contacts the liquid on the slide to move the liquid across a biological specimen on the slide; determining a replenishing rate based on an evaporation rate of the liquid; delivering a supplemental liquid based on the replenishing rate to substantially compensate for evaporative losses of the liquid; and rolling the opposable element contacting the liquid, which comprises the supplemental liquid, so as to repeatedly contact the specimen with the liquid.~~

In accordance with a ~~fourth~~ third aspect, there is provided a method of processing a specimen on a slide~~,~~. ~~comprising~~The method comprises using the system of the second aspect for processing a specimen carried by a slide. The method further comprises: moving a liquid along a slide using an opposable element contacting the liquid; controlling a temperature of the liquid on the slide while moving the liquid; evaluating at least one of a volume of the liquid and/or a total evaporation rate of the liquid; and delivering a supplemental liquid onto the slide based on the evaluation to keep a volume of the liquid on the slide within an equilibrium volume range.

## BRIEF DESCRIPTION OF THE DRAWINGS

Non-limiting and non-exhaustive embodiments are described with reference to the following drawings. The same reference numerals refer to like parts or acts throughout the various views, unless otherwise specified.

Figure 1 is an isometric view of a specimen processing system in accordance with an embodiment of the disclosed technology.

Figure 2 is an exploded isometric view of the specimen processing system of Figure 1. Portions of a protective housing are shown removed.

Figure 3 is a detailed view of a portion of the specimen processing system of Figure 2.

## PATENT CLAIMS

1. A slide processing apparatus for processing a specimen carried by a slide, comprising:

a staining module including

a slide holder platen having a first sidewall, a second sidewall, and a slide receiving region between the first sidewall and the second sidewall,

a slide positioned on the slide receiving region, the slide including a first edge and an opposing second edge,

an opposable element disposed proximate to the slide and including a first edge portion and an opposing second edge portion, and

an opposable actuator for holding the opposable element,

wherein the opposable element ~~to~~ forms a capillary gap between the opposable element and the slide, the first edge portion of the opposable element being closer to the first sidewall than the first edge of the slide, and the second edge portion of the opposable element being closer to the second sidewall than the second edge of the slide,

characterized in that a width $W_{G1}$ of a first gap between the first edge portion of the opposable element and the first sidewall is smaller than the distance $D_1$ between the first edge portion of the opposable element to the first edge of the slide, and a width $W_{G2}$ of a second gap between the second edge portion of the opposable element to the second sidewall is smaller than the distance $D_2$ between the second edge portion of the opposable element to the second edge of the slide.

2. The slide processing apparatus of claim 1, further comprising:

a dispenser positioned to deliver a supplemental liquid between the opposable element and the slide while a liquid is held in the capillary gap, and.

~~3. The slide processing apparatus claim 2, further comprising:~~

a controller communicatively coupled to the dispenser and programmed to command the dispenser such that the dispenser delivers the supplemental liquid to keep a volume of the liquid between the opposable element and the slide within an equilibrium volume range.

~~4. The slide processing apparatus of claim 3, wherein the controller is programmed to deliver the supplemental liquid at a rate equal to or less than about 100 µL per minute.~~

~~5. The slide processing apparatus of claim 1, further comprising:~~

~~a plurality of additional staining modules and a controller configured to independently control each of the staining modules.~~

~~6.~~3. The slide processing apparatus of claim 1, wherein the width $W_{G1}$ of the first gap between the first edge portion of the opposable element ~~extends past the first edge of the slide towards the first sidewall~~is less than 50% of the distance $D_1$ between the first edge portion of the opposable element to the first edge of the slide.

~~7.~~4. The slide processing apparatus of claim ~~6~~3, wherein the width $W_{G2}$ of the second gap between the second edge portion of the opposable element ~~extends past the second edge of the slide towards the second sidewall~~ is less than 50% of the distance $D_2$ between the second edge portion of the opposable element to the second edge of the slide.

~~8. The slide processing apparatus of claim 1, wherein the opposable element includes a mounting end having at least one slot dimensioned to receive at least a portion of the opposable actuator.~~

~~9.~~5. The slide processing apparatus of claim 1 wherein the staining module includes at least one heating element positioned to conductively heat the first sidewall, the second sidewall, or both.

~~10. The slide processing apparatus of claim 1, wherein the opposable actuator is moveable to roll a curved portion of the opposable element along the slide to move a band of a liquid across at least a portion of the slide carrying a specimen.~~

~~11. The slide processing apparatus of claim 1, further comprising:~~

~~a slide supported by a contact surface of the slide receiving region such that the first edge portion and the second edge portion of the slide extend outwardly from edges of the contact surface.~~

~~12. The slide processing apparatus of claim 1, wherein the opposable element has a captivation end and an arcuate main body extending from the captivation end, the arcuate main body is configured to roll along the slide to move a liquid across a mounting region of the slide, and the captivation end has a radius of curvature equal to or less than about 0.08 inch.~~

~~13.~~6. A system for processing a specimen carried by a slide, comprising:

a specimen processing station including

~~an opposable actuator~~a slide processing apparatus for processing a specimen carried by a slide of claim 1,

wherein a slide holder platen ~~including~~ includes a slide support region, the slide holder platen being configured to heat a liquid on a slide at the slide support region while ~~an~~ the opposable element held by the opposable actuator contacts and moves the liquid along the slide, and

a replenishment device configured to deliver a supplemental liquid between the opposable element and the slide; and

a controller programmed to control the specimen processing station such that the replenishment device delivers the supplemental liquid at a replenishing rate to compensate for evaporative losses of the liquid, wherein the controller is programmed to control the specimen processing station to move the opposable element while the opposable element engages the liquid on the slide while an evaporation rate of the liquid is kept equal to or less than about 100 µL per minute.

