Ultrathin Nanoporous Silicon Nitride Membranes for Separations and Biotechnology

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BRIEF DESCRIPTION

An ultrathin silicon nitride membrane has been fabricated and tested to be useable in temperatures in excess of 1000 ˚C with mass flux rates several orders of magnitude greater than existing technlogies. Pore shape and size are also tunable.

FULL DESCRIPTION

Researchers at the University of California, Irvine have developed ultrathin membranes made from silicon nitride and other inorganic compounds, which contain nanopores of controllable diameter, geometry and chemical functionality of the pore walls. Ultrathin character and tunable porosity of our membranes makes them an ideal candidate for high-resolution transmission electron microscopy supports. The membranes can be used in temperatures >1000 ˚C and at harsh chemical conditions. Mass flux through these membranes exceeds by three orders of magnitude the fluxes that can be obtained in several micrometers thick polycarbonate membrane. The shape of pores in the silicon nitride membranes can be tuned so that conical and hourglass shaped pores can be produced. The effective length of these membranes is close to the dimensions of biological cell membrane. Porosity of the UCI membranes can be controlled on a large scale from 1 pore/cm^2 to 10^{11} pores/cm^2.

The technology is based on techniques that are widely applied in micro and nanofabrication industries thus the cost of these membranes is predicted to be low.

BACKGROUND

Membrane technologies are the core of many industrial and academic applications. They are used in desalination, food production, separation, waste treatment, and other processes. Currently available polymer filters have thickness of several micrometers, which limits the flux when used in filtration processes. Current polymer membranes cannot be used at harsh chemical conditions and their operation is typically limited to ~200 ˚C. Other technologies offer silicon ultrathin membranes with high porosity, as well as membranes with just one or several pores in inorganic films. None of the available techniques for ultrathin silicon material filters offers a possibility of controlling the number of pores on a large scale or tuning the pore geometry.

APPLICATIONS

Ultrathin silicon nitride nanoporous membranes can find multiple applications. Several examples are listed:

microscopy techniques e.g. as supports and windows for **transmission electron microscopy**;
molecular sieves: separation/filtration of molecules by size and surface charge etc;
rejection of ions in the **desalination** process; **in-line filtration** for micro- and nanofluidic devices
template for **biosensors and masks** for lithography; model systems for biological channels;
membranes for **fuel cells**; **cell cultures**; **system for studying transport properties** on the nanoscale;
single molecule detection and characterization.

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OTHER INFORMATION

KEYWORDS

ultrathin membranes, nanopores, molecular sieve, silicon nitride membrane

CATEGORIZED AS

- **Environment**
  - Other
- **Materials & Chemicals**
  - Biological

ADVANTAGES

Advantages over the existing techniques:

Given the ultrathin character of these membranes in silicon nitride, they can be used as windows for high-resolution transmission electron microscopy imaging.
These membranes can be very thin, down to (< 10 nanometers) which enhances the transport rate compared to micrometer thick polymer membranes. In some applications, these membranes are more efficient by over 1000 times compared to current products.
The material of these membranes can withstand very harsh conditions such as high temperatures (>1000 ° C) which widens the window of applications for such nanoporous membranes
Easy control over the pore shape and porosity (number of the pores).
The material of the membrane is established in semiconductor industry and common lithographic techniques can be used for easy integration into micro/nanofluidic devices.
The surface of the silicon nitride membrane and the pore walls can be easily functionalized with desirable biological/chemical molecules.

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	9,873,090	01/23/2018	2009-749

» Composites
» Nanomaterials
» Thin Films
» **Medical**
» Diagnostics
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