



2021 Miller Drive, Suite B
Longmont, CO 80501
www.synkera.com

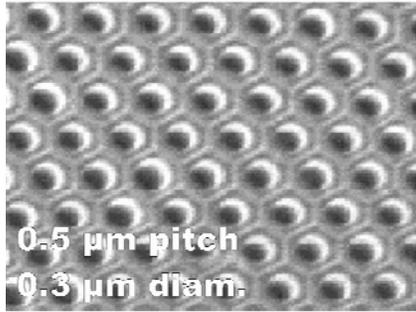
LAPD MCP Godparent Review
ANL, Chicago IL
March 25, 2010

AAO MCP SUBSTRATES DEVELOPMENT AT SYNKERA

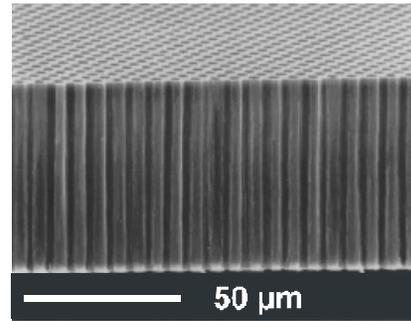
CUMULATIVE STATUS UPDATE
Oct. 10, 2009 - March 24, 2010

© 2006-2010 Synkera Technologies, Inc.

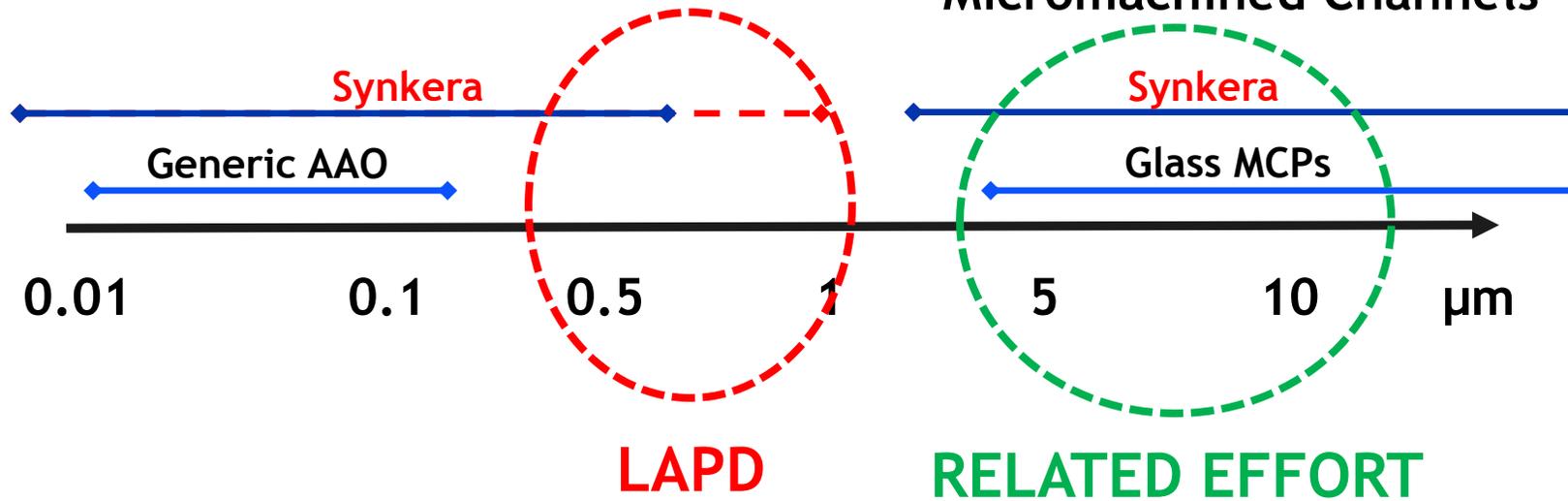
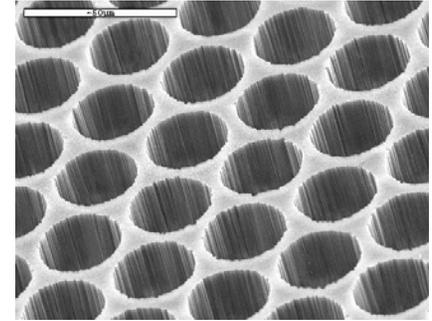
AAO AS MCP SUBSTRATE



Intrinsic Pores



Micromachined Channels



SYNKERA LAPD SUBCONTRACT

Status: contract and NDA signed, work started

Overall goal: develop ceramic MCPs substrates for low-cost large area detectors.

