rod with a 0.375" by 0.045" axial microchannel that also had 20 axial capillary features (group in two sets of 10 separated by a large central rib) that were 0.010" deep by 0.012" wide and separated by 0.004" ribs. The axial capillary features gave the second test device 40% more geometric surface area than the first test device. Each test device was heat treated to produce a chromia scale and catalyst was wash coated on to the interior surfaces. For each device there were 7 washcoating steps of 15 wt %/o alumina sol, followed by 1 washcoating step of 10 wt % Pr and 2 washcoating steps of 10 wt % Pt. Total uptake of catalyst on the first device (flat microchannel) was measured to be 7.9 mg/in^2. Total uptake of catalyst on the second device with capillary features was measured to be 14 mg/in^2 (an increase of more than 77% or 1.77×). Each test device received the same number of sol alumina and active metal wash coats. When methane combustion (2% methane, 15% excess air, 10% steam, balance nitrogen) was conducted it was found that the steady state conversion of methane in the microchannel with capillary features was 2.4 times as great as that in the first flat microreactor without any surface or capillary features. The initial conversion was 1.24× higher with the microchannel with capillary features than for the flat microchannel. The deactivation rate was substantially more pronouced for the flat microchannel over the capillary-featured microchannel. It is theorized that the catalyst on the flat microchannel sees a higher wall shear stress resulting from the high gas velocity flowing past the flat wall. The average velocity for the flat microchannel exceeds 100 m/s for this example. The resulting shear stress for the calculated laminar flow exceeds 6 Pa, as defined by the product of the viscosity and the velocity gradient normal to the direction of flow. The expected wall shear stress within the capillary feature is expected to be less than 1 Pa as very little flow is expected within the recessed capillary feature. As the temperature of the coating increases from the exothermic combustion reaction, the resulting material stress between the coating and the wall (each material with very different coefficients of thermal expansion) may make the coating more prone to cracks and flaking—thus exacerbating the catalyst deactivation resulting from loss of material. Correspondingly, the catalyst retained within the capillary feature does not see as high of a wall shear stress and thus is less likely to undergo flaking even though the expected temperature in the catalyst coating is higher because the methane conversion and thus heat release is higher. Further, the coating in the capillary feature has more surface area and the base metal structure upon which the coating sits is stiffer, thus the coating will be stronger in tension. The CTE mismatch between the microchannel metal wall and the alumina coating will put the coating into tension at the elevated temperature and thus prone to cracks. It should also be noted that the metal microchannel in this example was not aluminidized, but rather contained an alumina sol washcoated directly onto a heat treated surface. The aluminidized channel is theorized to create a graded material from the bulk metal to the ceramic overlaying coating wherein the CTE mismatch issue is minimized by the graded coefficient of thermal expansion. The resulting ceramic coatings applied over an aluminized surface are theorized to be stronger in tension and less prone to crack formation.

[0350] The experimental results are shown in **FIG. 19**. The total reactant flowrate was 19 SLPM and the temperature was 800 C. The relative amount of increase in performance (2.4×) exceeded the measured amount of surface catalyst loading (1.7×) and also exceded the amount of increase in geometric surface area (1.4×). Further, the increase in residence time if all the volume of the capillary features is open for flow is 1.14×. Model predictions were done where an assumed uniform coating was created on all capillary features and the intervening flat walls and ribs; for this calculation a predicted conversion improvement of 2% (1.02×) was calculated. This predicted enhancement was quite low compared to actual as a result of higher catalyst loading in the capillary features and possibly a higher than calculated effectiveness factor for area found within the capillary features. It is further theorized that capillary features act to create stagnant areas for flow such that a residence time distribution is created in the microchannel. The reactant molecule on average has slightly more time to react in the device that contains capillary features because the reactant molecules may not be convectively swept away from the bulk flow microchannel during the short contact time operation.

[0351] Capillary features demonstrated surprisingly superior results as compared with identically prepared channels without capillary features.

[0352] In preferred embodiments of the invention, washcoating produces 0.5 mg/cm^2 or more increase in coating thickness, more preferably 1 mg/cm^2 or more, as compared with washcoating a microchannel under identical conditions except without capillary features. In this case, cm^2 refers to the geometric surface area of the channel before coating and this value does not count the extra area provided by the capillary features.

We claim:

1. Microchannel apparatus, comprising:

an interior microchannel comprising a microchannel wall;

a contiguous post-assembly coating along a contiguous length of at least 1 cm of the microchannel wall;

wherein the contiguous post-assembly coating has a contiguous length of at least 1 cm that has an average thickness (measured perpendicular to the microchannel length and in the direction in which a coating grows away from the wall) of at least 5 μm and wherein at least 90% of the contiguous length of coating is within +/−20% of the average thickness.

2. The microchannel apparatus of claim 1 wherein the contiguous post-assembly coating has a contiguous length of at least 1 cm that has an average thickness (measured perpendicular to the microchannel length and in the direction in which a coating grows away from the wall) of at least 15 μm and wherein at least 90% of the contiguous length of coating is within +/−3 μm of the average thickness.

4. A method of conducting a unit operation, comprising:

passing a fluid into the interior microchannel of the apparatus of claim 1; and

conducting a unit operation on the fluid in the interior microchannel.

5. The method of claim 4 wherein the interior microchannel comprises a catalytic material, and wherein the microchannel apparatus of claim 1 is a reactor, and wherein the unit operation comprises a chemical reaction.