selected region of the device; and monitoring liquid level in the device by use of a watch tube in communication with the microchannel device or the liquid source. In a preferred embodiment, the liquid flows through an inlet at the device bottom, into a manifold and then into the multiple microchannels, and liquid level is adjusted to a desired height by use of the watch tube.

[0031] Aluminide coatings in microchannels can be made by passing gaseous aluminum compounds over metal surfaces (especially a metal wall of a microchannel) and simultaneously or subsequently reacting with a metal in the substrate to form a surface layer of metal aluminide—this process is termed aluminization, perhaps more accurately, aluminidization. Conditions for aluminidization are conventionally known for jet engine parts, and the conventional steps are not described here. Certain steps such as excluding oxygen, controlling flow, and passage through manifolds are discussed in greater detail below.

[0032] In one aspect, the invention provides a method of forming a catalyst that comprises the steps of: (1) depositing a layer of Al, (2) forming a layer of metal aluminide on a metal alloy; (3) oxidizing the metal aluminide to form an alumina scale (4) optionally coating with a metal oxide sol (or metal oxide slurry); and (5) adding a catalyst material (typically by impregnation). Preferably the metal oxide sol or slurry is an alumina sol (here, alumina sol means a sol that after being deposited and heated, forms alumina) or alumina slurry. The invention also includes each of the individual steps or any combination thereof. For example, steps (1) and (2), deposition of Al and formation of a metal aluminide can be accomplished in a single step. In another example, steps (4) and (5), coating with a catalyst precursor sol, and addition of a catalyst metal, can be incorporated into a single step.

[0033] The invention further includes microchannel apparatus that is treated by any of the inventive methods; for example, the invention includes microchannel apparatus that comprises a uniform or tailored coating, or an apparatus that is made by oxidizing a nickel aluminide or applying a wash coat. The invention also includes the optional coating of pipes, tubes, or other structures attached to the microchannel apparatus.

[0034] The invention also includes methods for catalytic chemical conversion, such method comprising flowing a reactant fluid composition into a microchannel, wherein a catalyst composition is present in the microchannel, and reacting the reactant fluid composition into a desired product (or products) in the microchannel. The invention further includes methods for catalytic chemical conversion comprising contacting at least one reactant with an inventive catalyst. The invention also includes methods of conducting unit operations using any of the apparatus described herein.

[0035] The inventive methods are broadly applicable to wash coating compositions and coating compositions are well-known for a wide variety of desired coatings. Preferred coatings of the present invention include catalyst, passivation layer, or adsorbent coatings. A preferred coating composition is alumina sol.

[0036] Glossary of Terms Used

[0037] "Capillary features" are features associated with a microchannel that are used to hold liquid substances. They are either recessed within a wall of a microchannel or protrude from a wall of the microchannel into the flow path that is adjacent to the microchannel wall. The features create a spacing that is less than 1 mm, more preferably 250 microns or less, still more preferably a spacing of 100 μm or less. The features have at least one dimension that is smaller than any dimension of the microchannel in which they are situated.

[0038] A "catalyst material" is a material that catalyzes a desired reaction. It is not alumina. A catalyst material may include metals, metal oxides, and acidic sites.

[0039] A "catalyst metal" is the preferred form of catalyst material and is a material in metallic form that catalyzes a desired reaction. Particularly preferred catalyst metals are Pd, Rh and Pt.

[0040] A "chemical unit operation" comprises reactions, separations, heating, cooling, vaporization, condensation, and mixing.

[0041] A "complex microchannel" is in apparatus that includes one or more of the following characteristics: at least one contiguous microchannel has a turn of at least 45°, in some embodiments at least 90°, in some embodiments a u-bend, a length of 50 cm or more, or a length of 20 cm or more along with a dimension of 2 mm or less, and in some embodiments a length of 50-500 cm; at least 2 adjacent channels, having an adjacent length of at least one cm, are connected by plural orifices along a common microchannel wall where the area of orifices amounts to 20% or less of the area of the microchannel wall in which the orifices are located and where each orifice is 2 mm^2 or smaller, in some embodiments 1 mm^2 or smaller, in some embodiments 0.6 or 0.1 mm^2 or smaller—this is a particularly challenging configuration because a coating should be applied without clogging the holes; or at least two, in some embodiments at least 5, parallel microchannels having a length of at least 1 cm, have openings to an integral manifold, where the manifold includes at least one dimension that is no more than three times the minimum dimension of the parallel microchannels (for example, if one of the parallel microchannels had a height of 1 mm (as the smallest dimension in the set of parallel microchannels), then the manifold would possess a height of no more than 3 mm). An integral manifold is part of the assembled device and is not a connecting tube. A complex microchannel is one type of interior microchannel.

[0042] A "contiguous microchannel" is a microchannel enclosed by a microchannel wall or walls without substantial breaks or openings—meaning that openings (if present) amount to no more than 20% (in some embodiments no more than 5%, and in some embodiments without any openings) of the area of the microchannel wall or walls on which the opening(s) are present.

[0043] The phrase a "coating grows away from the wall" refers to the direction that a coating grows—either by thermal oxidation or an accretion process such as washcoating.

[0044] An "interior microchannel" is a microchannel within a device that is surrounded on all sides by a microchannel wall or walls except for inlets and outlets, and, optionally, connecting holes along the length of a microchannel such as a porous partition or orifices such as