The project will benefit from prior and related IP, established facilities and on-going R&D and scale-up efforts at Synkera.

Year 1 - Development of Required Channel Structure

- Objective: maximize the channel diameter and enable a funnel-shaped opening, while maintaining well-aligned channels.
- Deliverables:
 - Demonstrate AAO with channel diameter $\geq 0.5 \mu\text{m}$, OAR $\geq 60\%$, L/D of 50-100
 - MCP substrates for the LAPD project team (32.8 mm, qty ≥ 15) targeting above specs
 - Initial cost projections for 8"x8" AAO substrates

Year 2 Option - Support of MCP Development and Scale-Up

- Objective: enable targeted MCP performance via development of AAO substrates; limited scale-up to validate the size (8"x8") and cost reduction potential.
- Deliverables:
 - Demonstrate channel diameter $\geq 0.7 \mu\text{m}$, funnel-shaped opening, OAR $\geq 65\%$, and L/D 40-100.
 - MCP substrates for the LAPD project team (32.8 mm, qty ≥ 40) targeting above specs
 - Optional: scaled 8"x8" "demo" substrates
 - Validated cost projections for 8"x8" AAO substrates.

SYNKERA SUBCONTRACT - YEAR 1

Year 1 Objectives:

- Maximize channel diameter & enable funnel-shaped opening, while maintaining well-aligned channels
- Produce and deliver prototypes to LAPD project team

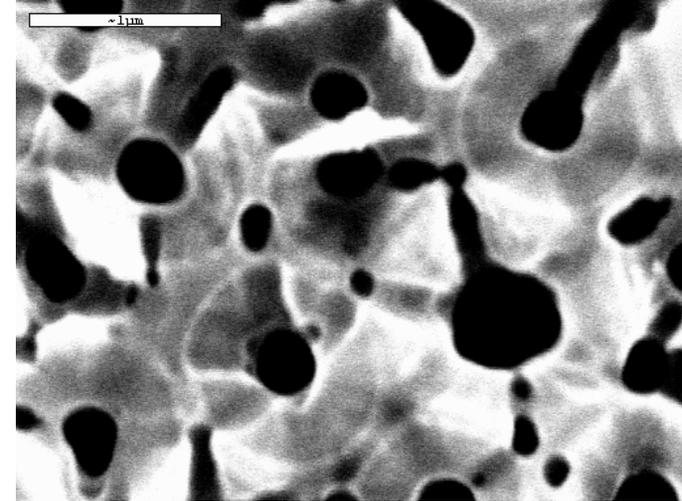
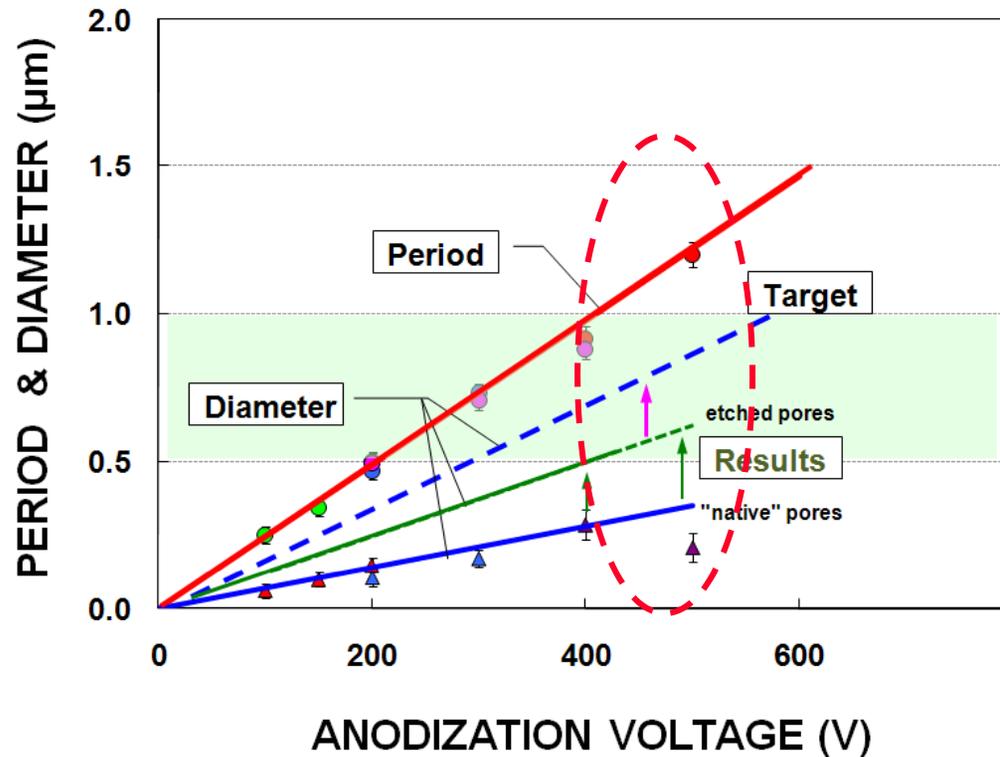
Deliverables:

