Porous Silicon

Porous silicon is a mixture of solid silicon and void. The pore size and shape depend on the fabrication method and can range from the nanoscale to the microscale. We employ electroless etching to produce porous silicon on any sort of substrate including powders. When combined with an array of metal nanoparticles or holes in a metal film, electroless etching creates etch track pores that produce a forest of ridges or nanowires. The etched structures are themselves either solid or porous.

Significant advances in the processing of porous silicon powders are embodied in the regenerative electroless etching (ReEtching) and injection metal-assisted catalytic etching (iMACE) processes. These advances greatly expand the functionality of electroless etching such that the etching of silicon of arbitrary shape and size is controlled with respect to its porosity and pore size distribution. Therefore, any type of silicon-comprising powder can be used as a feedstock including wafers, high-purity granules, metallurgical grade powders, as well as silicon alloys and porous silicon powder produced by any other method, e.g. magnesio-thermal reduction, or pulverization of anodized wafers.

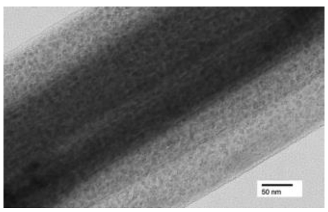
Wound Care

Porous silicon is a particularly effective platform for controlled time-released dosing of nitric oxide (NO), which is an endogenous gasotransmitter with an important role in intra- and extra-cellular signaling. NO is produced in a variety of cells found on and in the skin and is involved in all stages of the wound healing process. Exogenous NO has been applied successfully in the dissipation of biofilms and as an antimicrobial agent.

Porous silicon can deliver NO in a time-released manner. NO-loaded porous Si nanoparticles have significant inhibitory activity against planctonic *P. aeruginosa*, *E. coli*, and *S. aureus*, all three of which are common pathogens found in wounds. Porous Si nanoparticles also exhibited effective biofilm reduction in the treatment of *S. epidermidis*. Porous Si nanoparticles exhibit lower cytotoxicity on fibroblast cells compared to silica nanoparticles, silver nanoparticles and other clinical wound treatments. They also have extremely versatile surface chemistry to facilitate molecular binding and resorption at a controllable rate.

Resorption of porous Si particles depends upon the surface termination and pH. This is particularly advantageous in wound care because the wound healing process exhibits a strong relationship with pH. Normal skin is acidic but both acute and chronic wounds exhibit raised pH values at and above 7.4. The rate of silicon dissolution increases with increasing pH, which enhances release of NO stored within the porous structure. The rough texture of porous Si promotes proliferation of endothelial cells. Porous Si can also deliver other antibiotics or copper or silver nanoparticles. In addition, it can be photoluminescent. The combination of imaging and delivery capabilities make porous silicon particles suitable for theranostics.

Custom porous silicon materials, for research, development and manufacturing.



1. Variable pore size and distribution
2. Variable surface chemistry
3. Variable surface area
4. Hierarchical pore distributions
5. Resorbable and low toxicity

Ram Nanotech

We offer a variety of porous silicon products. Etching can be performed either to leave a solid core or such that the particles are completely porosified. Powder particles can have a mean size between 1 and 75 µm and still be etched completely through the core. Larger particles can also be etched but will generally have a solid core.

Tortuous pores with mean size in the range of roughly 3 nm to 20 nm are available. Microparticles of this type produce porous nanoparticles with irregular shapes when ground or subjected to sonication.

Alternatively, straight or meandering pores in the range of 20–100 nm range can be formed. Microparticles of this type produce high-aspect-ratio elongated particles when ground or subjected to sonication. These particles have widths on the order of 100 nm to several hundred nanometers and lengths of several micrometers.

Hierarchical pore size distributions can also be produced, for example, combinations of 3–5 nm pores with larger mesopores in the 10–20 nm range or with macropores larger than 50 nm. Porosity can be varied up to approximately 50% and specific surface areas of 50–450 cm^3/g are available.

Custom Specifications

If companies/researchers have a particular type of raw silicon-comprising powder that they would like to etch, we can work with them to develop custom batches. For example, we have produced hierarchical por-Si in which non-luminescent mesoporous Si is transformed into a luminescent nanomaterial with specific surface area in excess of 1000 cm^3/g. This material is characterized by a bimodal pore size distribution because ~4 nm pores are etched into the walls of the ~15 nm mesopores.

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