aged in light- and radiation-resistant, easy-to-use dispensers. The resins in the tapes would be formulated to be curable by low-power light at specific wavelengths that could be generated by light-emitting diodes (LEDs). Each such tape dispenser would be marketed as part of a repair kit that would also include a companion battery-powered LED source operating at the required wavelength.

Each tape consists of a fine-weave fabric impregnated by a resin. On one side of the tape there is a cover ply that prevents the tape from sticking to itself when it is rolled up as in a dispenser. Depending on the specific intended application, the cover ply and resin can be selected such that the cover ply can be either released from the tape or cured in place as an integral part of a repair patch.

The feasibility of the light-curing tapes was demonstrated in experiments in which tapes were made from fiberglass fabric impregnated, variously, with (1) cationic epoxy resins plus a sensitizer that preferentially absorbs light at a wavelength of 380 nm, (2) free-radical curing acrylate resins, or (3) blends of resins of both types. Methods of incorporating adducts into the epoxies to tailor their viscosities were developed. The tapes were applied to aluminum and carbon/epoxy composite substrates that had been prepared by sanding and wiping with alcohol. The resins were cured by 380-nm light from LEDs. The blends of resins of both types were found to be advantageous in that during exposure to the light, their acrylate components contributed rapid buildup of strength, while their epoxy components contributed adhesion and longer-term strength.

Poly(ethylene terephthalate) backing films were shown to pass the needed 380-nm light and, when prepared with corona treatment, to adhere well as parts of cured tapes. Peel tests confirmed generally high degrees of adhesion to aluminum substrates. Demonstrations of repairs were made, including bonding pipes of various materials together, patching burst pipes, and patching punctures. A 1-in. (2.54-cm) patch over a 1/2-in. (1.27-cm)-diameter hole was pressurized to 120 psi (≈0.83 MPa) without failure or delamination.

Thin-Film Solid Oxide Fuel Cells

Mass, volume, and the cost of materials can be reduced for a given power level.

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The development of thin-film solid oxide fuel cells (TFSOFCs) and a method of fabricating them have progressed to the prototype stage. A TFSOFC consists of the following:

• A fuel electrode (anode) of nickel or other suitable metal, about 10 micrometers thick, made porous in a required pattern as described below;
• A solid electrolyte deposited on the anode of 0.5- to 2-micrometer thickness;
• An oxidizer electrode (cathode) in the form of a layer of a mixed ionic-electronic conductive oxide deposited to a typical thickness between 1 and 10 micrometers on the solid-electrolyte face opposite that of the anode; and
• An electrically insulating structure that encloses the aforementioned components and includes manifolds for the delivery of fuel to the anode, delivery of air or other oxidizing gas mixture to the cathode, and removal of combustion products.

The porosity of the anode in a TFSOFC is necessary to enable delivery of the fuel to the anode side of the solid electrolyte. The cathode is required to be porous or at least permeable to the oxidizer to enable delivery of oxygen to the cathode side of the solid electrolyte. The solid electrolyte layer is required to be dense and free of defects so that neither the fuel nor the oxidizer leaks through it. The relatively small thickness of the electrolyte also makes it possible to operate the TFSOFC at temperature lower than is necessary for a thicker-electrolyte fuel cell of older design. In turn, operation at lower temperature increases the reliability and enables a wider choice of materials for constructing the TFSOFC.

In the fabrication of a TFSOFC, nickel foil to be used as the anode material can be rolled or otherwise processed to produce an ordered crystal structure so that subsequent epitaxial deposition of the solid electrolyte material on the anode will cause the solid electrolyte to be also crystallographically ordered and, therefore, to be dense and relatively free of defects, as required. The epitaxial deposition of the solid electrolyte and the deposition of the electronically and ionically conductive cathode layer on the electrolyte can be effected by any of several established processes for deposition of thin oxide films. After deposition of the solid electrolyte, the required porosity is introduced into the nickel by photolithographic patterning and etching.

The cathode layer can be deposited either before or after patterning of the anode. Optionally, to enhance the activity of the porous anode structure, a mixed-ionic-and-electronic-conductor film can be deposited on the anode patterning and etching.

Typically, the total thickness of the anode/solid electrolyte/cathode sandwich of a TFSOFC is only about 15–25 micrometers. Operating at a temperature between 450 and 500 °C, a TFSOFC can utilize hydrogen or methane as a fuel. The power density of a TFSOFC can exceed 10 W/cm^3 (10 kW/liter), while the power per unit mass is ≈3 W/g (or ≈3 kW/kg). Relative to older thicker-electrolyte fuel-cell designs, TFSOFC designs can reduce costs of materials and reduce the volumes and masses of fuel cells capable of a generating a given amount of electric power.