

Commercialization of Nanofibers produced by Hybrid Electrospinning

2019. 01. 31

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Amogreentech Co., Ltd.

I

Introduction of Amogreentech

II

Development of Nanofiber Membrane

III

Difficulty of Commercialization

IV

Optimization of Nanofiber Manufacturing Process

V

Application of Nanofiber Membrane

VI

Conclusion

Global Leader in IT, Automotive, High Efficient Energy & Bio Technologies



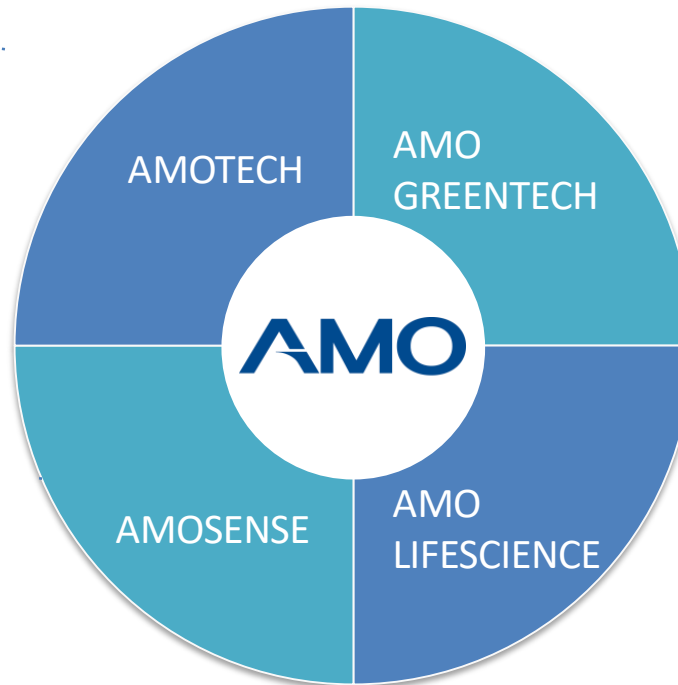
Established in Oct., 1994
(Public since 2003)

- EMC
- Antenna
- BLDC Motor



Established in Nov., 2008

- Wireless Charging
- Ceramic Division
- Packaging Division
- Sensors
- Circuitry
- Integration S/W



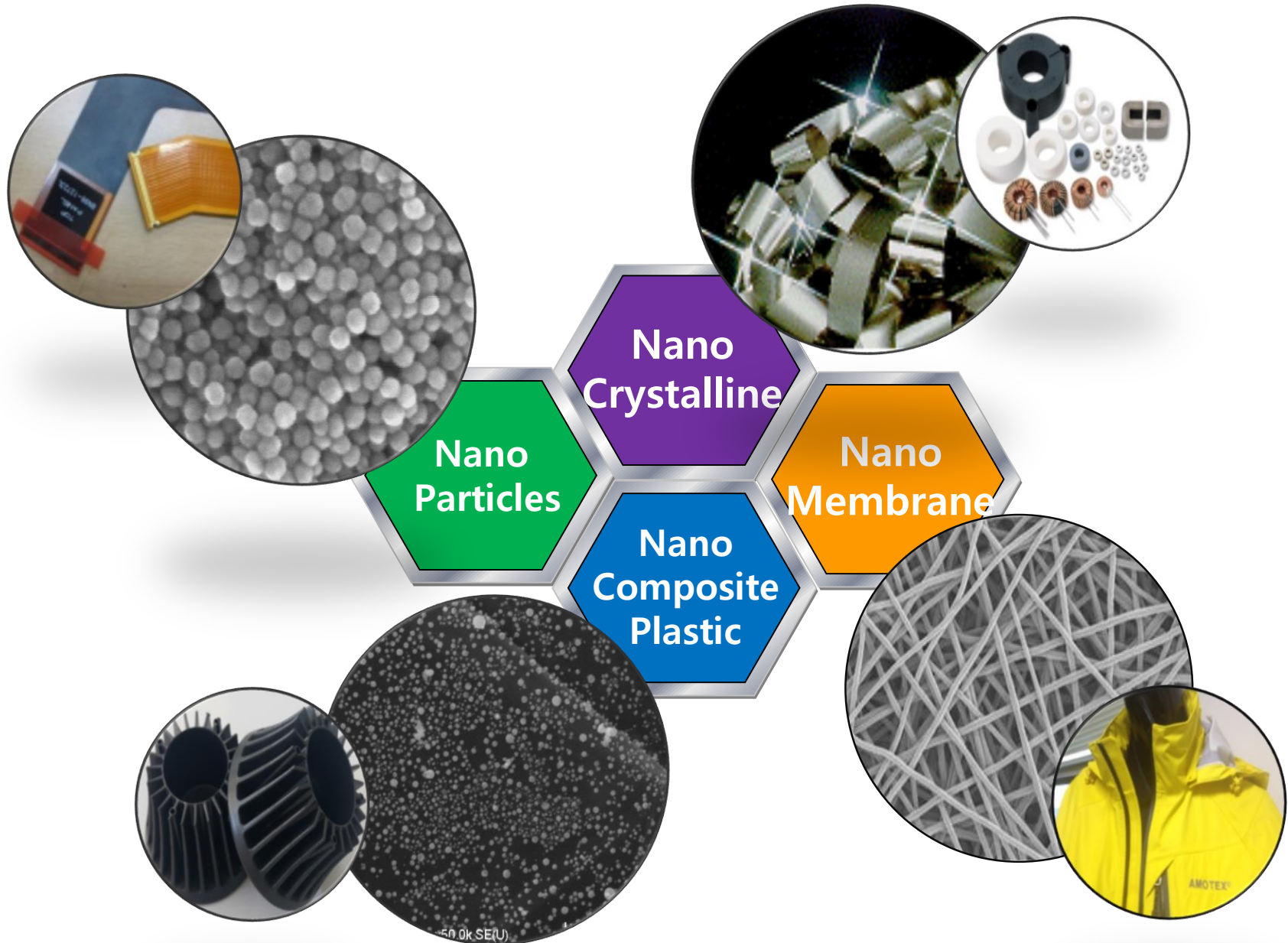
Established in Jan, 2004

- Nanocrystalline Core
- Nano Fiber
- Thermal Plastic / Materials
- Flexible Battery
- Thin FPCB
- Water/Air Filter



Established in Sept, 2016

- Cell Culture
- Magnetic Beads
- Wound Patch
- Smart Skin
- E-Health Care Device



Nanocrystalline

Core

- CT
- CMC/Powder Core

Wireless Power Supply

LF Antennas materials



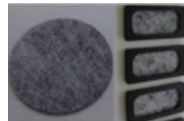
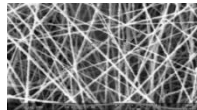
Nano Membrane

Air Vent (IPX4)

IP67/ 68 membrane with High resistance to water pressure

Nano Sensors

Water Treatment Filter



Thermal Materials

Thermal Plastic

Thermal Coating

Thermal Interface Material



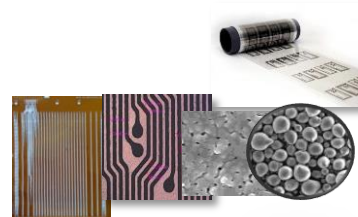
Flex / Nano Ink

Nano Ink

Metal Mesh

FPCB

- Ultra Thin FPCB
- Multi Layer FPCB
- Direct Printing FPCB



Battery

ESS(UPS)

