ethane and oxygen in a reaction microchannel; wherein (a) at least 50% of the ethane entering the reaction microchannel is converted to products and the selectivity to ethene is at least 85%; or (b) at least 70% of the ethane entering the reaction microchannel is converted to products and the selectivity to ethene is at least 80%; and wherein the levels of selectivity and conversion are based on a single pass through the reaction microchannel. The reaction microchannel comprises a catalyst coated on a substrate. In a preferred embodiment, the substrate is a wall of the reaction microchannel. Preferably, this reaction is conducted with relatively little diluent. Preferably, in this process, heat is removed from the reaction microchannel into an adjacent heat exchanger, preferably a microchannel heat exchanger.

[0025] In a further aspect, the invention provides a process for oxidative dehydrogenation, comprising: passing an alkane over a fixed catalyst comprising Pt and Sn in a Pt/Sn atomic ratio in the range of 1 to 4 directly disposed on a dense and substantially defect-free oxide layer.

[0026] In another aspect, the invention provides a process of making a catalyst in a microchannel reactor, comprising: forming an aluminide layer in an interior microchannel; thermally growing an alumina layer from the aluminide layer; and depositing a catalyst material directly onto the thermally-grown alumina.

[0027] In a further aspect, the invention provides a catalyst comprising: an aluminide-containing substrate; a thermally-grown alumina layer disposed on the aluminum containing substrate; and a catalyst material directly disposed on the thermally-grown alumina layer.

[0028] The invention includes methods for catalytic chemical conversion, such method comprising flowing a reactant fluid composition into a microchannel, wherein a catalyst composition is present in the microchannel (on a microchannel wall or elsewhere within the microchannel), and reacting the reactant fluid composition to form a desired product (or products) in the microchannel. The invention further includes methods for catalytic chemical conversion comprising contacting at least one reactant with an inventive catalyst.

[0029] Some aspects of the present invention include passage of gaseous aluminum compounds over metal surfaces (especially a metal wall of a microchannel) and simultaneously or subsequently reacting with a metal in the substrate to form a surface layer of metal aluminide—this process is termed aluminization, perhaps more accurately, aluminidization. Conditions for aluminidization are conventionally known for jet engine parts, and the conventional steps are not described here. Certain steps such as excluding oxygen, controlling flow, and passage through manifolds are discussed in greater detail below.

[0030] Conventional wisdom is to form catalysts by depositing catalyst materials on high surface area supports. In contrast, the present invention provides catalysts in which a catalytic material is deposited directly on a dense or thermally-grown alumina layer. The thermally-grown alumina layer has excellent adhesion and the resulting catalyst (including alumina layer and deposited catalytic material) has excellent activity in a microchannel reactor, especially for high temperature reactions at high flow rates (low contact times).

[0031] Glossary of Terms Used

[0032] "Metal aluminide" refers to a metallic material containing 10% or more Metal and 5%, more preferably 10%, 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.

[0033] A preferred metal aluminide is nickel aluminide (NiAl). "Nickel aluminide" refers to a material containing 10% or more Ni and 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.

[0034] A "catalyst material" is a material that catalyzes a desired reaction. It is not alumina. A catalyst material "disposed over" a layer can be a physically separate layer (such as a sol-deposited layer) or a catalyst material disposed within a porous, catalyst support layer. "Disposed onto" or "disposed over" mean directly on or indirectly on with intervening layers. In some preferred embodiments, the catalyst material is directly on a thermally-grown alumina layer.

[0035] A "catalyst metal" is the preferred form of catalyst material and is a material in metallic form that catalyzes a desired reaction. Particularly preferred catalyst metals are Pd, Rh and Pt.

[0036] As is conventional patent terminology, "comprising" means including and when this term is used the invention can, in some narrower preferred embodiments, be described as "consisting essentially of" or in the narrowest embodiments as "consisting of" Aspects of the invention described as "comprising a" are not intended to be limited to a single component, but may contain additional components. Compositions "consisting essentially of" a set of components allow other components that so not substantially affect the character of the invention, and, similarly, compositions that are "essentially" without a specified element do not contain amounts of the element as would substantially affect the desired properties.

[0037] Unless stated otherwise, "conversion percent" refers to absolute conversion percent throughout these descriptions. "Contact time" is defined as the total catalyst chamber volume (including the catalyst substrate volume) divided by the total volumetric inlet flowrate of reactants at standard temperature and pressure (STP: 273 K and 1.013 bar absolute). Catalyst chamber volume includes any volume between a catalyst coating (or other flow-by catalyst arrangement) and the opposite wall of a reaction channel.