[0058] **FIG. 4** is an illustrative sketch of washcoat model variables.

[0059] **FIG. 5** is the calculated film thickness of a channel that is filled and drained with a washcoat composition.

[0060] **FIGS. 6***a* and **6***b* show calculated shape of the meniscus in a horizontal groove. **FIG. 6***a* is the shape of the meniscus in horizontal groove as predicted by 1-D model assuming a 5 mm deep by 5 mm wide channel, a 45 degree contact angle, and a gravity factor of 1. **FIG. 6***b* is the shape of the meniscus in horizontal groove as predicted by 1-D model assuming a 0.125 mm deep by 0.5 mm wide channel, an 80 degree contact angle, and a gravity factor of 10.

[0061] **FIG. 7** illustrates the stages of filling of a capillary feature (niche).

[0062] **FIG. 8** is a schematic illustration of capillary retention.

[0063] **FIGS. 9***a***-9***i* illustrate various embodiments of capillary features.

[0064] **FIG. 10** is a partly exploded view of a multichannel, microchannel device in which the interior microchannels were coated with aluminide.

[0065] **FIGS. 11 and 12** are cross-sectional SEM micrographs of aluminidized channels within the device of **FIG. 10**.

[0066] **FIG. 13***a* shows a cross-sectional SEM micrograph of an aluminidized corner within a microchannel.

[0067] **FIG. 13***b* illustrates distances that can be measured to characterize a corner coating.

[0068] **FIG. 14** shows a cross-sectional SEM micrograph of an aluminidized crevice at a microchannel corner.

[0069] **FIG. 15** shows calculated performance of a combustion reaction in selected microchannel apparatus as a function of deviation from uniform coating.

[0070] **FIG. 16** shows a cross-sectional SEM micrograph of an aluminidized sample of Inconel™ 617.

[0071] **FIG. 17** shows a cross-sectional SEM micrograph of a coupon of Inconel™ 617 that was aluminidized (left), or exposed to air at 400° C. for one hour to grow some surface oxide prior to growing the aluminide layer.

[0072] **FIG. 18** shows a cross-sectional SEM micrograph of a coupon of Inconel™ 617 that was aluminidized in the presence of alumina disks.

[0073] **FIG. 19** illustrates results of methane steam reforming comparing washcoated channels with (○) and without (□) capillary features.

DESCRIPTION OF THE INVENTION

[0074] Microchannel Apparatus

[0075] Microchannel reactors are characterized by the presence of at least one reaction channel having at least one dimension (wall-to-wall, not counting catalyst) of 1.0 cm or less, preferably 2.0 mm or less (in some embodiments about 1.0 mm or less) and greater than 100 nm (preferably greater than 1 μm), and in some embodiments 50 to 500 μm. A catalytic reaction channel is a channel containing a catalyst, where the catalyst may be heterogeneous or homogeneous. A homogeneous catalyst may be co-flowing with the reactants. Microchannel apparatus is similarly characterized, except that a catalyst-containing reaction channel is not required. Both height and width are substantially perpendicular to the direction of flow of reactants through the reactor. Microchannels are also defined by the presence of at least one inlet that is distinct from at least one outlet—microchannels are not merely channels through zeolites or mesoporous materials. The height and/or width of a reaction microchannel is preferably about 2 mm or less, and more preferably 1 mm or less. The length of a reaction channel is typically longer. Preferably, the length of a reaction channel is greater than 1 cm, in some embodiments greater than 50 cm, in some embodiments greater than 20 cm, and in some embodiments in the range of 1 to 100 cm. The sides of a microchannel are defined by reaction channel walls. These walls are preferably made of a hard material such as a ceramic, an iron based alloy such as steel, or a Ni-, Co- or Fe-based superalloy such as monel. The choice of material for the walls of the reaction channel may depend on the reaction for which the reactor is intended. In some embodiments, the reaction chamber walls are comprised of a stainless steel or Inconel® which is durable and has good thermal conductivity. The alloys should be low in sulfer, and in some embodiments are subjected to a desulfurization treatment prior to formation of an aluminide. Typically, reaction channel walls are formed of the material that provides the primary structural support for the microchannel apparatus. The microchannel apparatus can be made by known methods (except for the coatings and treatments described herein), and in some preferred embodiments are made by laminating interleaved plates (also known as "shims"), and preferably where shims designed for reaction channels are interleaved with shims designed for heat exchange. Of course, as is conventionally known, "reactors' or 'separators' do not include jet engine parts. In preferred embodiments, microchannel apparatus does not include jet engine parts. Some microchannel apparatus includes at least 10 layers laminated in a device, where each of these layers contain at least 10 channels; the device may contain other layers with less channels.

[0076] **FIG. 1** is a schematic and simplified view of one embodiment of a microchannel reactor in which reactant feed passes through a reaction microchannel (bottom) while coolant (in a cross-flow arrangement) flows through an adjacent heat exchanger (top). Microchannel reactors preferably include a plurality of microchannel reaction channels and a plurality of adjacent heat exchange microchannels. The plurality of microchannel reaction channels may contain, for example, 2, 10, 100, 1000 or more channels. In preferred embodiments, the microchannels are arranged in parallel arrays of planar microchannels, for example, at least 3 arrays of planar microchannels. In some preferred embodiments, multiple microchannel inlets are connected to a common header and/or multiple microchannel outlets are connected to a common footer. During operation, the heat exchange microchannels (if present) contain flowing heating and/or cooling fluids. Non-limiting examples of this type of known reactor usable in the present invention include those of the microcomponent sheet architecture variety (for example, a laminate with microchannels) exemplified in U.S. Pat. Nos. 6,200,536 and 6,219,973 (both of which are hereby incorporated by reference). Performance advantages in the use of this type of reactor architecture for the purposes