Flexible Battery



Water / Air Filter

Water Filter

Air Filter

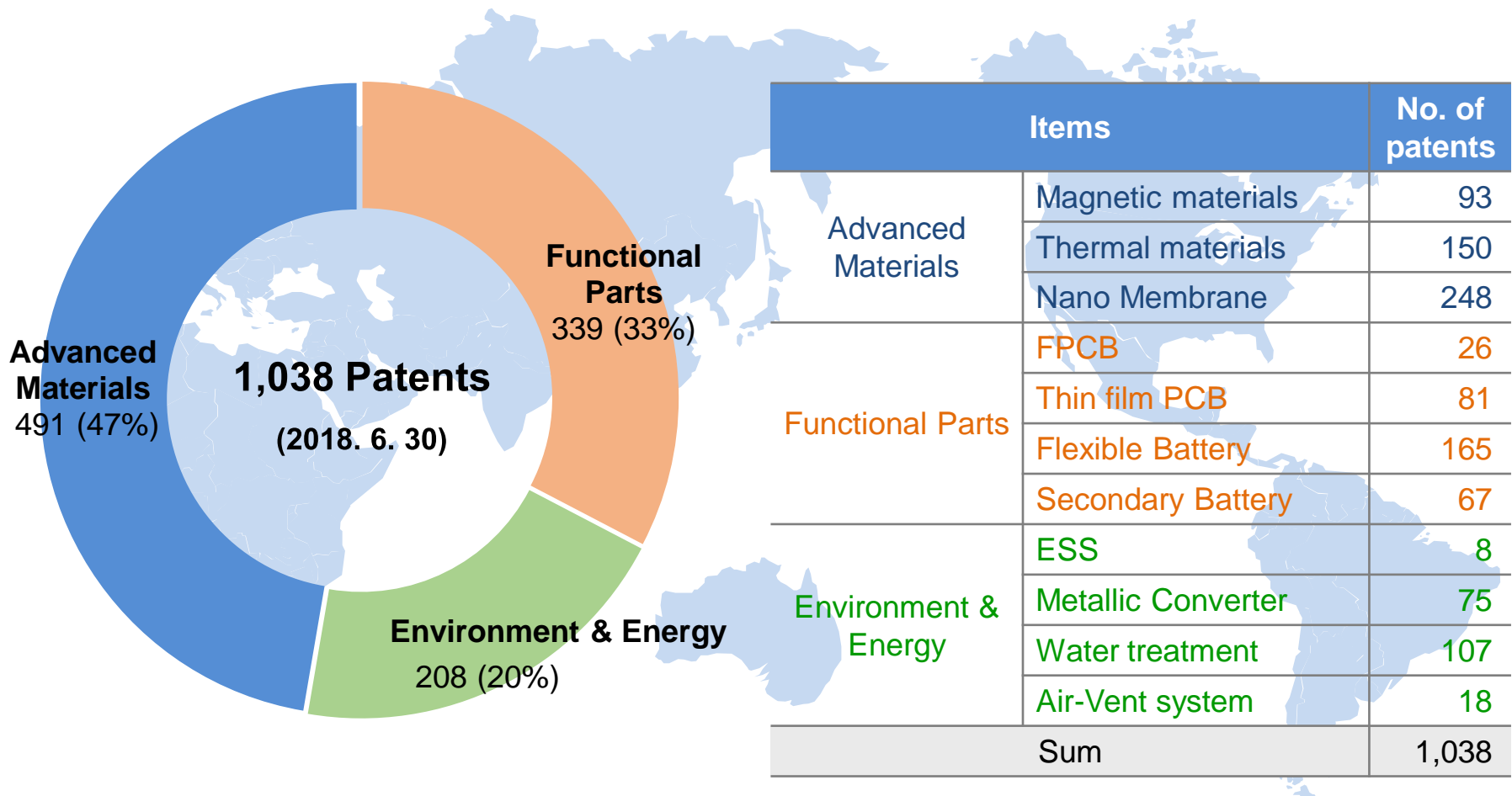
Fuel Filter



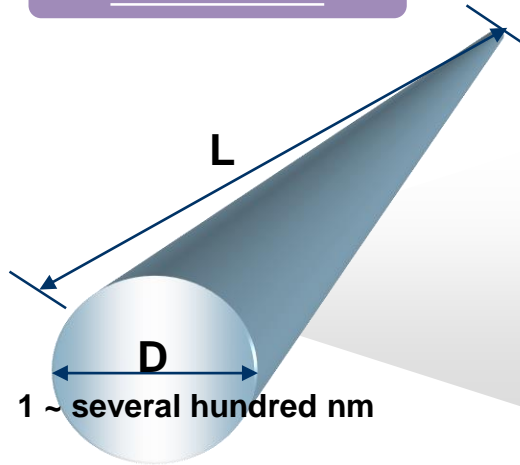


Based on Nano technology

Patents Acquisition to become Global Leader in Materials Field



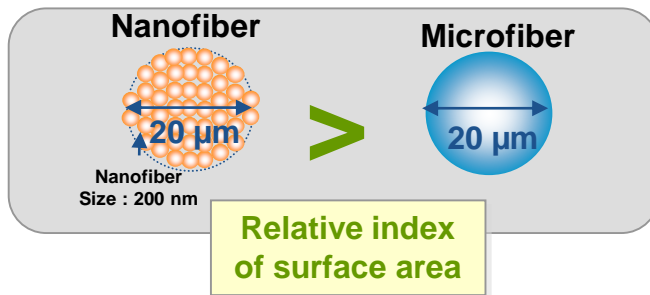
Overview



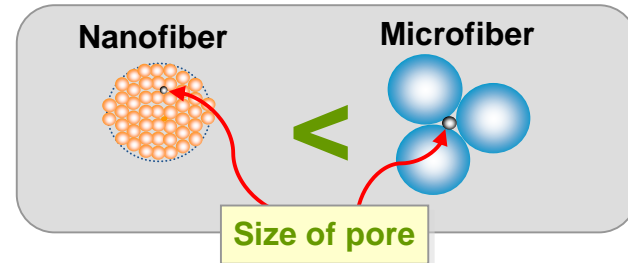
- 1/20 diameter compared to conventional microfiber
: Diameter below several hundred nm
- Expanding applications with innovative performance
: Functional Textile, Vent, Filter, Sound Absorber, Next Generation Energy, Bio application, etc.

