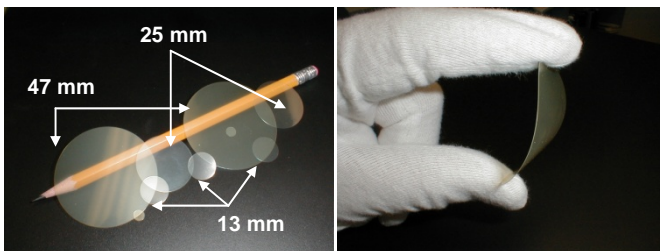


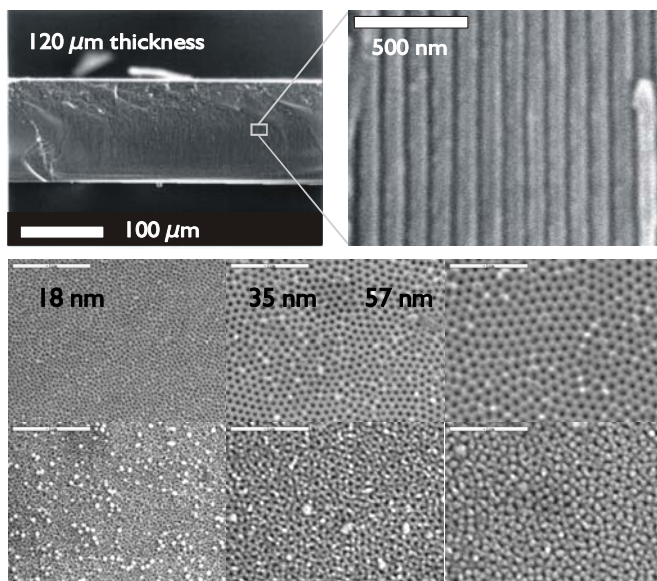
### OVERVIEW

Due to their structural robustness, thermal stability, chemical resistance and reliability, ceramic membranes are used in a variety of applications, from nanofiltration and water purification to gas separation and membrane-reactor systems. However, cost-effective fabrication of scaled ceramic membranes with narrow pore size distribution in the sub-nanometer to 100's of nanometers range is a formidable challenge. Moreover, difficulties with affordable and reliable sealing of high performance ceramic membranes hindered their broader applications in separation processes.

Synkera Technologies Inc. addresses these issues using nanoporous anodic aluminum oxide (AAO) with controllable, self-organized and intrinsically defect-free nanoporous morphology as a platform for a new generation of ceramic and composite membranes.



*Standard nanoporous membranes offered by Synkera. Sizes: 13, 25 and 47 mm; thicknesses: 0.02 – 0.2 mm.*



*SEM of the cross-section and the surface of the opposite faces of nanoporous AAO membranes*

### MEMBRANE FEATURES

#### Unique Morphology

AAO membranes have high density cylindrical pores that are highly uniform and aligned perpendicular to the membrane plane. The fabrication process is intrinsically self-healing and yields defect-free nanoporous membranes.

#### Precision Control of the Pore Diameter

Pore diameter is controlled with great precision and reproducibility in a wide range, from  $<1$  nm to  $>200$  nm. The corresponding pore density is from  $10^{12}$  to  $10^8$  cm<sup>-2</sup>. The porosity varies from 5 to 50%, depending on other specifications. The standard deviation of pore diameters is typically  $<10\%$  and as low as  $5\%$  for optimized conditions. No other type of membrane can match such pore uniformity.

#### Membrane Size / Thickness / Format

Membranes as large as  $750$  cm<sup>2</sup> in area were demonstrated. Several standard sizes (3 mm to 47 mm) are offered as stock items. Thickness of AAO can be varied from 10 to  $>200$  µm for free-standing membranes and from 0.1 to 150 µm for supported AAO films. Planar membranes of almost any shape can be produced.

#### Chemical and Thermal Stability / Mechanical Properties

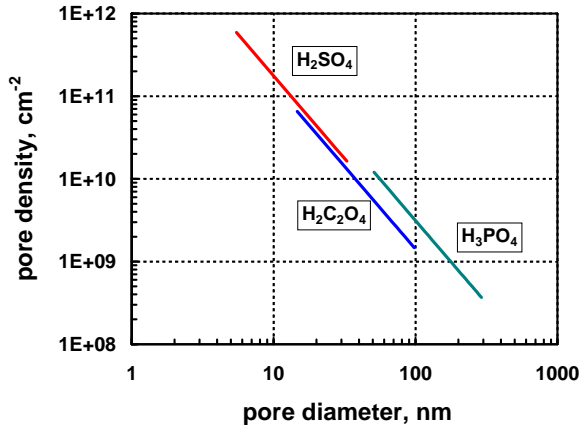
As-prepared amorphous AAO can be converted into polycrystalline  $\gamma$ - and  $\alpha$ -alumina that retain nanoporous morphology. Such membranes have excellent chemical resistance and long-term stability in water. Their upper operating temperature is up to 1000°C for  $\gamma$ -alumina and up to 1100°C for  $\alpha$ -alumina membranes. AAO membranes are **mechanically robust** and exhibit good flexibility, hardness, and fracture toughness.

