

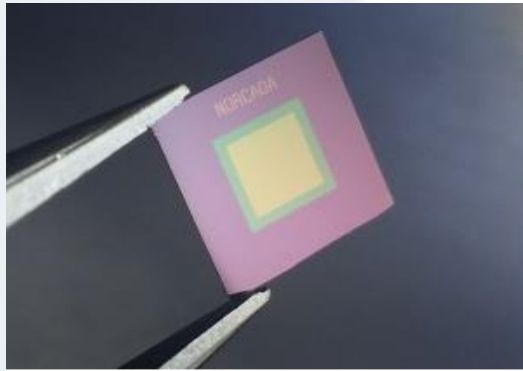
EUV Pellicle Development via Accelerated Neutral Atom Beam (ANAB) Processing of Ultra-thin Membranes

Sean Kirkpatrick

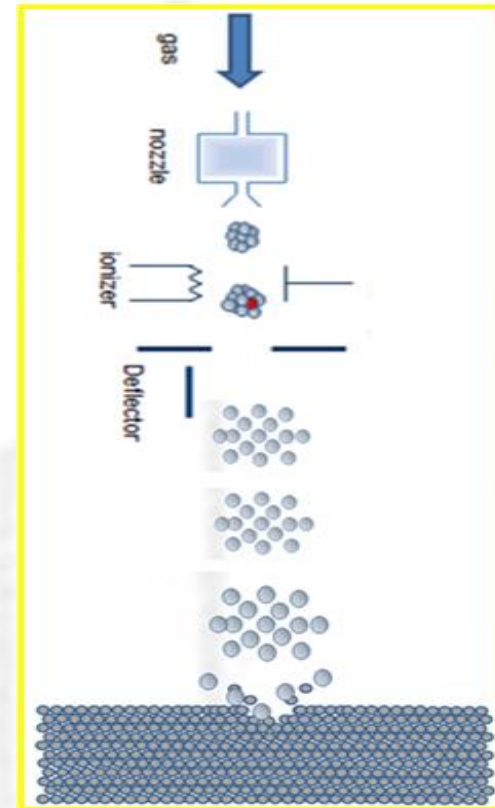
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Development Road Map



**Norcada
membrane fabrication**

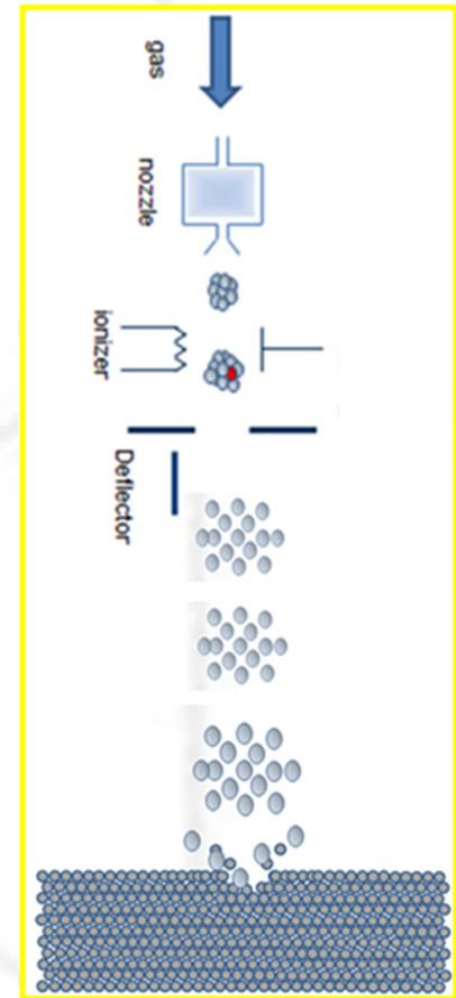


**Exogenesis
ANAB Processing**

EUV Testing and Evaluation

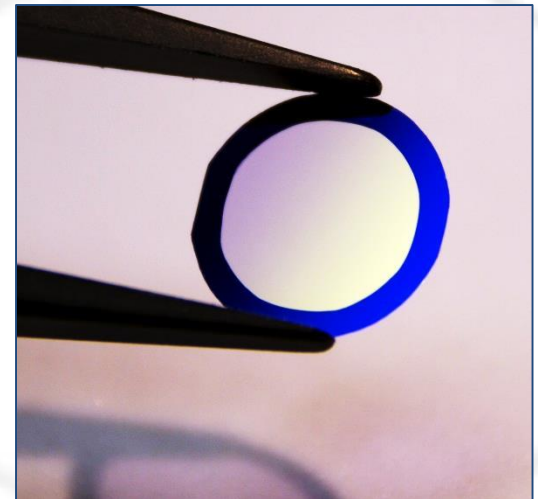
Accelerated Neutral Atom Beam Technology (ANAB)

- Unique Accelerated Particle Beam
- Nanoscale Surface Modification
- High Intensity Flux
- Low Energy Particles (10-100+ eV)
- Electrically Neutral
- Surface Penetration ≤ 3 nm