Features

High specific surface area

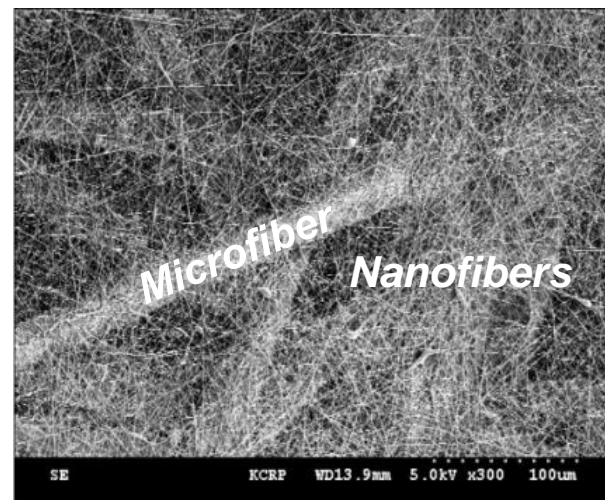


Small pore structure

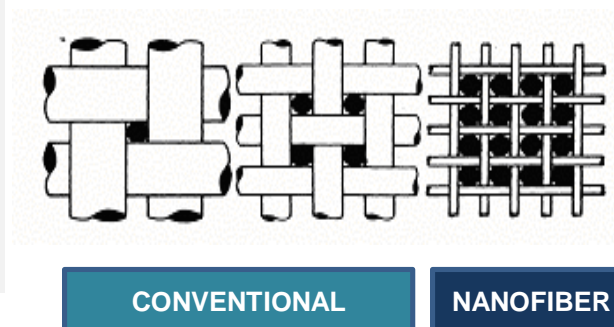


Features

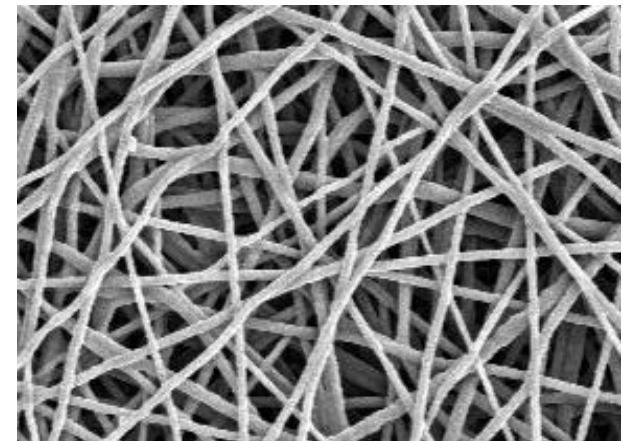
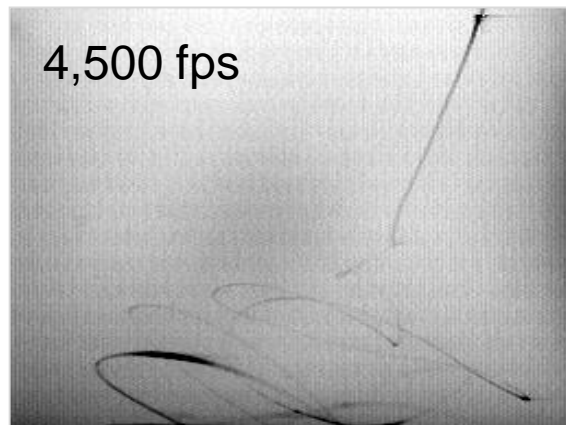
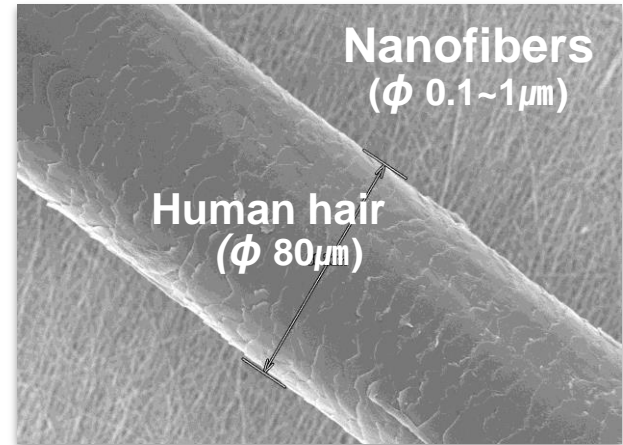
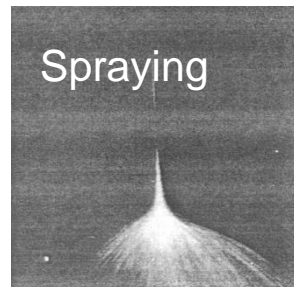
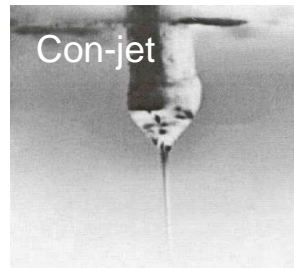
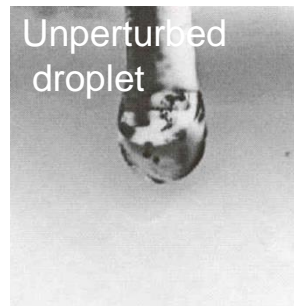
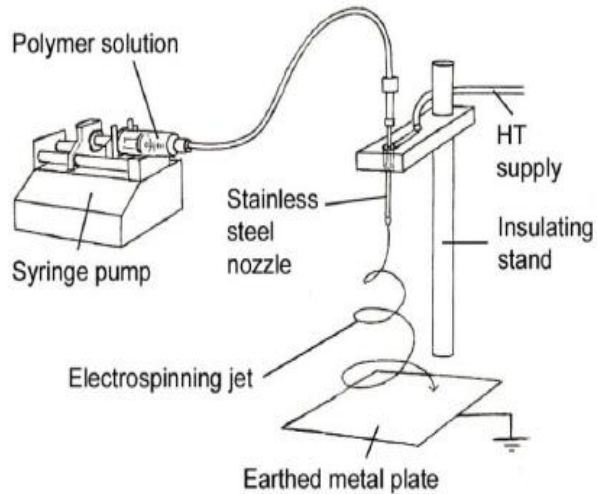
- Super specific surface area
- Narrow pore size distribution
- High Porosity (70~85%)
- Perfect 3D Open pore structure (No blinded pore)
- Excellent uniformity
- Excellent breathability
- Excellent molecular recognition ability
- Excellent adsorb-ability
- Easy to incorporate functional additives



Microfibers vs. Nanofibers

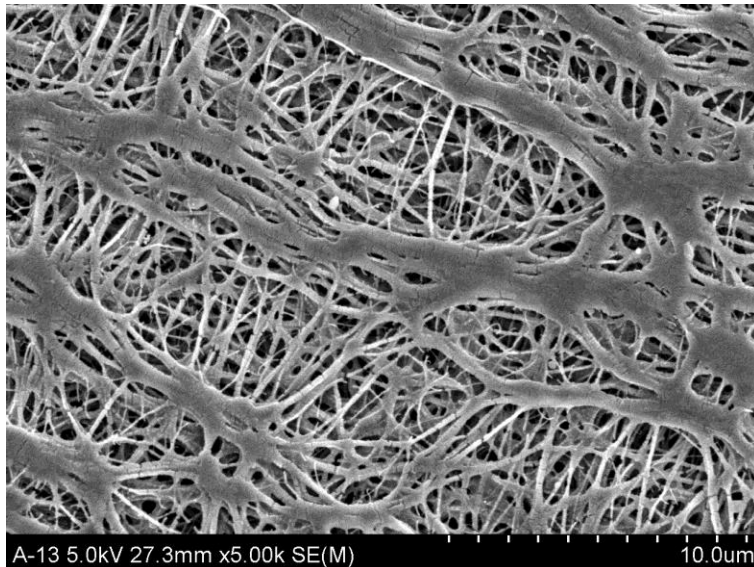


Nanofiber Membrane : Manufactured by Electrospinning



Membrane formed by nanofibers

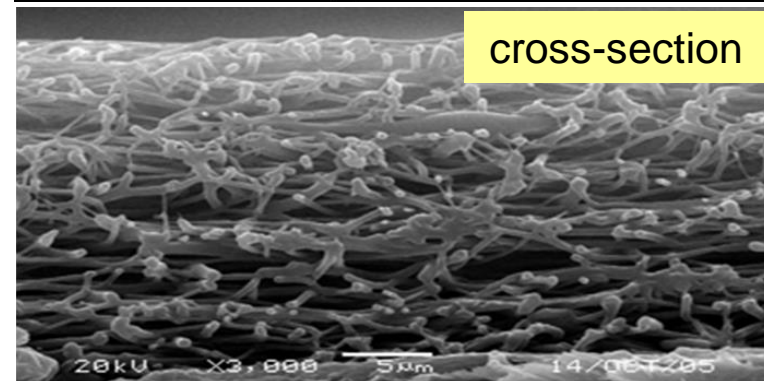
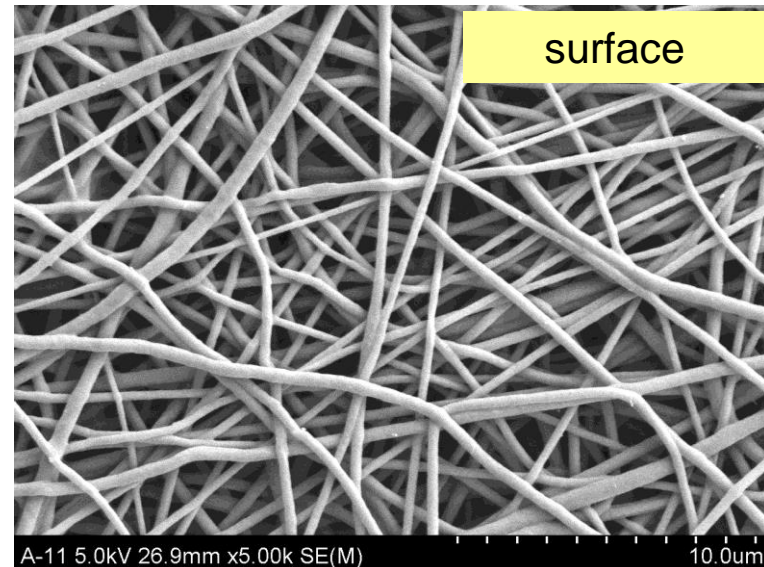
Existing membrane