1. Demonstrate AAO with channel diam. $\geq 0.5 \mu\text{m}$, OAR $\geq 60\%$, L/D of 50-100.
2. Deliver at least 15 of 32.8 mm MCP substrates targeting above specs.
3. Develop initial cost projections for 8"x8" AAO substrates.

TASK 1: DEMONSTRATING AAO STRUCTURE

Target	Prerequisite	Demonstrated	Goal
Channel Period >1 μ m	Anodization at 400 - 600 V	<ul style="list-style-type: none"> • 0.8-1 μm @ 400V, reliable process; • 1.2 μm @ 500V 	Eliminate voltage ramp for uniform period across AAO
Channel Diameter \geq 0.5 μ m	Period >1 μ m, conformal etch	~0.5 μ m @ 400V	Achieve 0.7 μ m for 500V; Improve uniformity for 400V
L/D 50-100	Appropriate thickness (<20 μ m AAO is too fragile)	For 50-100 μ m thick AAO, L/D = 100-200	Improve growth rate uniformity
OAR \geq 60%	Conformal pore etching	55-60% for 400V, reliable process	\geq 60% depending on mechanical prop.
Funnel Entrance	-	Default feature	TBD

ACHIEVING TARGET CHANNEL PITCH



Pore Period:

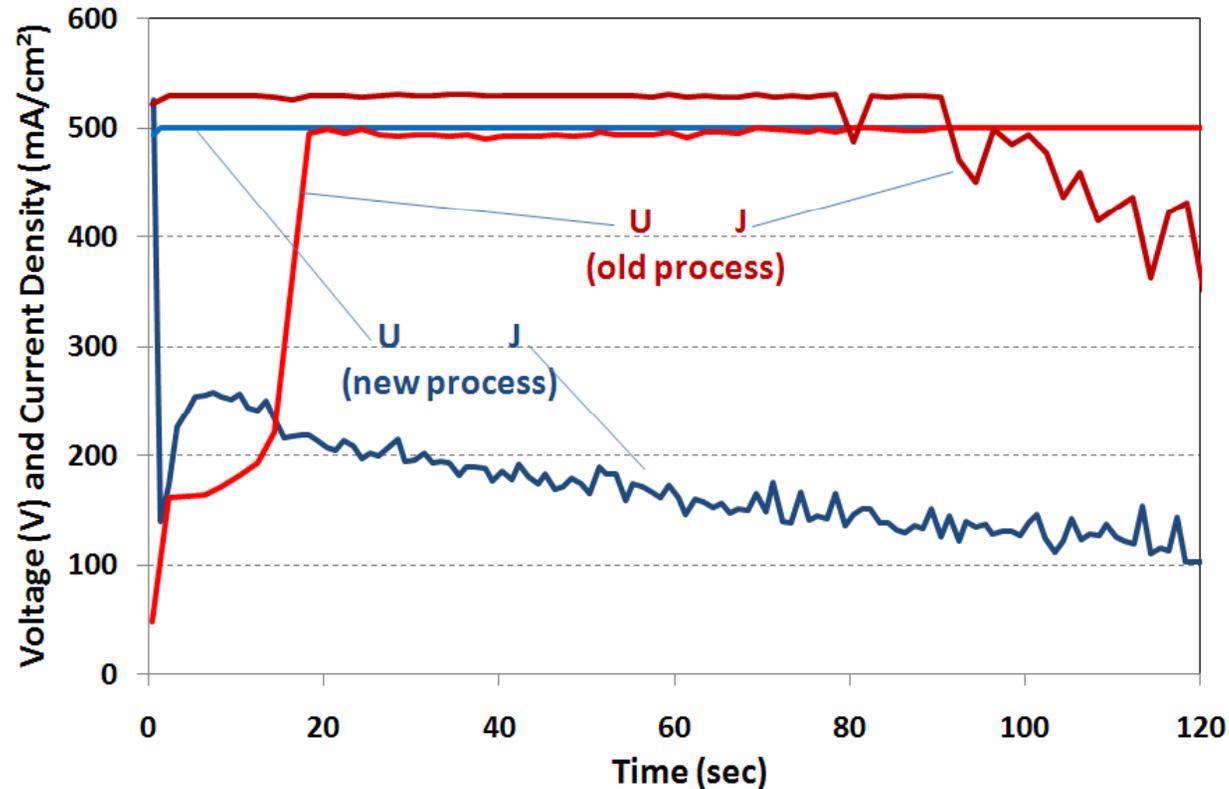
- Proportional to anodization voltage
- Does not depend on electrolyte, temp.

