JOINING OF DISSIMILAR MATERIALS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application No. 60/632,030 filed Nov. 30, 2004, entitled JOINING OF DISSIMILAR MATERIALS. This provisional patent application is incorporated herein by reference in its entirety for all purposes.

STATEMENT OF GOVERNMENT SUPPORT

[0002] This invention was made with government support under Contract DE-AC02-05CH11231 awarded by the United States Department of Energy to The Regents of the University of California for the management and operation of the Lawrence Berkeley National Laboratory. The government has certain rights in this invention.

FIELD OF THE INVENTION

[0003] The invention relates to the joining of dissimilar materials, such as metal and ceramic, by means of decoration and sinter bonding.

BACKGROUND

[0004] Numerous methods are available for joining dissimilar materials, such as metal and ceramic, having different ductility, Many methods require the introduction of a third material into the joint, e.g., solder, braze, weld filler, or adhesive. This can limit the usefulness of the joint, especially for devices where utility is derived from the interface itself (such as electrochemical devices), or where the third material is incompatible with the system requirements (such as in medical implants). Typical methods for joining metals to ceramics include: chemical reaction between the metal and ceramic; brazing using a filler alloy that bonds to both the metal and ceramic; and, the use of a cermet (mixture of metal and ceramic typically of similar particle size) between the metal and ceramic to act as a transition zone. All of these methods have limitations.

[0005] Thus, there exists a need for improved techniques for joining dissimilar materials, such as ceramics and metals.

SUMMARY OF THE INVENTION

[0006] The present invention provides a method of joining dissimilar materials having different ductility. The method involves two principal steps: Decoration of the more ductile material's surface with particles of a less ductile material to produce a composite; and, sinter-bonding the composite produced to a joining member of a less ductile material. The joining method is suitable for joining dissimilar materials that are chemically inert towards each other (e.g., metal and ceramic), while resulting in a strong bond with a sharp interface between the two materials.

[0007] The joining materials may differ greatly in form or particle size. For example, the joining member may be a dense, monolithic piece of the less ductile material, a porous piece of the less ductile material, or particles of the less ductile material. Structures with interlayers or multiple layers may be formed. For example, a decorated composite may be sintered to a dense less ductile material via a porous less ductile material interlayer.

[0008] The particles decorating the more ductile material surface, the joining member and any additional members may be composed of the same material (e.g., ceramic such as YSZ) or different materials that sinter to one another (e.g., one or more ceramics and/or cermets, such as YSZ and LSM).

[0009] For the purposes of illustration, the invention is described in the context of joining metal (more ductile) and ceramic (less ductile). However, it should be understood that the invention is applicable to other types of materials as well (glass, glass-ceramic, polymer, cermet, semiconductor, etc.). The materials can be in various geometrical forms, such as powders, fibers, or bulk bodies (foil, wire, plate, etc.).

[0010] Also provided are composites and devices with a decorated and sintered interface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. **1** conceptually illustrates a bond relying on mechanical interlocking to particles or fibers at the interface of two surfaces.

[0012] FIGS. **2**A and B show scanning electron micrographs (SEMs) of the surface of steel particles decorated with yttria-stabilized zirconia (YSZ) ceramic particles.

[0013] FIG. **3** is a schematic figure of sintering.

[0014] FIGS. **4**A and B show cross-sectional SEM images of the joint between decorated metal particles and a dense YSZ member via a porous YSZ interlayer in accordance with one embodiment of the invention.

[0015] FIG. **5** is a schematic representation of the joint shown in FIGS. **4**A and B

[0016] FIG. **6** illustrates a steel current collector joined to a ceramic in a solid oxide fuel cell in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0017] Reference will now be made in detail to specific embodiments of the invention. Examples of the specific embodiments are illustrated in the accompanying drawings. While the invention will be described in conjunction with these specific embodiments, it will be understood that it is not intended to limit the invention to such specific embodiments. On the contrary, it is intended to cover alternatives, modifications, and equivalents as may be included within the scope and equivalents of the appended claims. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. The present invention may be practiced without some or all of these specific details. In other instances, well known process operations have not been described in detail in order not to unnecessarily obscure the present invention.

[0018] Bonds relying on mechanical interlocking to particles or fibers at the interface of two surfaces are known. The particles or fibers can be created from the material of the surface or added to the surface by melting or pressing. However, techniques for joining dissimilar materials like ceramics and metals using this concept, schematically illustrated in FIG. **1**, are unknown.

[0019] Examples of sinter bonding between dissimilar materials, e.g., ceramics and metals are also known. Generally, a graded joint is formed from an interlayer mixture of metal and ceramic powders. Near the ceramic joining surface the interlayer mixture is rich in ceramic powder. Near the metal joining surface, the interlayer is rich in metal. The composite structure is sintered, yielding two interpenetrating