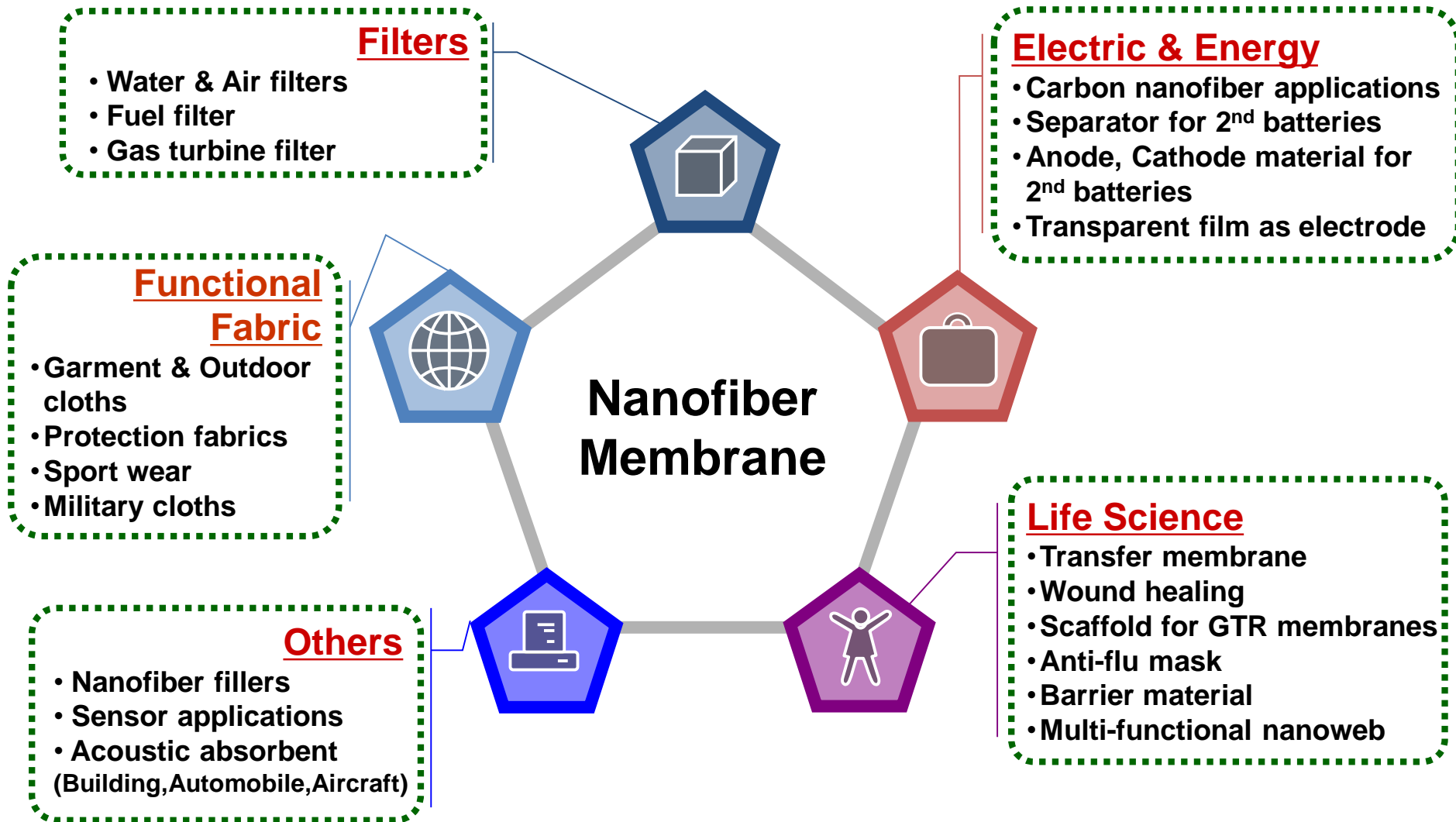


Features of Nano Membrane

- High specific surface area
- Fiber diameter of 5 ~ 500 nm
- High porosity (3D structure)
- small pore structure

Nanofiber membrane(AMOTEX®)





2007

- R&D started
- Lab. Scale facilities were installed

2010

- Pilot plants were installed
 - Spinning width of 500, 1,000mm

2012

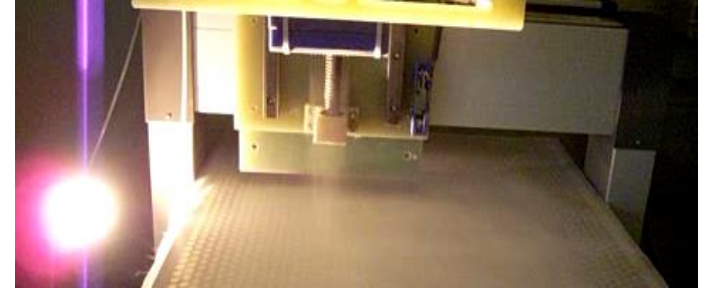
- Mass production lines were installed
 - Spinning width of 1,100, 1,700mm
- Productive Capacity was 60,000m²/month

2015

- Facilities for the vents and adhesive area were added



Appearance of the Nanofiber Membrane



▲ *Lab. Scale equipment*



▲ *Production line(1,700mm line)*



▲ *1,700mm line in operation*

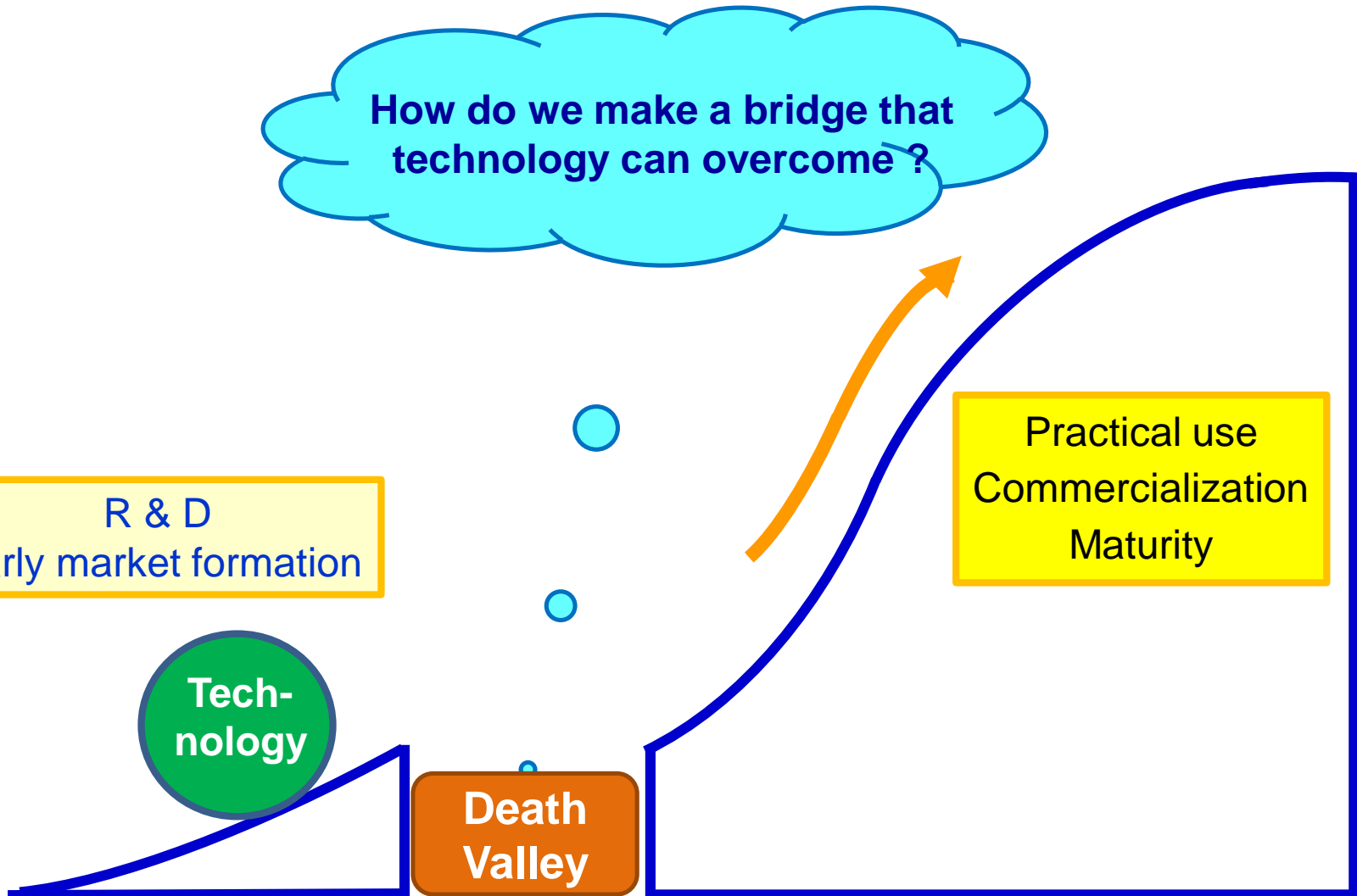
How do we make a bridge that technology can overcome ?