Pore Diameter:

- Increases with voltage, [H⁺] and temp.

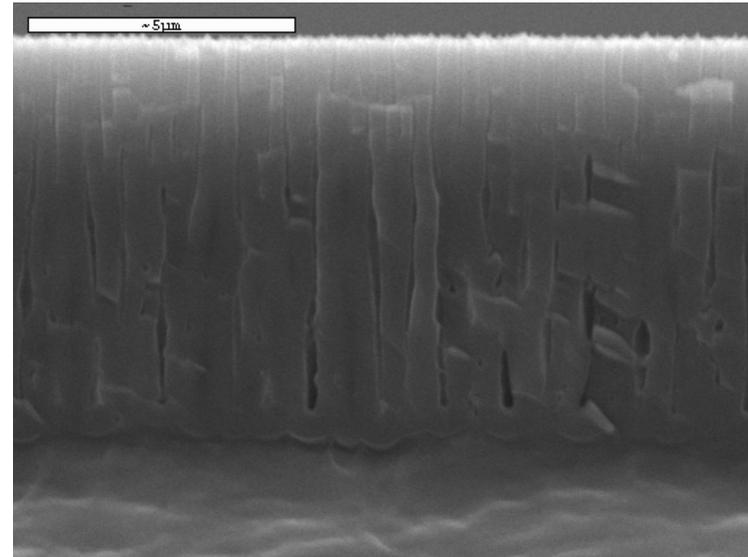
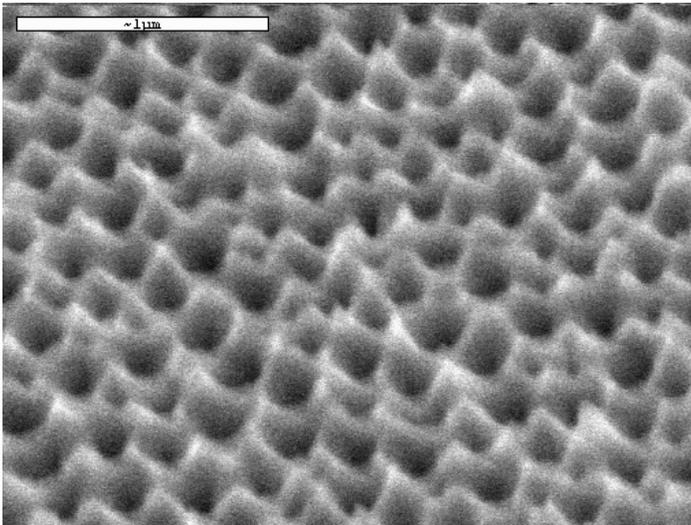
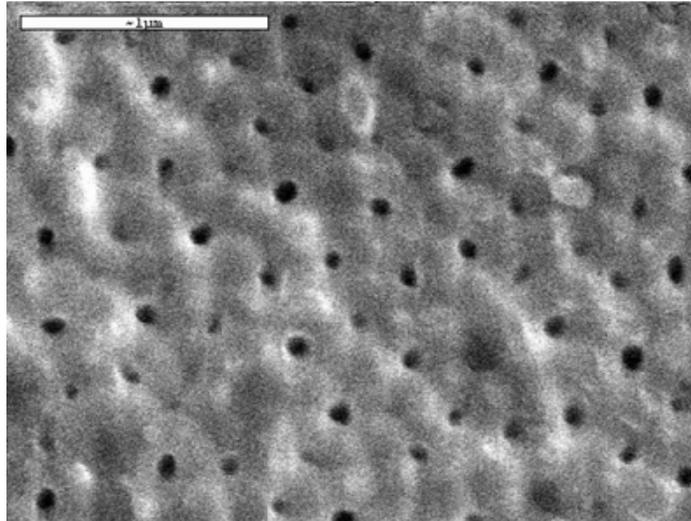
Starting point - patent-pending electrolytes & procedures developed in 2006 - 2009 (in part under NSF SBIR funding)

