[0011] In one embodiment, for each microchannel distillation section the process microchannel comprises a liquid inlet for permitting liquid to flow into the process microchannel, a liquid outlet for permitting liquid to flow out of the process microchannel, an interior wall extending from the liquid inlet to the liquid outlet, and a capture structure, the liquid inlet being downstream from the liquid outlet. In one embodiment, the liquid phase flows along the interior wall, the liquid phase being in the form of a thin film.

[0012] In one embodiment, part of the wicking region forms a wall of the process microchannel.

[0013] In one embodiment, the liquid phase flows in the wicking region and the vapor phase flows in the process microchannel and contacts at least part of the liquid phase in the wicking region.

[0014] In one embodiment, the more volatile component rich vapor phase is a first section more volatile component rich vapor phase formed in the first microchannel distillation section of the process microchannel, the process microchannel comprising the first microchannel distillation section and downstream second and third microchannel distillation sections, the first section more volatile component rich vapor phase flowing from the first microchannel distillation section into the downstream second microchannel distillation section, a downstream third section less volatile component rich liquid phase formed in the downstream third microchannel distillation section flowing from the downstream third microchannel distillation section into the downstream second microchannel distillation section and contacting the first section more volatile component rich vapor phase in the downstream second microchannel distillation section, the downstream third section less volatile component rich liquid phase flowing in a thin film along an interior wall in the downstream second microchannel distillation section, part of the more volatile component transferring from the downstream third section less volatile component rich liquid phase to the first section more volatile component rich vapor phase to form a downstream second section more volatile component rich vapor phase, part of the less volatile component transferring from the first section more volatile component rich vapor phase to the downstream third section less volatile component rich liquid phase to form a downstream second section less volatile component rich liquid phase; and separating the downstream second section more volatile component rich vapor phase from the downstream second section less volatile component rich liquid phase.

[0015] In one embodiment, the less volatile component rich liquid phase is a first section less volatile component rich liquid phase formed in the first microchannel distillation section of the process microchannel, the process microchannel comprising the first microchannel distillation section and upstream second and third microchannel distillation sections, the first section less volatile component rich liquid phase flowing from the first microchannel distillation section into the upstream second microchannel distillation section, an upstream third section more volatile component rich vapor phase formed in the upstream third microchannel distillation section flowing from the upstream third microchannel distillation section into the upstream second microchannel distillation section and contacting the first section less volatile component rich liquid phase in the upstream second microchannel distillation section, the first section less volatile component rich liquid phase flowing in a thin film along an interior wall in the upstream second microchannel distillation section, part of the more volatile component transferring from first section less volatile component rich liquid phase to the upstream third section more volatile component rich vapor phase to form an upstream second section more volatile component rich vapor phase, part of the less volatile component transferring from the upstream third section more volatile component rich vapor phase to the first section less volatile component rich liquid phase to form an upstream second section less volatile component rich liquid phase; and separating the upstream second section more volatile component rich vapor phase from the upstream second section less volatile component rich liquid phase.

[0016] In one embodiment, each microchannel distillation section further comprises a heat exchange channel adjacent to the liquid channel, the process microchannel, or both the liquid channel and the process microchannel.

[0017] In one embodiment, the microchannel distillation unit further comprises a first supplemental vapor channel and a second supplemental vapor channel, each microchannel distillation section further comprising a supplemental vapor inlet and a supplemental vapor outlet, part of the vapor phase flowing from the first supplemental vapor channel through the supplemental vapor inlet into the microchannel distillation section, through the microchannel distillation section in contact with the liquid phase, and then through the supplemental vapor outlet to the second supplemental vapor channel.

[0018] In one embodiment, each microchannel distillation section comprises a liquid channel, a first process microchannel, a second process microchannel, a first vapor channel, a second vapor channel, a third vapor channel, a vapor inlet and a vapor outlet, the first process microchannel and the second process microchannel being adjacent to the liquid channel, the liquid channel comprising a wicking region, part of the wicking region forming a wall of the first process microchannel and a wall of the second process microchannel; the liquid phase flowing through the wicking region; the vapor phase flowing through the vapor inlet into the first vapor channel, through the first vapor channel into the first process microchannel, through the first process microchannel in contact with at least part of the liquid phase in the wicking region, from the first process microchannel into the second vapor channel, through the second vapor channel into the second process microchannel, through the second process microchannel in contact with at least part of the liquid phase in the wicking region, from the second process microchannel into the third vapor channel, and through the third vapor channel into the vapor outlet.

[0019] In one embodiment, the invention relates to a process for distilling a fluid mixture in a microchannel distillation unit, the microchannel distillation unit comprising a process microchannel and an adjacent liquid channel, the fluid mixture comprising a more volatile component and a less volatile component, the process comprising: flowing a vapor phase of the fluid mixture in one direction through the process microchannel, the process microchannel comprising a plurality of microchannel distillation sections, each microchannel distillation section comprising an interior space for permitting vapor flow, an interior wall, a capture