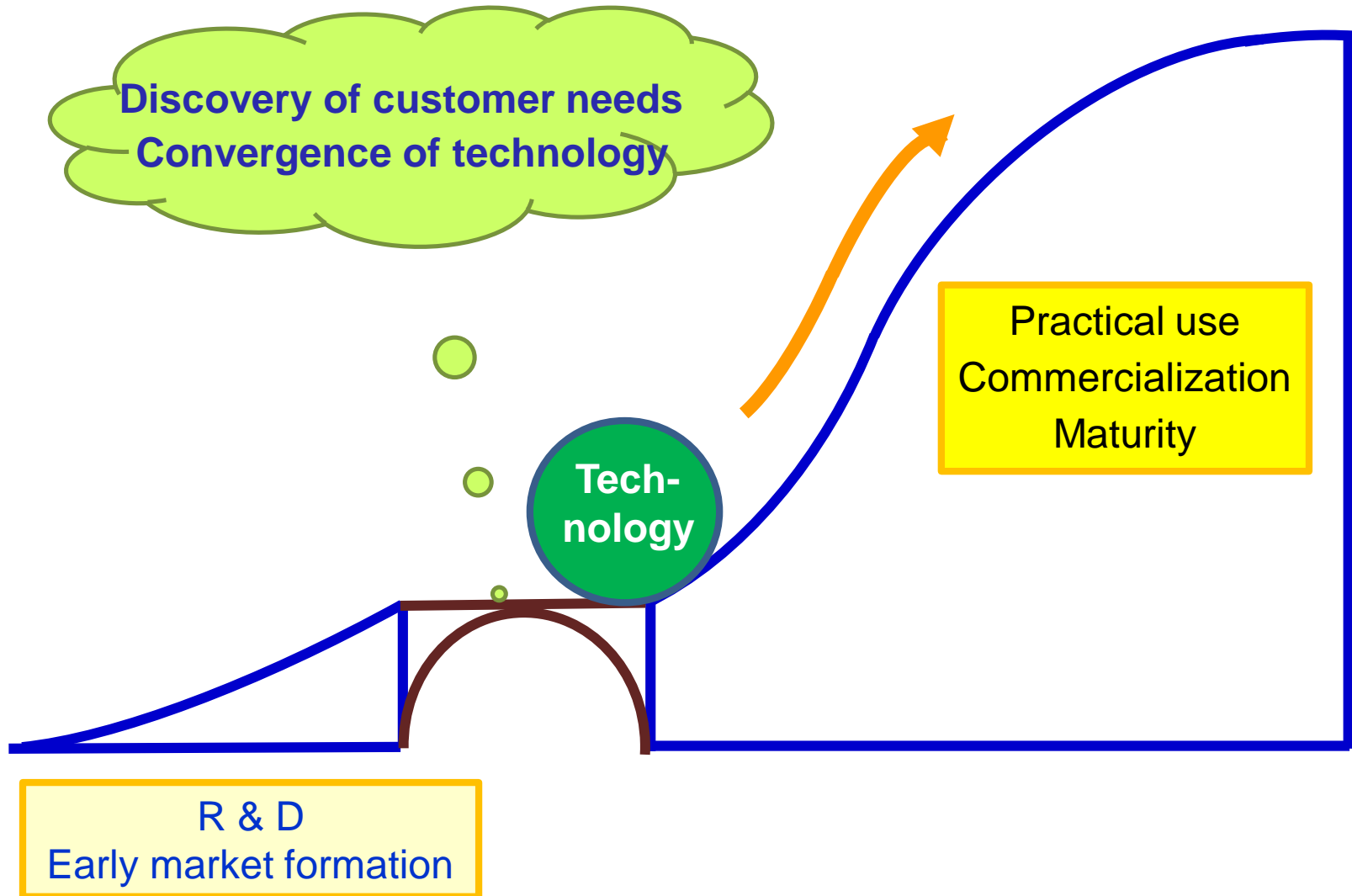
R & D
Early market formation

Tech-
nology

Death
Valley

Practical use
Commercialization
Maturity





Fiber & Web Flexibility

- Fiber dia. : $> 0.1, < 1\mu\text{m}$
- Weight : 0.3 ~ 100gsm
- Thickness : $\sim 100\mu\text{m}$
- Pore size : 0.1 ~ $10\mu\text{m}$

Production Flexibility

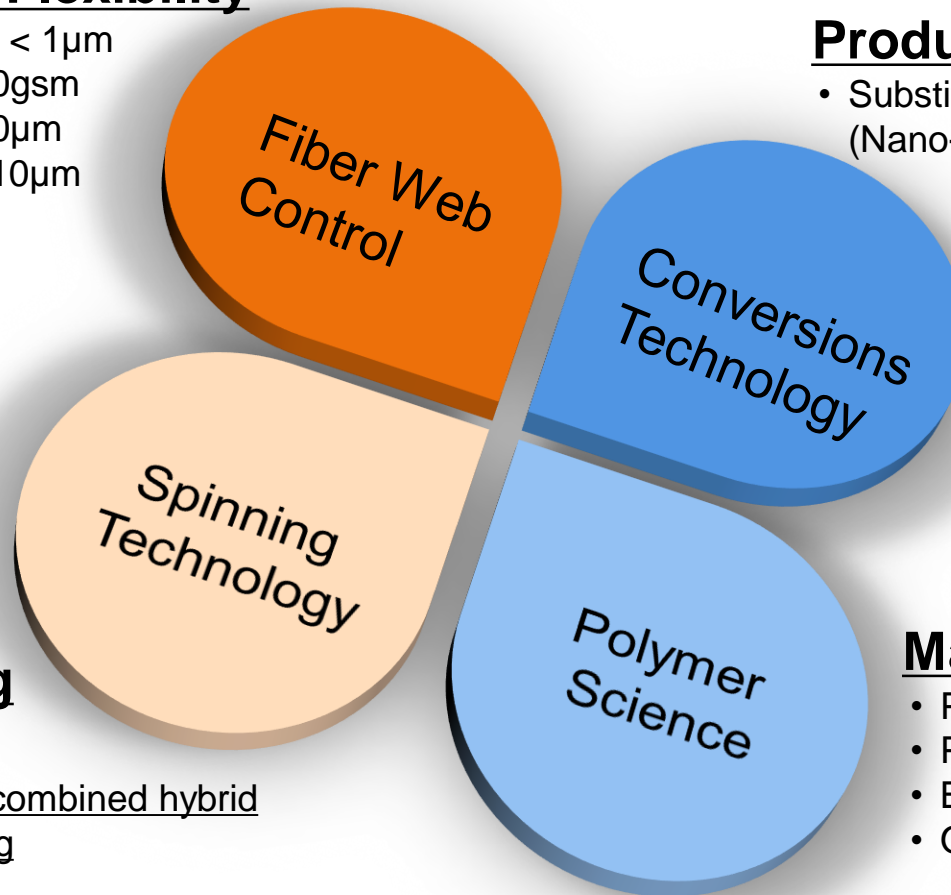
- Substitution of existing products (Nano+substrate)
 - Pure nanomembrane products

Processing Flexibility

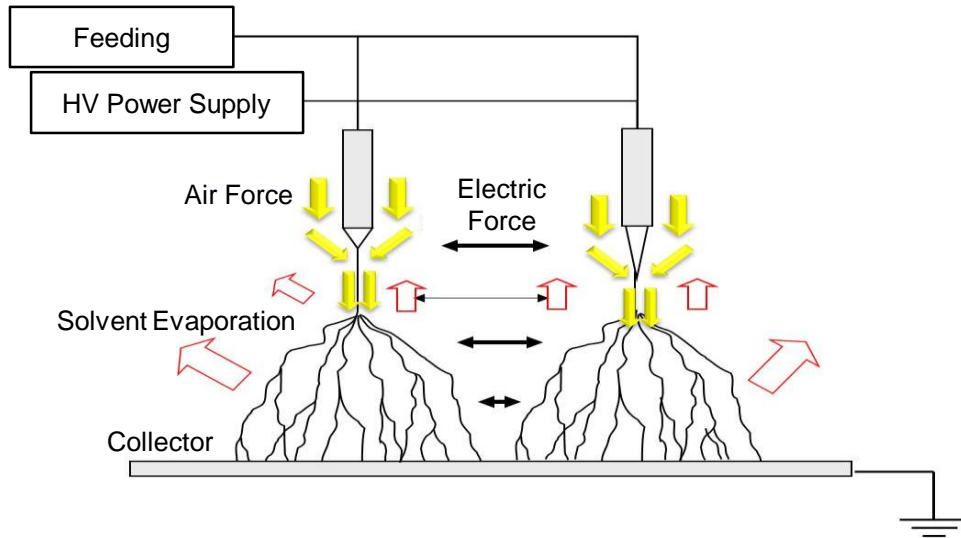
- Electric & Air combined hybrid electrospinning
- post process
 - Calendering
 - Oleophobic(hydrophobic)
 - Hydrophilic

