Method for Producing Components with Internal Architectures, Such as Micro-Channel Reactors, via Diffusion Bonding Sheets

Opportunity

The Department of Energy's National Energy Technology Laboratory (NETL) is seeking collaborative research and licensing partners interested in implementing United States Patent Number 7,900,811 entitled "Method for Producing Components with Internal Architectures, Such as Micro-Channel Reactors, via Diffusion Bonding Sheets."Disclosed in this patent is a method for producing microchannels using graduated diffusion bonding of a stack of precision machined foils or sheets (laminates) to make a micro-channel reactor. The method is a novel multi-step process for the diffusion bonding of laminates, which is independent of the channel width-to-fin lamina thickness (fin aspect ratio) and allows for laminae to uniformly and effectively bond. Unlike conventional hot-pressing methods, the NETL invention increases functional reaction surface area for higher conversion efficiency and reactor performance, and avoids micro-channel distortion that degrades fluid flow characteristics. This invention will have utility in micro-reactor design for heat exchangers, recuperators, heat-pumps, chemical separators, chemical reactors, fuel processing, and combustors.

Overview

Microchannel technology is an emerging field of advanced chemical processing with applications in many industrial processes including chemical synthesis and biomass and synthesis gas fuel conversion. Microchannel reactors are composed of multiple stacked laminae containing multiple parallel arrays of microchannels with diameters in the range of 100–500 µm. When incorporated into microreactor designs, heat and mass transfer limitations are minimized allowing for process intensification. Compared to conventional reactors, the design allows for efficient and precise temperature control resulting in higher reaction rates, feedstock throughput, and conversion efficiency.

Conventional vacuum hot-pressing methods for bonding laminae to form multichannel reactors are limited by the channel fin aspect ratio at a given uniaxial pressure. Exceeding the fin aspect ratio results in distortion of the fins and produces a structure with poor flow properties. The current invention relates to a novel multi-step process for the graduated diffusion bonding of laminates, which is independent of the fin aspect ratio and allows for laminae to uniformly and effectively bond. The first process step uses low uniaxial pressure and temperature to form weak diffusion bonding of laminates at interfacial contact areas. The second process step occurs under high isostatic gas pressure and temperature, producing a uniform pressure gradient across all laminate surfaces, which acts to further increase interfacial diffusion bonding. This invention allows for the fabrication of seamless monolith structures containing nondistorted multiple parallel arrays of microchannels resulting in improved fluid flow characteristics. Additionally, pores and unintentional voids present in the laminates are greatly diminished. Use of this method will increase functional reaction surface within stacked laminates allowing for higher conversion efficiency.

Significance

- Laminates may be diffusion bonded regardless of fin aspect ratio.
- Fluid flow characteristics are not degraded as a result of microchannel distortion.
- Increased functional reaction surface area allows for higher conversion efficiency.
- Fabrication process diminishes pores and unintentional voids present in the laminates.
- No need for sacrificial cores, internal gaskets, templates, brazing alloys, or binders.

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