be fabricated using the state-of-the-art photolithography. The pores in silicon can be fabricated by exposing the silicon in an HF/ethanol solution and then subjecting the pores to an electrical current. The size and shape of the pores inside silicon can be adjusted by the doping of the silicon, electrical current application, the composition of the electrolyte solution, and etching time.

The surface of the silicon particles can be modified by many means to provide targeted delivery and on-site permanence for extended release. Multiple active agents can be co-loaded into the particles. Because the surface modification of particles can be done on wafers before the mechanical release, asymmetrical surface modification is feasible.

Starting from silicon wafers, a treatment, such as KOH dipping or reactive-ion etching (RIE), may be applied to make the surface rough. This helps remove the nucleation layer. A protective layer is then deposited on the wafer. The protective layer, such as silicon nitride film or photoresist film, protects the wafer from electrochemical etching in an HF-based solution. A lithography technique is applied to pattern the particles onto the protective film. The undesired area of the protective film is removed, and the protective film on the back side of the wafer is also removed. Then the pattern is exposed to HF/surfactant solution, and a larger DC electrical current is applied to the wafers for a selected time. This step removes the nucleation layer. Then a DC current is applied to generate the nanopores. Next, a large electrical current is applied to generate a release layer. The particles are mechanically suspended in the solvent and collected by filtration or centrifuge.

This work was done by Mauro Ferrari and Xuewu Liu of the University of Texas Health Science Center for Johnson Space Center. For further information, contact the Johnson Technology Transfer Office at (281) 483-3809.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to MSC-24479-1, volume and number of this NASA Tech Briefs *issue, and the page number.*

High-Altitude Hydration System

Multiple methods of keeping water from freezing can be used by law enforcement personnel, skiers, and campers, and underwater by military personnel.

Lyndon B. Johnson Space Center, Houston, Texas

Three methods are being developed for keeping water from freezing during high-altitude climbs so that mountaineers can remain hydrated. Three strategies have been developed. At the time of this reporting two needed to be tested in the field and one was conceptual.

The first method is Passive Thermal Control Using Aerogels. This involves mounting the fluid reservoir of the climber's canteen to an inner layer of clothing for better heat retention. For the field test, bottles were mounted to the inner fleece layer of clothing, and then aerogel insulation was placed on the outside of the bottle, and circumferentially around the drink straw. When climbers need to drink, they can pull up the insulated straw from underneath the down suit, take a sip, and then put it back into the relative warmth of the suit. For the field test, a data logger assessed the temperatures of the water reservoir, as well as near the tip of the drink straw.

The second method is Passive Thermal Control with Copper-Shielded Drink Straw and Aerogels, also mounted to inner layers of clothing for better heat retention. Braided wire emanates from the inside of the fleece jacket layer, and continues up and around the drink straw in order to use body heat to keep the system-critical drink straw warm enough to keep water in the liquid state. For the field test, a data logger will be used to compare this with the above concept.

The third, and still conceptual, method is Active Thermal Control with Microcontroller. If the above methods do not work, microcontrollers and tape heaters have been identified that could keep the drink straw warm even under extremely cold conditions. Power requirements are not yet determined because the thermal environment inside the down suit relative to the external environment has not been established. A data logger will be used to track both the external and internal temperatures of the suit on a summit day.

This work was done by Scott E. Parazynski, Evelyne Orndoff, and Grant C. Bue of Johnson Space Center and Mark E. Schaefbauer and Kase Urban of Jacobs Technology. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-1003. Refer to MSC-24490-1.