Material Flexibility

- PVDF, PAN, PES,
- PU, Biopolymers,
- Blendable,
- Organic & inorganic hybrid



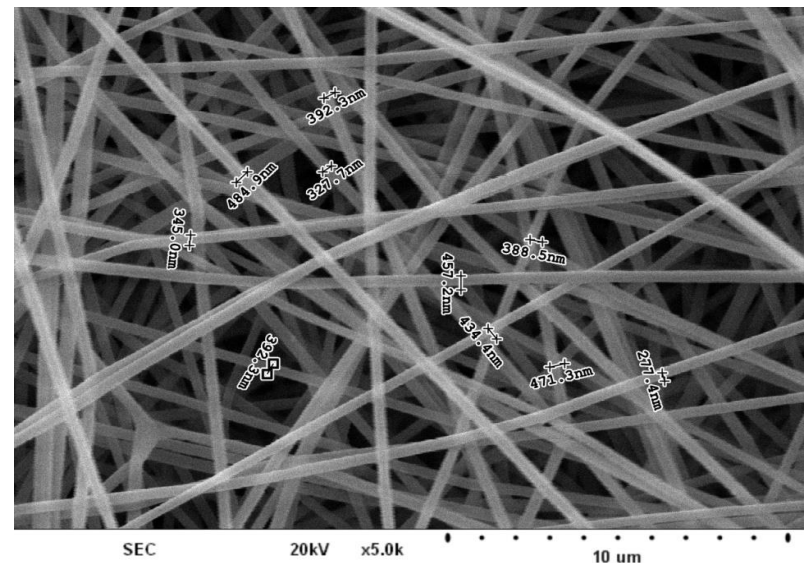
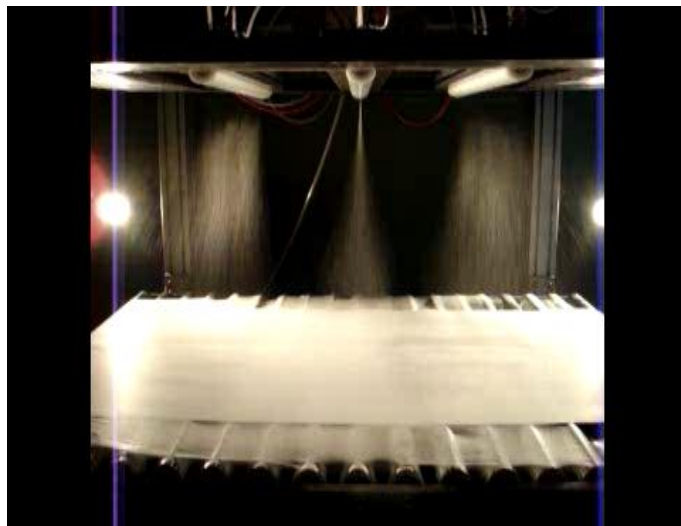
Hybrid Electrospinning (Electric & Air)



Morphology Control
By Air Force



Setup of mass
production technology



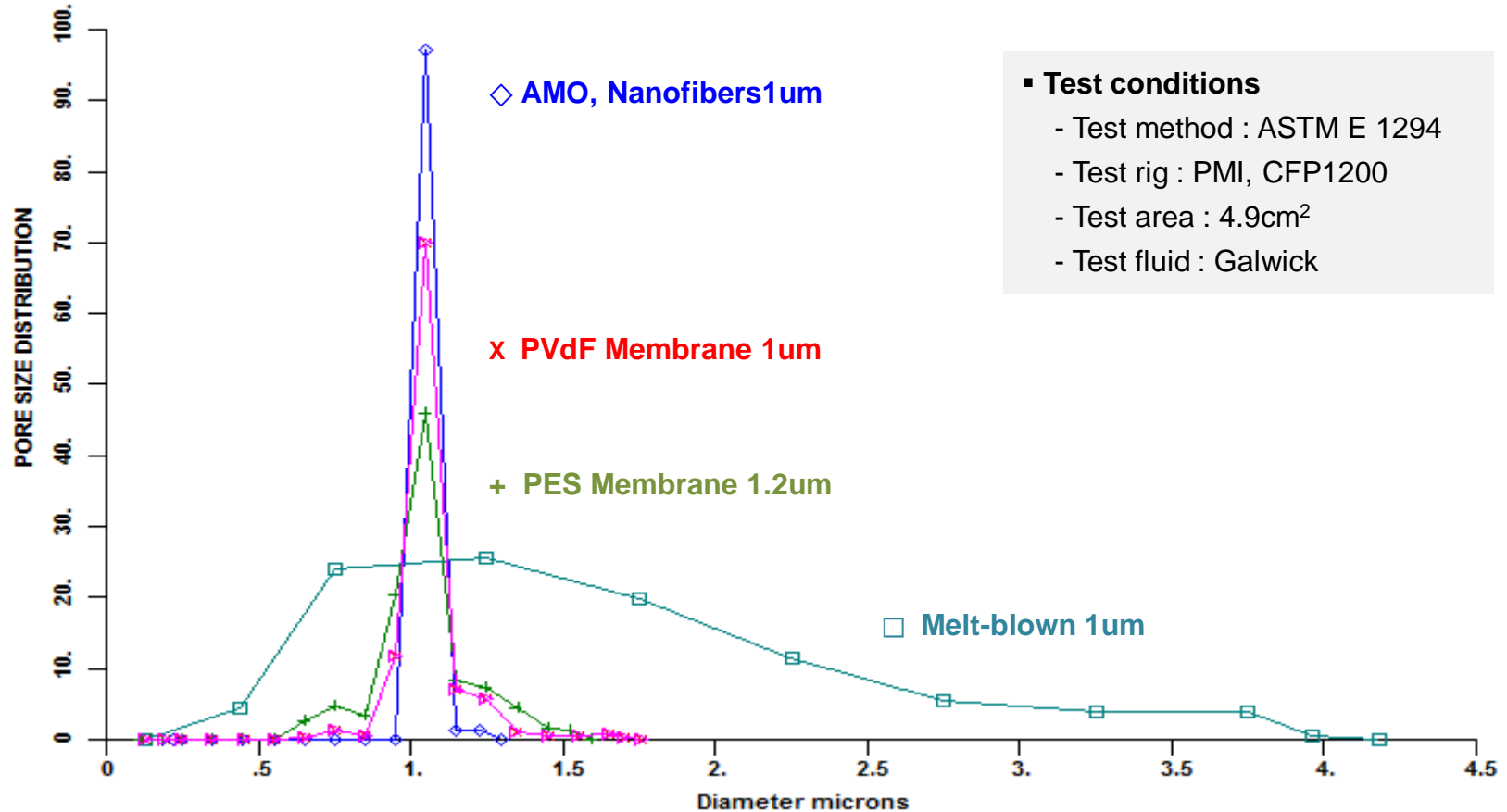
Electric & Air Hybrid Electrospinning

Superior uniformity and productivity  Enables mass production

Classification	Hybrid E-spinning	Electro Blown	Pure E-spinning	Nozzless E-spinning
Methods	Electric+Air	Air+Electric	Electric	Electric
Nozzle	Yes	Yes	Yes	No
<u>Productivity</u>	○	◎	X	△
<u>Polymer versatility</u>	○	△	△	○
Web thickness	◎	◎	X	X
Web evenness	○	X	○	X
<u>Control of fiber diameter</u>	○	X	△	△
Web density	○	X	X	○

X: Poor, △: Moderate, ○ : Good, ◎ : Excellent

“Very narrow pore size distribution & easy to optimize”



Changes in customer demand for outdoor clothing materials



protect



comport

Breathable Fabric

**Improvement of
permeability**

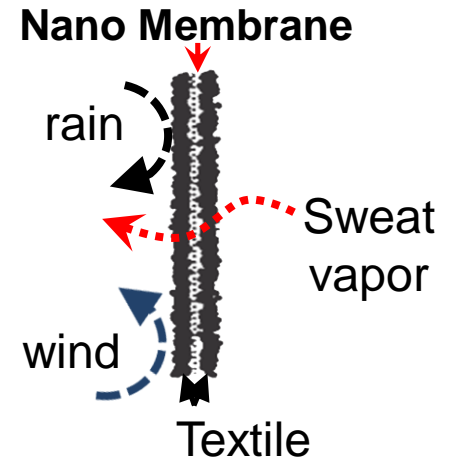
Nanofiber Membrane

Moisture-proof(waterproof)



Breathable (air, sweat permeability)

- Waterproof : pore size control OK !
- Breathable : pore size control OK !
high porosity OK !
- Wash durability OK !
- Reduction of friction noise OK !
- Price competitiveness OK !




