coating processes that are non-reactive, e.g., washcoating of an aqueous metal salt solution.

[0307] Other Coating Modifications

[0308] Various other modifications can be used to enhance adhesion or other properties of alumina coatings over the alumina scale. An alumina coating can be deposited using an alumina sol or slurry.

[0309] To achieve greater uniformity in microchannels, coating solutions may contain surfactants such as polyvinylalcohol (PVA), and polyvinylpyrrolidone. Surfactants reduce the contact angle of a fluid to the wall which allows the fluid to more fully wet and cover the microchannel walls.

[0310] Draining Liquid Coating Compositions

[0311] One problem with washcoating is that during draining a liquid from a microchannel, the top of the microchannel(s) is effectively drained while the bottom of the microchannel(s) remains wet because some liquid is retained in the microchannel(s) by capillary action. One technique to remove the last liquid is by purging with a gas flow; however, when liquid is being removed from a plurality of microchannels (for example, at least 2, at least 10, or at least 100 microchannels) the flow of gas is, or becomes, unequal through the microchannels, resulting in nonuniform channel-to-channel coating thickness. The non-uniformity may arise in two ways: (1) slower liquid removal from a channel which allows more deposition onto the channel wall(s), or (2) faster gas flow through some microchannels that strips off coating from the channel wall(s). To minimize this effect, purge flow through the microchannels is controlled to a low rate such that flow through each of the microchannels varies by 70% or less, preferably 40% or less (as a percent of the highest flow). This flow can be caused by back pressure or by pulling with vacuum through a drain (typically a manifold inlet or manifold outlet). A more preferred method is to use a suction conduit that is moved through a manifold to suck fluid from a subset of microchannels (preferably one microchannel) of a set of microchannels that are connected to the manifold; in this method, drainage suction applied to (or conversely, gas flow through) microchannels is made more equal than if suction were applied to the manifold as a whole. One issue with applying suction to a connecting channel that feeds more than 2 or more than 10 or more channels is the resulting pressure differential created by flow in the connecting channel circuit. After the first channel (as defined with the lowest pressure drop) is drained, the loss of suction or continuous liquid flow makes it challenging to remove the liquid retained in the remaining channels. This is analogous to the difficulting in draining the final liquid from a soda can with suction from a straw.

[0312] Another possibility to improve coating uniformity is to use a wick to assist in draining liquid from microchannels. For this purpose, wicking features can be integral with the microchannel device or inserted temporarily during the draining process but removed prior to use. The wicks could be used to create a capillary siphon effect to drain the remaining liquid.

[0313] To control height of a coating solution in microchannels, a watch tube can be employed. A watch tube is a clear tube that is connected to the microchannel device. A coating liquid can be injected into a port of a microchannel device—a watch tube is connected to the microchannel device (for example by a w-connection with a syringe attached to the center of the W with one side of the W connected to the microchannel device and one side connected to the watch tube); in this fashion, the height of the liquid level in the watch tube matches the height of liquid in the microchannels if the hydraulic diameter of the watchtube is similar to the channel hydraulic diameter for the case when the hydraulic diameter of the microchannel is sufficiently small to create a capillary force. For hydraulic diameters less than 2 mm, it is anticipated that some capillary force will be exerted such that a liquid rise will occur especially in a non-wetted microchannel. In another selective coating technique, coatings are excluded from selected microchannels by temporarily plugging (such as with a removeable cap) selected channels so that gas pressure prevents those channels from filling while other unplugged channels are filled with liquid while gas escapes from an exit port.

[0314] Catalyst Coatings

[0315] Catalysts can be applied using techniques that are known in the art. Impregnation with aqueous salts is preferred. Pt, Rh, and/or Pd are preferrred in some embodiments. Typically this is followed by heat treatment and activation steps as are known in the art. Salts which form solutions of pH>0 are preferred.

[0316] Other Liquid Coating Techniques

[0317] Coatings could also be applied onto microchannel walls by filling channels to the desired height with a liquid coating composition and removing volatile components (typically solvent) under reduced pressure. Care may need to be exercised to avoid bubbling defects.

[0318] Another way coatings could be applied to microchannel walls is to used supersaturated washcoat solutions or to cool the solutions in a microchannel to create supersaturation in situ. Solids will then deposit onto the microchannel walls. This technique offers a potential for selective coating by using an adjacent cooling channel to cool selected portions of a microchannel, for example a section that is no more than 50% (or no more than 20%) of the length of the microchannel can be cooled selectively. The amount of applied cooling is small and controlled such that the wall is preferentially cooled while the liquid in the channels is substantially not cooled thus avoiding the formation of particulates in the bulk liquid.

[0319] Reactions

[0320] The coated microchannel apparatus is especially useful when used with a surface catalyst and at high temperature, for example, at temperatures above 180° C., above 250° C., above 500° C., in some embodiments 700° C. or higher, or in some embodiments 900° C. or higher.

[0321] In some aspects, the invention provides a method of conducting a reaction, comprising: flowing at least one reactant into a microchannel, and reacting the at least one reactant in the presence of a catalyst within the microchannel to form at least one product. In some embodiments, the reaction consists essentially of a reaction selected from: acetylation, addition reactions, alkylation, dealkylation, hydrodealkylation, reductive alkylation, amination, ammoxidation, ammonia synthesis, aromatization, arylation, autothermal reforming, carbonylation, decarbonyla-