~~14.~~7. The system of claim ~~13~~6, wherein the controller includes:

a memory for storing a first sequence of program instructions and a second sequence of program instructions; and

a programmable processor configured to execute the first sequence of program instructions in order to process a specimen on the slide with a first liquid and configured to execute the second sequence of

program instructions to process the specimen with a second liquid that is different from the first liquid.

~~15.~~8. The system of claim ~~14~~7, wherein the programmable processor is configured to execute the first sequence of program instructions in order to heat the slide to a first temperature using the slide holder platen, the controller is configured to execute the second sequence of program instructions in order to heat the slide to a second temperature using the slide holder platen, and the second temperature is different from the first temperature.

~~16.~~9. The system of claim ~~13~~6, wherein the controller is configured to execute a first sequence of program instructions to command the replenishment device to deliver a first liquid to the slide at a first rate, and the controller is configured to execute a second sequence of program instructions to command the replenishment device to deliver a second liquid to the slide at a second rate that is different from the first rate.

~~17.~~10. The system of claim ~~16~~9, wherein the first rate corresponds to an evaporation rate of the first liquid, and the second rate corresponds to an evaporation rate of the second liquid.

~~18.~~11. The system of claim ~~13~~6, wherein the controller includes a memory that stores a replenishment program executable by the controller in order to keep a volume of the liquid on the slide within an equilibrium volume range.

~~19. The system of claim 18, wherein the equilibrium volume range is in a range of about 75 µL to about 125 µL.~~

~~20.~~12. The system of claim ~~18~~11, wherein the controller is programmed to command the specimen processing station to keep a volume of the liquid between a maximum equilibrium volume corresponding to an over-wetting condition and a minimum equilibrium volume corresponding to an under-wetting condition.

~~21. The system of claim 13, further comprising:~~

~~an opposable element held by the opposable actuator, the opposable element extending outwardly past edges of the slide; and~~

~~wherein the controller programmed to control the specimen processing station to move the opposable element while the opposable element engages the liquid on the slide while an evaporation rate of the liquid is kept equal to or less than about 100 µL per minute.~~

~~22.~~13. The system of claim ~~13~~6, wherein the controller is programmed to command the specimen processing station to

move a volume of the liquid across a specimen held on the slide by moving an opposable element held by the opposable actuator relative to the slide; and

deliver the supplemental liquid from the replenishment device to generally compensate for a decrease in the volume of the liquid due to evaporation.

~~23. The system of claim 13, wherein the slide holder platen includes a heating element that receives electrical energy and outputs thermal energy to heat the slide via conduction.~~

~~24.~~14. The system of claim ~~13~~6, wherein the controller is configured to receive reference evaporation rate information for the liquid from a memory and to control the specimen processing station based on the reference evaporation rate information.

~~25.~~15. The system of claim ~~13~~6, wherein the controller is programmed to command the specimen processing station such that the replenishment device provides the supplemental liquid at a rate selected based on an evaporation rate of the liquid.

~~26. A method of processing a biological specimen carried by a slide, comprising:~~

~~heating a liquid on a slide held by a slide holder;~~

~~rolling an opposable element that contacts the liquid on the slide to move the liquid across a biological specimen on the slide;~~

~~determining a replenishing rate based on an evaporation rate of the liquid;~~

~~delivering a supplemental liquid based on the replenishing rate to substantially compensate for evaporative losses of the liquid; and~~

~~rolling the opposable element contacting the liquid, which comprises the supplemental liquid, so as to repeatedly contact the specimen with the liquid.~~

~~27. The method of claim 26, wherein delivering the supplemental liquid includes delivering a volume of the supplemental liquid that is equal to or greater than a decrease in a volume of the liquid via evaporation.~~

~~28. The method of claim 26, wherein delivering the supplemental liquid onto the slide comprises delivering the supplemental liquid onto the slide to keep a volume of the liquid on the slide equal to or greater than a minimum equilibrium~~

~~volume for the liquid and at or below a maximum equilibrium volume for the liquid.~~

~~29. The method of claim 26, wherein delivering the supplemental liquid comprises delivering the supplemental liquid onto the slide while the opposable element rolls along the slide.~~

~~30.~~16. A method of processing a specimen on a slide, the method comprising using the system for processing a specimen carried by a slide of claim 6, the method further comprising:

moving a liquid along a slide using an opposable element contacting the liquid;

controlling a temperature of the liquid on the slide while moving the liquid;

evaluating at least one of a volume of the liquid and/or a total evaporation rate of the liquid; and

delivering a supplemental liquid onto the slide based on the evaluation to keep a volume of the liquid on the slide within an equilibrium volume range.

~~31.~~17. The method of claim ~~30~~16, wherein evaluating the at least one of the volume of the liquid and/or the total evaporation rate of the liquid includes receiving the volume of the liquid and the total evaporation rate of the liquid from a memory.

~~32. The method of claim 30, wherein the equilibrium volume range is about 125 µL to about 175 µL.~~