

the device based on the metrics developed here. Examples of the aluminide coating resulting from this guidance produced aluminide coatings without visual defects.

[0094] Masking

[0095] The aluminizing processes discussed above produce aluminide coatings throughout a channel. However, it is theoretically possible to selectively coat portions of a channel by masking off sections of a channel. This might be done by masking portions of a sheet with a refractory material and then laminating the masked sheet into a laminate. After aluminization the mask could be removed, such as by burning. Possible refractory materials might include Mo, diamond, and graphite.

[0096] FIG. 3 schematically illustrates an application in which a metal substrate 42 has an optional nickel-containing layer (such as a nickel strike) 44, a layer of aluminide 46, and a layer of alumina 48. In preferred embodiments, the outermost layer further comprises an additional catalytically active material 49.

[0097] Catalyst Coatings

[0098] Catalysts can be applied directly deposited onto an oxide using techniques that are known in the art such as chemical vapor deposition (CVD) and electroless plating. Impregnation with soluble aqueous salts is preferred. Pt, Rh, and/or Pd are preferred in some embodiments. Typically this is followed by heat treatment and activation steps as are known in the art. Salts which form solutions of pH>0 are preferred.

[0099] The catalytically-active material of the present invention is not particularly limited. Among preferred catalytic materials of the present invention are the so-called high-temperature catalysts, i.e., those comprising noble metals, preferably catalyst materials comprising at least one metal selected from the group consisting of Pt, Pd, Rh, Ni, Co, Ag, Au, Ir and Ru. For oxidative dehydrogenation, preferred catalytically-active materials of the present invention also include the so-called low-temperature catalysts, which may comprise at least one oxide or phosphate of a metal selected from the group consisting of Li, Mo, V, Nb, Sb, Sn, Zr, Cr, Mg, Mn, Ni, Co, Ce, rare-earth metals (such as Sm), and mixtures thereof. The low or high temperature catalyst may contain additional components such as alkali or alkaline earth promoters, or metals such as Cu, Ag, or Sn. Catalysts can be, for example, vanadia dispersed on alumina, or platinum on alumina. For oxidative dehydrogenation (ODH), Pt, Sn, Cu and combinations thereof are especially preferred. In some preferred embodiments, the Pt: Sn ratio is in the range of 1 to 4, more preferably 2.1-2.7, still more preferably 2.3 to 2.5. Surprisingly, it was discovered that superior results could be obtained in a microchannel with these relatively high Pt:Sn ratios. Lanthanum manganate is another preferred catalytic material for ODH. Pt is a preferred catalyst for combustion.

[0100] For flat or substantially flat substrates (such as a flat microchannel wall), catalyst can be characterized by the amount of catalytic material on a geometric surface area; that is, an area that can be measured with a ruler. In some preferred embodiments, the catalyst contains at least 0.3 mg/cm² catalytic material, in some preferred embodiments at least 0.6 mg/cm² catalytic material, and in some embodiments 0.2 to 2 mg/cm² catalytic material.

[0101] Unless otherwise specified, elemental analyses of wall coatings should be determined using energy dispersive spectroscopy (EDS) at 20 kV excitation energy (at 100 \times , or if 100 \times is larger than the area available, then the largest available area for SEM, recognizing that some modifications may be required if such measurement conditions are impracticable for particular systems). As is well-known, this technique measures the surface composition, as well as some thickness below the surface.

[0102] Some catalysts of this invention have a surface area, as measured by N₂ adsorption BET, of 10 m²/g or less, and in some embodiments a surface area of 5 m²/g or less.

[0103] Electroless Plating

[0104] The use of electroless plating, where a chemical reaction is used to plate a metal along the reactor walls may also create a catalyst coating. It should be noted that the electroless plating solution is preferably filled (to the desired height) within the channels prior to the initiation of the reaction. The solution could be introduced at room temperature or below and then heated to the requisite plating temperature. Conversely, the plating reaction should preferably be minimized before draining the fluid from the microchannel or else a non-uniform coating could be obtained along the channel length and from channel to channel. Specifically, a thicker coating would be expected near the bottom of the channel as the fluid will remain in contact with the channel walls near the bottom of the microchannel for substantially more time during drying.

[0105] As is known, an electroless plating solution comprises a metal compound and a reducing chemical. A complexing agent may be added to prevent reduction of the metal ions in solution. In some embodiments, the reduction process may be catalyzed by a small amount of catalytic metal ions. The microchannel walls could be ceramic, metal, alumina-coated aluminide, etc. Preferred metals for the electroless deposition include Cu, Ni, Fe, Co, Au, Ag, Pd, Pt, Sn, Ir, Rh and combinations thereof. After plating, the residual solution could be drained out.

[0106] Reactions

[0107] The coated microchannel apparatus is especially useful when used with a surface catalyst and at high temperature, for example, at temperatures above 180° C., above 250° C., above 500° C., in some embodiments 700° C. or higher, or in some embodiments 900° C. or higher.

[0108] In some aspects, the invention provides a method of conducting a reaction, comprising: flowing at least one reactant into a microchannel, and reacting the at least one reactant in the presence of a catalyst within the microchannel to form at least one product. In some embodiments, the reaction consists essentially of a reaction selected from: acetylation, addition reactions, alkylation, dealkylation, hydrodealkylation, reductive alkylation, amination, ammoxidation, ammonia synthesis, aromatization, arylation, autothermal reforming, carbonylation, decarbonylation, reductive carbonylation, carboxylation, reductive carboxylation, reductive coupling, condensation, cracking, hydrocracking, cyclization, cyclooligomerization, dehalogenation, dimerization, epoxidation, esterification, exchange, Fischer-Tropsch, halogenation, hydrohalogenation, homologation, hydration, dehydration, hydrogenation, dehydrogenation, hydrocarboxylation, hydroformylation, hydro-