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.

[0045] An "insert" is a component that can be inserted into a channel either before or after assembly of the reactor or separator.

[0046] "Interior microchannel" refers to a microchannel that is bounded 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.

[0047] A "manifold" is a header or footer that connects plural microchannels and is integral with the apparatus.

[0048] Measurement techniques—For all coatings, "average thickness" can be measured by cross-sectional microscopy (obtained by cutting open a microchannel device) or, for coatings that are about 5 μm thick or less, by EDS elemental analysis. In the case of channels connected to a common manifold or otherwise connected to be filled from the same inlet, the "average thickness" is averaged over all the channels, or for a large number of connected channels, at least 10 channels selected to fairly represent the totality of the connected channels. Measurements should be made over the entire length of a continguous coating; that is, not just for 1 cm selected out of a larger contiguous coating. "Coating loading" is measured the same as average thickness except that height and/or thickness (or elemental analysis) of the coating is measured to get a volume or mass. Unless specified as a corner measurment, average coating thickness should be measured along the center line between corners (if present), and any set of corners can be selected. Corner thickness can be measured on a single corner; however, the corner must be representative (not an aberration).

[0049] "Metal aluminide" refers to a metallic material containing 10% or more Metal and 5% or greater Aluminum (Al) with the sum of Metal and Al being 50% or more. These percentages refer to mass percents. Preferably, a metal aluminide contains 50% or more Metal and 10% or greater Al with the sum of Ni and Al being 80% or more. In embodiments in which Metal and Al have undergone significant thermal diffusion, it is expected that the the composition of a Metal-Al layer will vary gradually as a function of thickness so that there may not be a distinct line separating the Metal-Al layer from an underlying Metal-containing alloy substrate. The term "aluminide" is used synonamously with metal aluminide.

[0050] A preferred metal aluminide is nickel aluminide (NiAl). "Nickel aluminide" refers to a material containing 10% or more Ni and 5%, more preferably 10% or greater Al with the sum of Ni and Al being 50% or more. These percentages refer to mass percents. Preferably, a nickel aluminide contains 20% or more Ni and 10% or greater Al with the sum of Ni and Al being 80% or more. In embodiments in which Ni and Al have undergone significant thermal diffusion, it is expected that the the composition of a Ni—Al layer will vary gradually as a function of thickness so that there may not be a distinct line separating the Ni—Al layer from an underlying Ni-based alloy substrate.

[0051] "Ni-based" alloys are those alloys comprising at least 30%, prefearbly 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.

[0052] 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 subassemblies, 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.

[0053] A "separator" is a type of chemical processing apparatus that is capable of separating a component or components from a fluid. For example, a device comprising an adsorbent, absorbent, distillation or reactive distillation apparatus, etc.

[0054] The phrase "substantially depleted within the microchannel" means that the reactant(s) are consumed such that if a slow draining process were conducted at the reactoin temperature, the draining process would not result in a substantially non-uniform (>20% variation) coating thickness. Preferably, more than 90% of one essential reactant has been reacted.

BRIEF DESCRIPTION OF THE FIGURES

[0055] **FIG. 1** is a simplified view of a microreactor with a set of reaction microchannels in a cross-flow relationship with a set of cooling microchannels.

[0056] **FIG. 2** is a photograph of a cut-open, microchannel device showing an aluminidized channel surface. This surface was on the side of a microchannel that was opposite a side having orifices (jets) and aluminidizing gas flowed through these orifices and impacted the surface, causing jet impingment defects.

[0057] **FIG. 3** is a schematic cross-sectional illustration of an aluminide coated substrate.