Customer needs for Vent materials

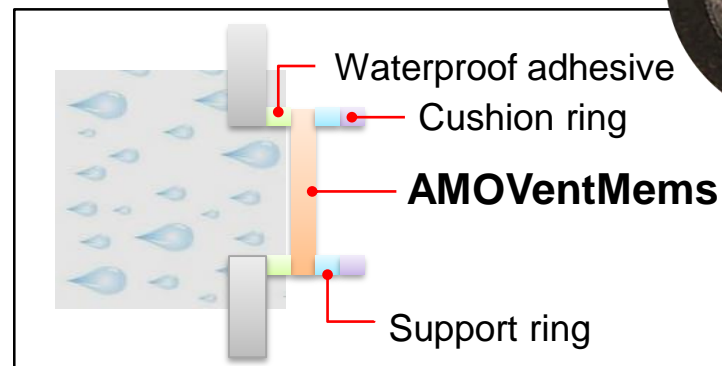
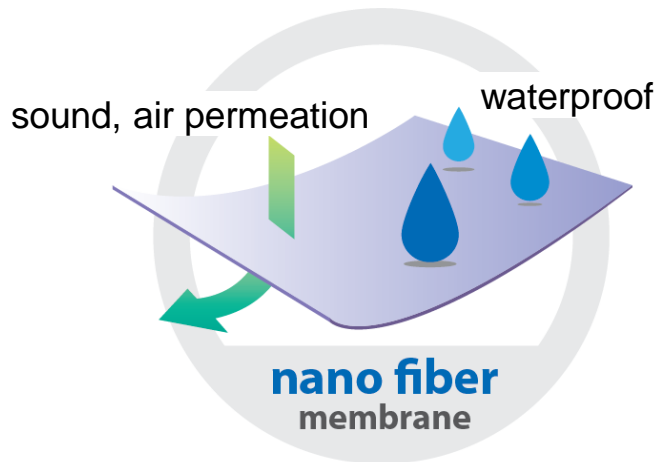
Vent Membrane for acoustic

Moisture-proof(waterproof)



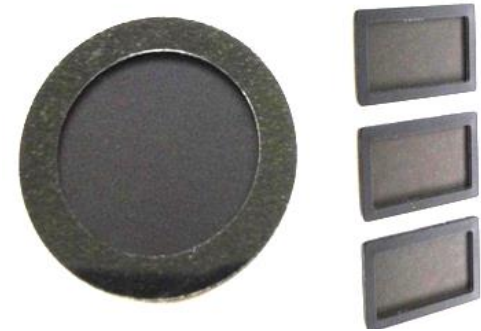
Sound permeability

- 
- Waterproof : pore size control OK !
 - Maintain sound permeability : lightweight, soft, high porosity OK !
 - Maintain mechanical strength OK !



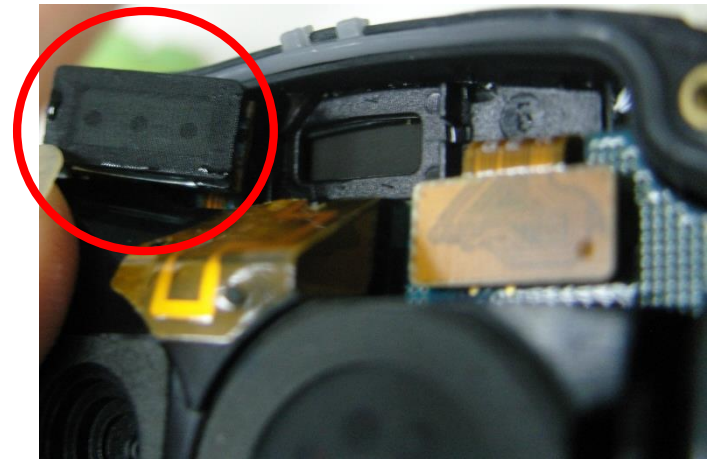
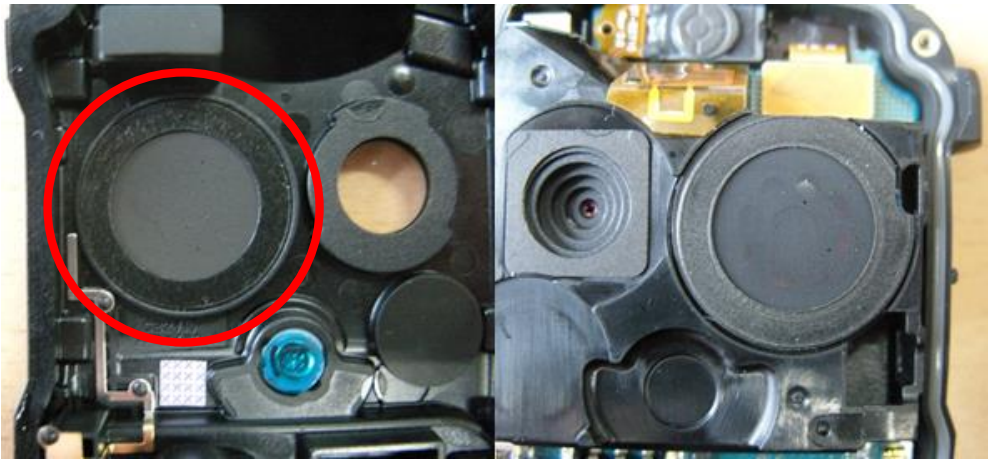
Example of actual use of Vent (speaker sound test) **AMO**

IPX7 grade 2 Point / Spk 1ea, Rcv 1ea



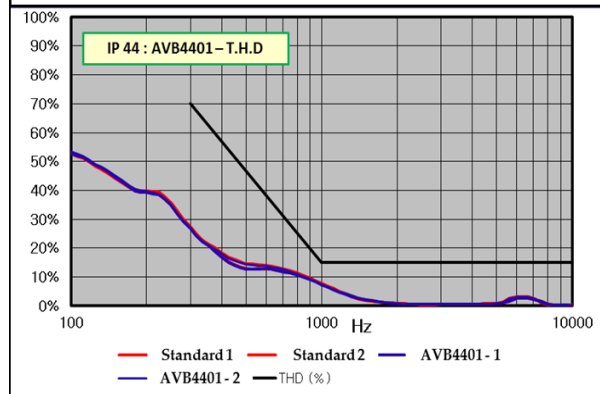
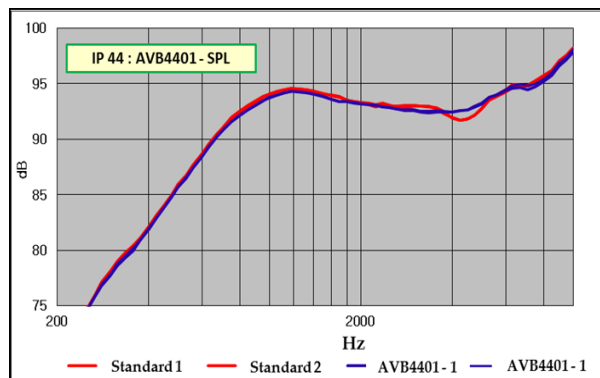
Speaker

Receiver

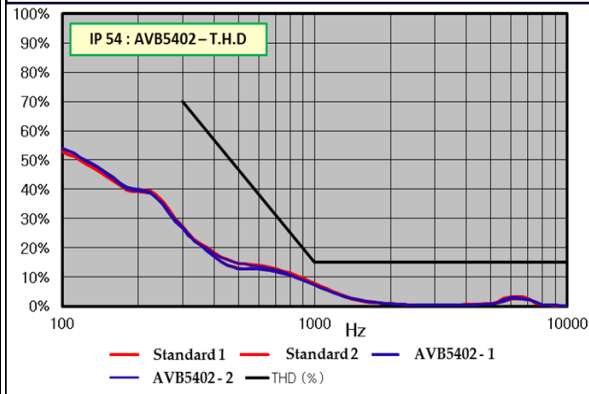
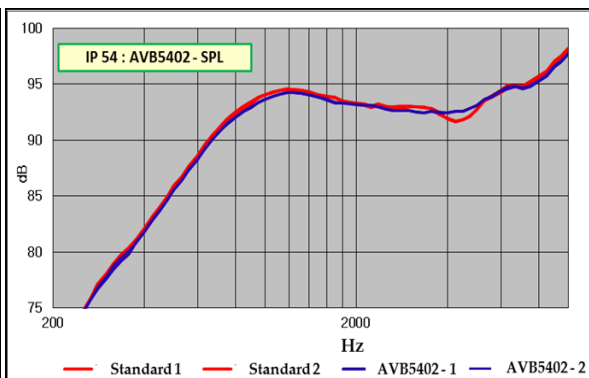