HIGH VOLTAGE ANODIZATION



- For the first time, no voltage ramp at 500V (new electrolyte)
- Reduced current density - slow growth rate
- Reduced current oscillations - better structure
- Process somewhat unstable, arching was observed

SEM OF THE 500V SAMPLES BEFORE ETCH



- Pore period 1.0-1.2 μm (except $\sim 1 \mu\text{m}$ surface layer)
- Pore diameter 0.2-0.3 μm ; $>0.5 \mu\text{m}$ after conformal etching
- Funnel-like channel opening
- Good pore structure
- Thickness 20 μm , rate slows down

TASK 2: FABRICATION OF PROTOTYPE SUBSTRATES

STATUS

- Dedicated anodization setup to support development and prototyping
- 400V process selected for initial scaling to 32.8 mm
- 1st batch - 4 substrates available; 12 in processing
- Previous 25 mm nMCPs with resistive layer and contacts sent to UC Berkeley

CHALLENGES IN SCALING HIGH VOLTAGE PROCESSING

- Voltage ramp increases with larger size due to high current
- Growing required thickness with aligned channels

APPROACHES TO MITIGATE

- Exploring additional electrolytes & regimes developed under NSF project
- Better masking of Al surface to avoid breakdown & arcing
- Use different chemistries and/or conditions at different AN stages

LAPD PROTOTYPE SPECIFICATIONS - 1st batch

Overall Size: 32 mm initial
32.8 mm current

Pore open: 24.5 mm area

Thickness : 100 μm

Pore Period: 1 - 1.2 μm (400V)