#### Permeability

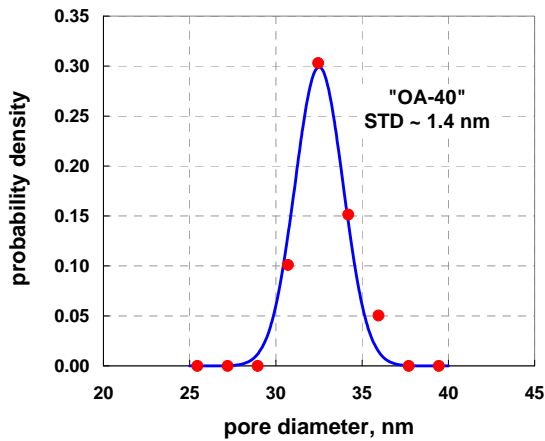
Permeability of AAO membranes depends on the filtered media, membrane structure (symmetric or asymmetric), pore diameter, porosity. Typical permeability range for dry nitrogen varies from  $10^{-9}$  to  $2 \times 10^{-7}$  cm<sup>2</sup>/s/Pa, and permeability of pure water varies from  $10^{-11}$  to  $2 \times 10^{-9}$  cm<sup>2</sup>/s/Pa.

#### Membrane Sealing.

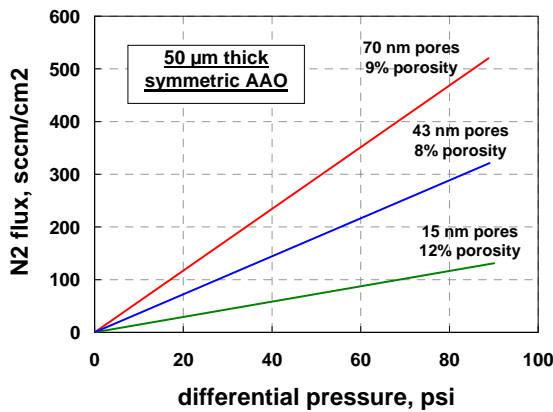
Commercially available membrane modules for standard membrane sizes (13 mm, 25 mm, 47 mm) can be used with Synkera AAO membranes. Conventional polymer gaskets can be used to seal the membranes at temperature below 150°C, and graphite gaskets can be used at higher temperatures. Membranes integrated onto an Al rim are also available to facilitate robust and reliable sealing and integration for more demanding applications.



*Pore density vs. pore diameter for three typical electrolytes used in membrane fabrication.*



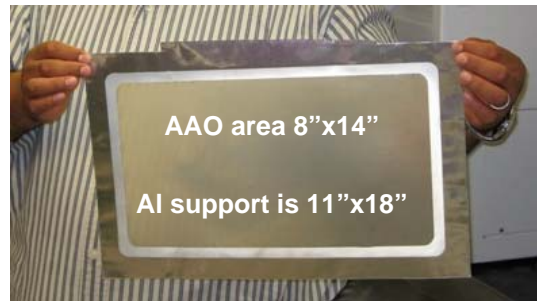
*Pore diameter distributions*



*Nitrogen flux through 50 μm thick AAO membranes at room temperature.*

### AVAILABLE PRODUCTS.

Synkera produces and sells AAO-based ceramic membranes and nanotemplates in a variety of formats, sizes and specifications. Our standard free-standing membranes include circular membranes of 3, 5, 7, 13, 25 and 47 mm in diameter, as well as 10 mm x 10 mm square membranes. AAO nanotemplates on Al and other substrates (glass, silicon) are produced as a custom order. For all of these products, pore diameters from <5 nm to >200 nm are available. Please visit our website at [www.synkera.com](http://www.synkera.com) for current selection of AAO-based products and additional product information.



*Scaled AAO membrane produced at Synkera.*

### APPLICATION

The core areas of applications for AAO membranes are:

- reverse osmosis, nano- and ultrafiltration
- diffusion- and size-based gas separation
- membrane reactors and contactors
- membrane-standards

Non-membrane applications for nanoporous anodic alumina extend into many diverse areas such as:

- templated synthesis of arrays of nanowires, nanotubes, quantum rods, and other nanostructures
- substrates for cell culturing and bioanalysis
- precursor for ceramic microsystems

Partners are being sought to support application development and commercialization of membrane products based on this technology. If you need additional information or would like to discuss this further, please contact:

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