Norcada Membrane Technology

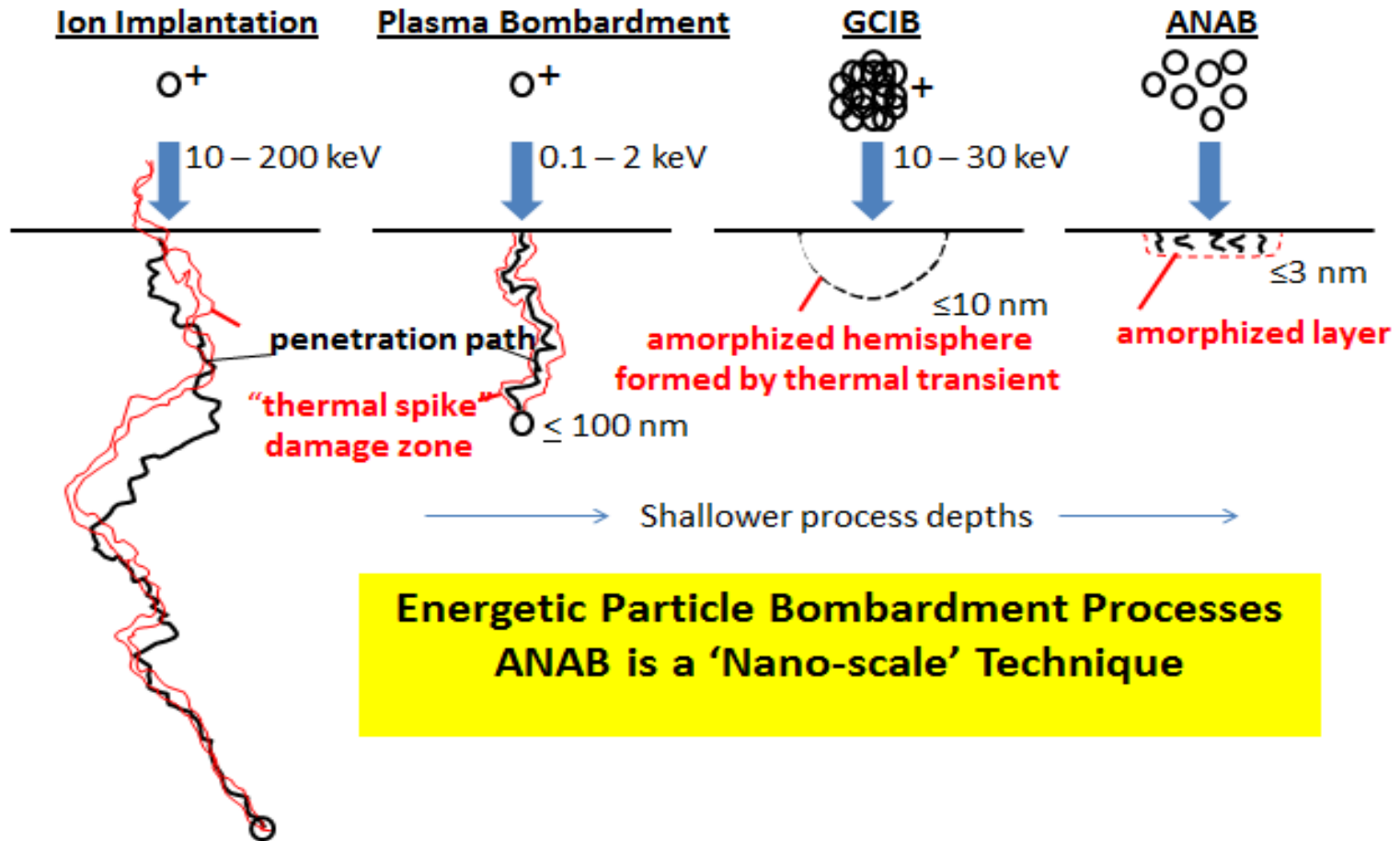
- Norcada is a MEMS and nanotechnology manufacturer in Edmonton, Canada
- Norcada has 'state of the art' manufacturing cleanroom facilities.
- Norcada offers ultrathin membranes for a variety of applications in industrial and scientific fields:
 - Poly and single crystal Silicon membranes
 - Silicon Nitride membranes
 - Metal oxide and nitride membranes
 - Polymeric membranes
 - Multilayer membranes with semiconductor materials and polymeric layers
 - Thin film semi-hole or holey features
 - Dual thickness membranes
 - Free standing carbon membranes



Exogenesis ANAB

- Exogenesis is a nanotechnology company in Billerica, MA USA.
- Exogenesis developed ANAB for surface modifications including:
 - *Nanoscale smoothing for reduced EUV scatter*
 - *Controlled thinning for increased transparency*
 - *Doping for improved high temperature performance*
 - *Cleaning / surface preparation / coating interfaces*
 - *Uniformity correction for production / scaling*
- Why is ANAB suited to processing of fragile pellicle materials?
 - *ANAB requires no target neutralization*
 - *ANAB does not apply mechanical forces during processing*
 - *ANAB is a 'dry' process*
 - *ANAB is limited to $\leq 3\text{nm}$ process depth – NANOSCALE!*