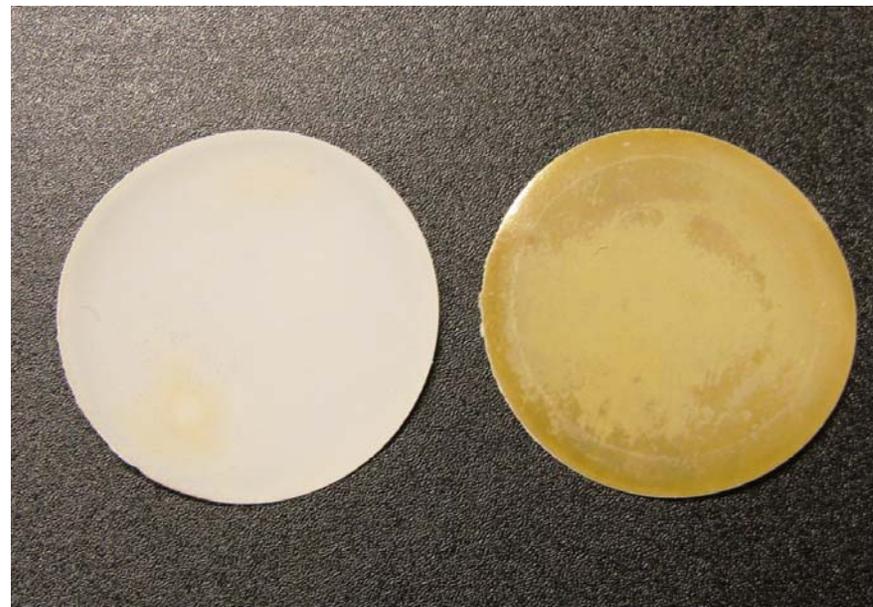
Etched Pore Diam.: targeted to 0.5 μm

- Surface may contain smaller channels
- Initial 4 substrates are not polished.

OAR: TBD

Annealed to: 500 $^{\circ}$ C
(could be higher to burn out residue)

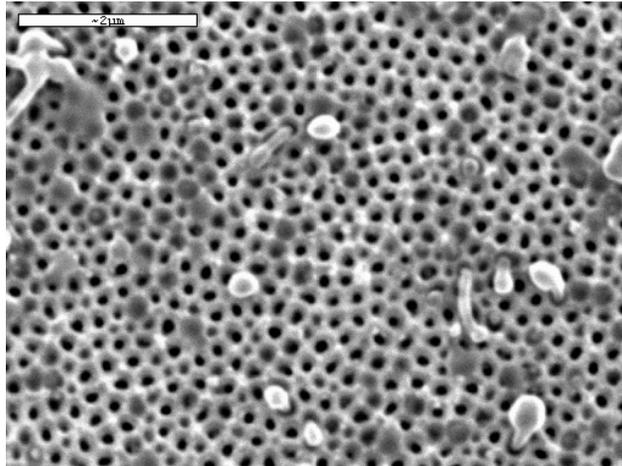
Opposite sides look different due to differences in surface topology and residue from processing



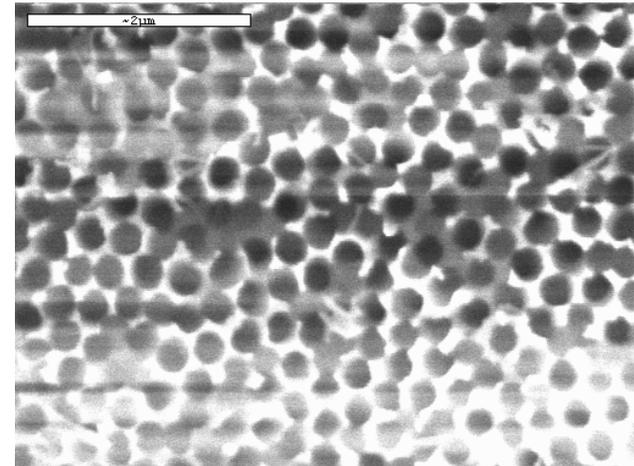
“Barrier Layer Side”
(facing Al substrate during growth)

“Solution Side”
(facing solution during growth)

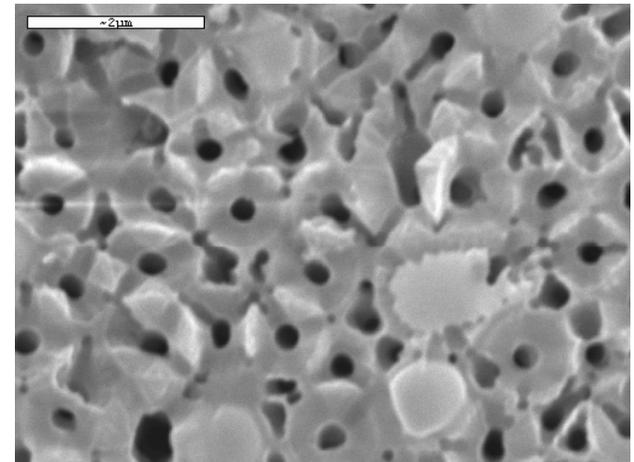
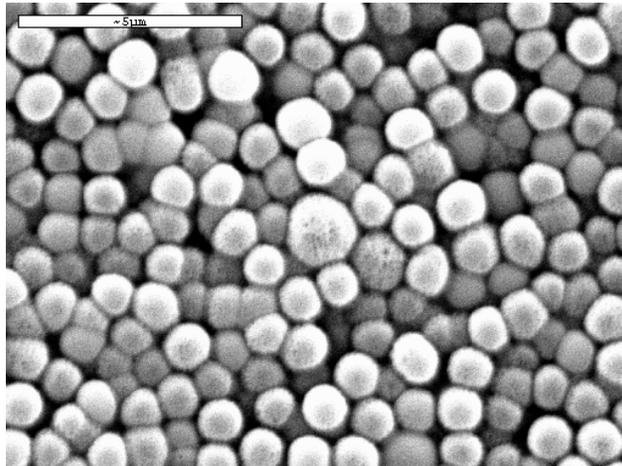
Before channel opening



