822, is inserted into a hole **824** in a laminated device. Preferably, the laminated device is formed by the ortho method. The mixing insert can be any structure that causes flow streams to cross and thus mix, preferred structures are helical, double helical, spriral, alternating spiral patterns, and the like.

[**0088**] Preferred materials for the shims are plastic, metal, ceramic, glasses and composites, depending on the desired characteristics. In some preferred embodiments, the shims are made of a nonporous material, although they could alternately be constructed with a porous or partially porous material. The presence of apertures for fluid flow and unit operations has been emphasized; however, it should be recognized that the shims may also contain additional features such as headers and connectors (for example inlets and outlets to fluid conduits) for connecting the inventive devices to other devices, fluid sources, reactors, etc., and alignment holes that are used to align shims prior to bonding. Additionally, components (such as, but not limited to, catalysts, mixers and sorbents) can be inserted into the apertures. In some preferred embodiments, the area of each individual aperture (such as an aperture that defines the boundary of a flow path) is less than 20 cm^2; and in some embodiments, the area of each individual aperture is in the range of 10^{-8} to 10^{-2} m^2. As an example an aperature could be as large as 80 cm wide and 0.25 cm thick, or much smaller.

[**0089**] The aperture-containing shims can be formed by processes including: conventional machining, wire EDM, laser cutting, photochemical machining, electrochemical machining, molding, water jet, stamping, etching (for example, chemical, photochemical and plasma etch) and combinations thereof. For low cost, stamping is especially desirable. The shims may be joined together by diffusion bonding methods such as a ram press or a HIP chamber. They may also be joined together by reactive metal bonding or other methods that create a face seal. Shims also may be joined by laser welding. Devices could alternatively be joined by the use of adhesives. In preferred embodiments, devices are laminated in a single step, in less preferred embodiments, a first set of shims is bonded together and subsequently bonded to a second (or more) set of shims. In some preferred embodiments, a set of shims are bonded together in a single step and then the resulting bonded article is cut into multiple devices.

[**0090**] The ortho design can be utilized to produce a multitude of integrated devices. Some nonlimiting examples of devices, include: chemical reactors (such as a steam reformer, integrated reformer/combustor, etc.), apparatus for phase change such as condensers or vaporizers, chemical separators such as distillation apparatus, temperature or pressure swing adsorption, and selective membrane separations, and chemical detectors or analyzers. Fluid passages may contain materials such as catalysts (in some preferred embodiments catalysts of two different types are disposed in adjacent fluid passages), adsorbents, absorbents, and heat exchange fluids (such as water, liquid metals, etc.). Thus there are a plethora of materials that could be disposed in the fluid passages. Examples of just a few such materials that could be used in the fluid passages include metal films (such as comprising Ni, Pd, etc.) and catalyst metals on a metal or oxide support. In some preferred embodiments, there are one, two or more heat exchange fluid passages (which, during operation, would contain a heat exchange fluid) adjacent one, two or more fluid passages containing catalysts, adsorbents, or absorbents. In some preferred embodiments, an exothermic reaction is conducted in one fluid passage while an endothermic reaction is conducted in an adjacent fluid passage.

[**0091**] For simplicity and ease of construction, in some preferred embodiments, devices are made with 30 or less, more preferably 10 or less, different shim designs. In some preferred embodiments, flow through every part of the device is substantially in the ortho direction (except for headers and footers). In other designs, a device contains both ortho and non-ortho flow paths. In some preferred embodiments, ortho and non-ortho paths are separate flow paths. In some other embodiments, the same flow path contains sections of ortho flow through at least 3 (or at least 5) adjacent shims and non-ortho flow through at least 1 (or at least 3 adjacent) shims. For example, in some devices there could be flow (alternatively stated, a flow path) through at least 3 (or at least 5) adjacent shims in the ortho direction, followed by flow in a non-ortho direction through at least 1 (or at least 3 adjacent) shims, and again flow through at least 3 (or at least 5) adjacent shims in the ortho direction.

[**0092**] The invention can also be characterized by certain properties, such as the ability to withstand pressure differences between internal fluid passages. For example, a high pressure vaporizer is operating with a 272 psig pressure differential and at temperatures exceeding 210° C. that is separated by only a 500 micron thick wall made entirely of stainless steel 316. Pressure containment is enabled by the use of microchannels with offset ribs and rounded edges. Thus, in some preferred embodiments, the inventive devices or processes are characterized by the ability to withstand and/or operate at pressure differences, between adjacent channels, of at least 100 psig (pounds per square inch gauge) per 1000 micron of web thickness separating the channels, more preferably at least 200 psig/1000 micron, still more preferably at least 500 psig/1000 micron. Design features such as rounded edges and/or offsetting supports are useful in withstanding such pressure differences.

[**0093**] The invention also provides processes using any of the designs described herein. A list of nonlimiting examples of processes, includes: distilling, reacting, adsorbing, heating, cooling, compressing, expanding, separating, absorbing, vaporizing, condensing, and combinations of these. Examples of catalysts, reactions, process conditions and parameters (such as productivities) and reactor types that can also be applied in the context of the present invention are described in U.S. patent application Ser. No. 09/640,903 which is incorporated herein as if reproduced below.

EXAMPLES

Example 1

[**0094**] An integrated endothermic reaction and exothermic reaction reactor **300** was designed using the ortho shim style, where the flow is substantially parallel to the thickness of the shim. A shim is defined as a thin slice of metal, plastic, ceramic, or composite material. The thickness of the shim may range from 50 microns to 5000 microns. A preferred range of shim thickness is 250 microns to 2000 microns. Microchannels can be formed by assembling shims with