Semiconductor Fabrication Technologies Progression Toward Nano-depth Processing



EUV %T Increased By ANAB Modification of Silicon and Polysilicon Membranes

Test Group	Sample ID	Part Number	Description		Quantity	Transmission @13.5 nm
1	ALP320140908A	SQ7300C	3mm X 3mm single crystal silicon membrane approx. 100nm thick silicon frame = 7.5 X 7.5mm	Control	1	82.2%
1	ALP320140908B	SQ7300C	3mm X 3mm single crystal silicon membrane approx. 100nm thick silicon frame = 7.5 X 7.5mm	ANAB Treated	1	90.5%

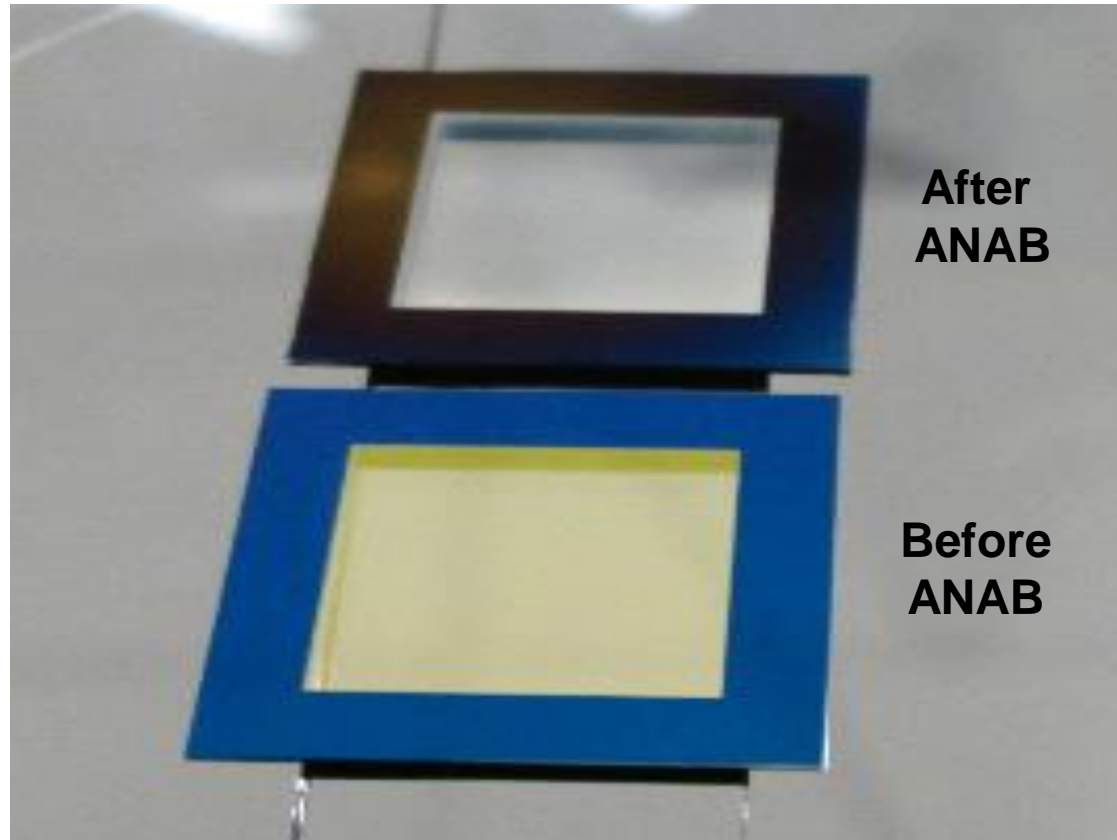
**Single crystal silicon membrane thinned from 100nm to 25nm
%T at 13.5nm increased from 82.2% to 90.5%**

Test Group	Sample ID	Part Number	Description		Quantity	Transmission @13.5 nm
2	ALP320140908C	PSM5200A	2mm X 2mm polysilicon membrane approx. 50nm thick silicon frame = 5.0 X 5.0mm	Control	1	90.9%
2	ALP320140908D	PSM5200A	2mm X 2mm polysilicon membrane approx. 50nm thick silicon frame = 5.0 X 5.0mm	ANAB Treated	1	94.4%

**Norcada Polycrystalline silicon membrane thinned from 50nm to 25nm
%T at 13.5nm increased from 90.9% to 94.4%**

*Presented at TWG San Jose 2/28/2015

ANAB Enhanced Membranes



Norcada Silicon Nitride Membrane Modified With ANAB

Pellicle Development Timeline

- Exogenesis and Norcada have demonstrated 'proof of performance' in multiple studies.
- Full capabilities to develop and produce final product.
- Focused development not yet been initiated.
- Focused development is contingent on funding.
- Scaling to size will require 12-18 months with funding.
- If development begins before end of 2015, production of actual pellicles would be feasible for mid 2017.

Thank You!