[0038] 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 that 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 0.6 mm^2 or smaller, in some embodiments 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.

[0039] 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.

[0040] A "dense and substantially defect-free alumina layer" is illustrated in **FIG. 1**. To the scientist or engineer skilled in analyzing catalysts, a microscopic examination of a surface will show whether a given alumina surface, or a the surface of a catalyst with an alumina support layer, is or is not "dense and substantially defect-free alumina layer." A preferred type of "dense and substantially defect-free alumina layer" is an alumina layer that is thermally grown from an aluminide at a temperature of 1000 to 1100 ° C.

[0041] "Directly disposed" means that the catalytic material is directly applied to the thermally-grown aluminum oxide layer. The catalytic material can be deposited from solution, electroless plating, or less preferably, CVD. There is not an intervening washcoating, nor is the catalytic material codeposited with a washcoated catalyst support. "Directly deposited" has the same meaning.

[0042] 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 connecting orifices between a fuel channel and an oxidant channel. Since it is surrounded by walls, it is not accessible by conventional lithography, conventional physical vapor deposition, or other surface techniques.

[0043] An "insert" is a component that can be inserted into a channel.

[0044] A "manifold" is a header or footer that connects plural microchannels and is integral with the apparatus.

[0045] "Ni-based" alloys are those alloys comprising at least 30%, preferably at least 45% Ni, more preferably at least 60% (by mass). In some preferred embodiments, these alloys also contain at least 5%, preferably at least 10% Cr.

[0046] A "post-assembly" coating is applied onto three dimensional microchannel apparatus. This is either after a laminating step in a multilayer device made by laminating sheets or after manufacture of a manufactured multi-level apparatus such as an apparatus in which microchannels are drilled into a block. This "post-assembly" coating can be contrasted with apparatus made by processes in which sheets are coated and then assembled and bonded or apparatus made by coating a sheet and then expanding the sheet to make a three-dimensional structure. For example, a coated sheet that is then expanded may have uncoated slit edges. The post-assembly coating provides advantages such as crack-filling and ease of manufacture. Additionally, the aluminide or other coating could interfere with diffusion bonding of a stack of coated sheets and result in an inferior bond since aluminide is not an ideal material for bonding a laminated device and may not satisfy mechanical requirements at high temperature. Whether an apparatus is made by a post-assembly coating is detectable by observable characteristics such as gap-filling, crack-filling, elemental analysis (for example, elemental composition of sheet surfaces versus bonded areas) Typically, these characterisitics are observed by optical microscopy, electron microscopy or electron microscopy in conjunction with elemental analysis. Thus, for a given apparatus, there is a difference between pre-assembled and post-assembled coated devices, and an analysis using well-known analytical techniques can establish whether a coating was applied before or after assembly (or manufacture in the case of drilled microchannels) of the microchannel device.

BRIEF DESCRIPTION OF THE FIGURES

[0047] **FIG. 1** is a photomicrograph of a dense and substantially defect-free alumina surface.

[0048] **FIG. 2** is a simplified view of a microreactor with a set of reaction microchannels in a cross-flow relationship with a set of cooling microchannels.

[0049] **FIG. 3** is a schematic cross-sectional illustration of an aluminide coated substrate.

[0050] **FIG. 4** is a schematic illustration of a microchannel system in which heat from a reaction microchannel is transferred to an adjacent endothermic reaction.

[0051] **FIG. 5** is a plot of Selectivity vs. conversion for Pt—Sn catalysts at 2.4:1 and 1:5 Pt:Sn loadings; also for $LaMnO_3$ catalyst. The Pt:Sn=2.4:1 catalyst and LaMnO3 catalyst were tested under 3:2:1 ethane:hydrogen:oxygen at 40 ms while the Pt:Sn=1:5 catalyst is tested under 4:2:1 ethane:hydrogen:oxygen at 50 ms. The Literature value is from BP Patent WO 02/04389.

[0052] **FIG. 6** is an SEM photomicrograph of a Pt:Sn=1:5 catalyst.

[0053] **FIG. 7** is an SEM photomicrograph of a Pt:Sn=2.4:1 catalyst.