After channel opening



“Solution” Surface



“Barrier Layer” Surface

TASK 3: COST PROJECTIONS

Assumptions:

- Rough estimate for current AAO membranes (conventional processing)
- Price per area is based on 1” units
- With larger size, lower cost per unit area is projected (less handling)

Projections:

Cum. Annual Area	<1 m²	10 m²	100 m²	1000 m²
Cum. Annual 8”x8” Units	<24	240	2,400	24,000
• Price, cm ² : (for small format)	<\$20	\$5-\$10	\$1-\$3	<\$1
• Est. Price for 8”x8” AAO: (current)	\$1.2-2.5K	\$0.75K-1K	\$200-\$700	<\$200

Projections for high voltage will be updated based on selected processing routes.

AAO TO SUPPORT MICROMACHINING AT ANL

- Synkera can provide AAO substrates for micromachining at ANL
 - Conventional AAO, current product
 - Pore diameter: selectable (20 - 100 nm range, recommend 35-50 nm)
 - Format: 32.8 mm x 0.10 - 0.15 mm
 - Attached or separated from Al
 - With or without AL rim
 - If separated, barrier layer can be opened or closed
- Cost depends on volume and format
- Example:
 - Free-standing 32.8 mm x 0.1 mm “membrane” , barrier layer open

Quantities	5-25	26-100	>100
Price, \$/ea	\$75	\$50	\$40

SUMMARY TO DATE

- Task 1: Develop targeted AAO structure - Nearly Completed
 - New process for high voltage anodization (up to 500V) validated
 - *Reduced voltage ramp (function of substrate size)*
 - *Improved (not perfect) pore structure and alignment*
 - Target AAO parameters demonstrated in small samples
 - *Pore period >1 μ m & diameter ~0.5 μ m*
 - *Thickness of 0.02 - 0.1 mm*
- Task 2: Deliver 33 mm prototypes - In progress
 - Equipment, tooling & processes scaled to 33 mm, test run completed
 - Etching and annealing validated in 33 mm
 - Fabrication of 1st batch of deliverables in progress
 - *Initial 4 substrates available to start ALD work*
 - *Additional 12 substrates in processing*
 - *Challenge - scaling "high voltage" AAO; thus focus on voltage ramp to eliminate need for polishing*
- Task 3 - Initial cost analysis performed, to be updated

SCHEDULE OF DELIVERABLES

Deliverable	Completion Date	Status	Payment
1. Report on completing set up of dedicated equipment, procurement of the tooling required for fabricating 32.8 mm AAO substrates and initiating MCP development.	11/30/2009	DONE	\$30,000
2. Progress report and the 1 st batch of the 32.8 mm AAO substrates to the project team.	01/31/2010	In progress	\$30,000
3. Progress report that demonstrates AAO with channel diameter $\geq 0.5 \mu\text{m}$.	03/31/2010	In progress	\$30,000
4. Progress report and the 2 nd batch of the 32.8 mm AAO substrates to the project team.	05/31/2010	05/31/2010	\$30,000
5. Progress report that demonstrates AAO with open-area-ratio $\geq 60\%$, funnel-shaped channels and channel diameter $\geq 0.5 \mu\text{m}$.	07/31/2010	07/31/2010	\$30,000
6. Progress report including cost projections for 8"x8" AAO substrates and remaining 32.8 mm AAO substrates to the project team and completion of all obligations under this contract and acceptance by the Laboratory of all work covered by the contract.	10/31/2010	10/31/2010	\$25,000
Total for Year 1			\$175,000