Example of actual use of Vent (speaker sound test)

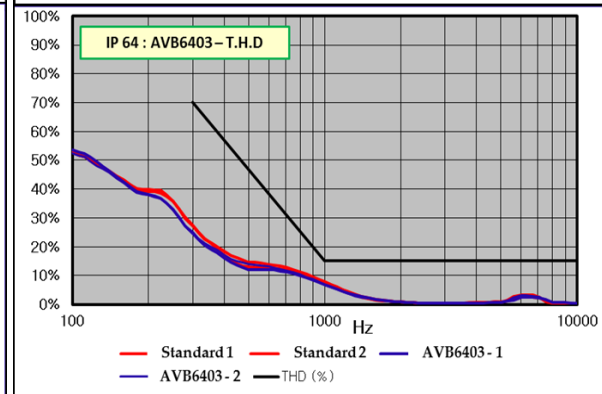
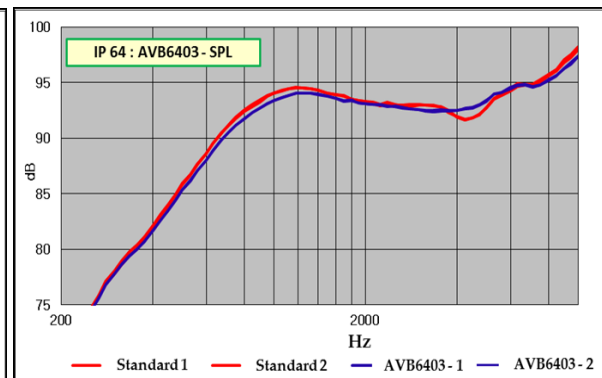
IP 44



IP 54



IP 64



Expanding application areas of Vent

Vents

Portable Electronics



Automotive



Packaging



Ink & Toner



Lamps



ECU



Battery



Agriculture



Consumer
Cleaner&Foods



Industrial



Ink

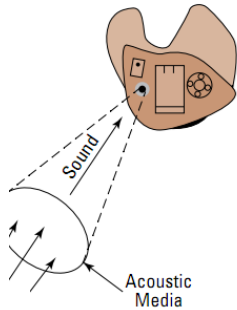


Toner cartridge

Expanding application areas of Vent

Vents

Hearing device



Others



Lights



Liquid Storage Tanks



Telecommunication Infrastructure



Solar panels



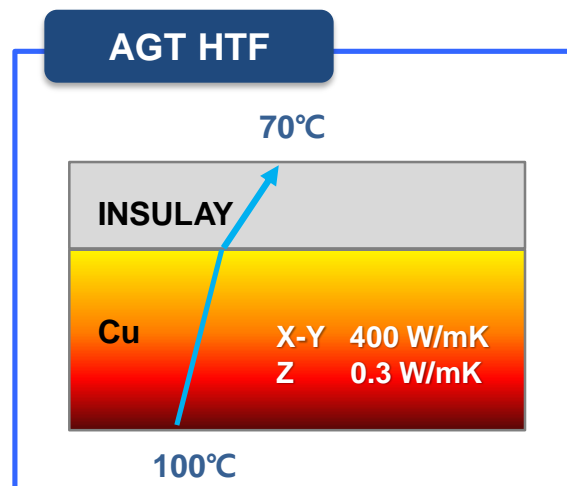
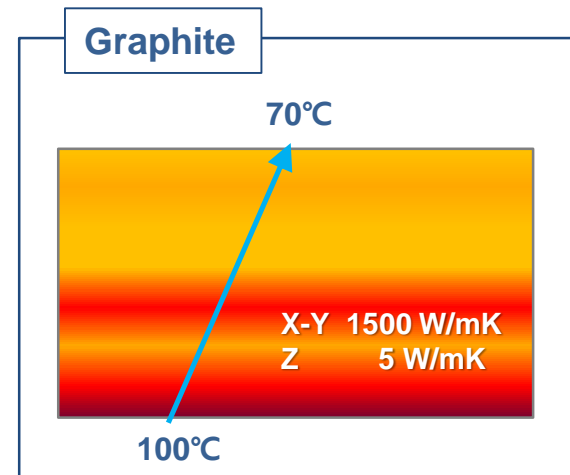
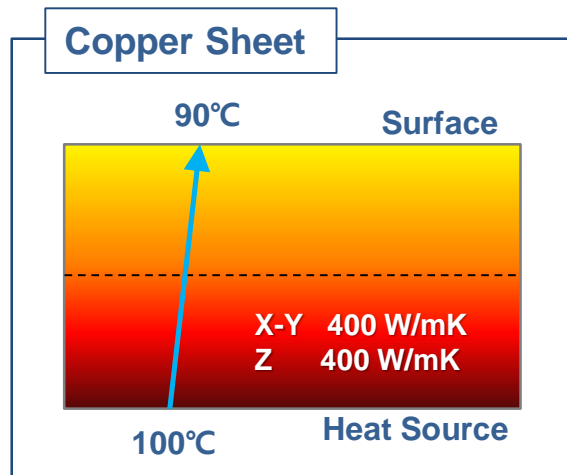
Sensor

Customer needs for heat dissipation(insulation)

Requires high performance & thinness



Needs for heat control

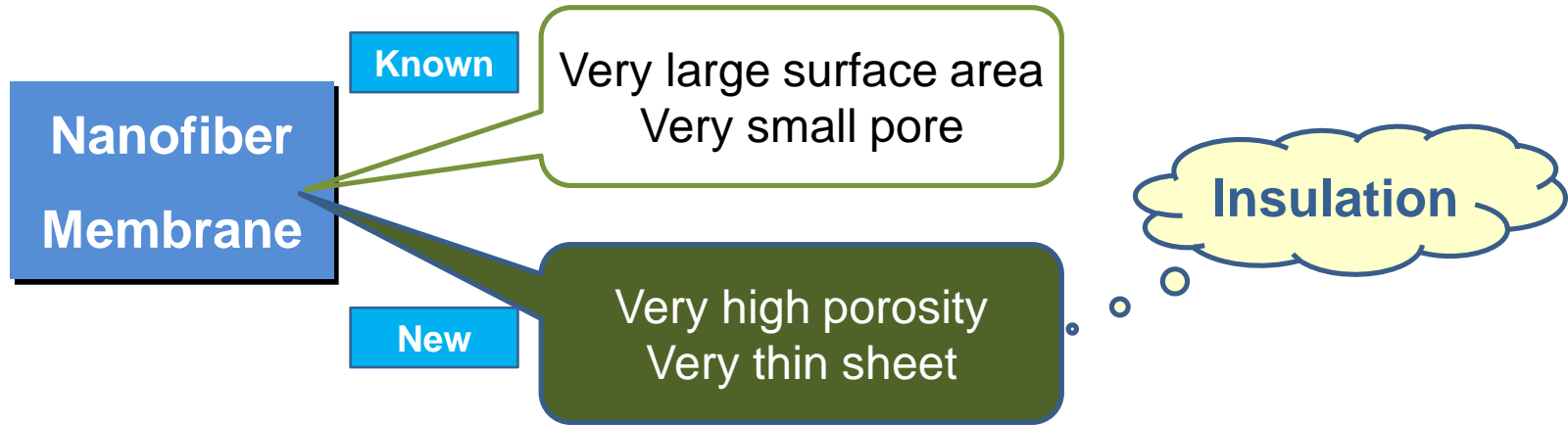


HTF : Hybrid Thermal Film

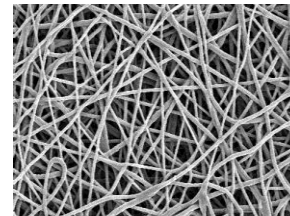
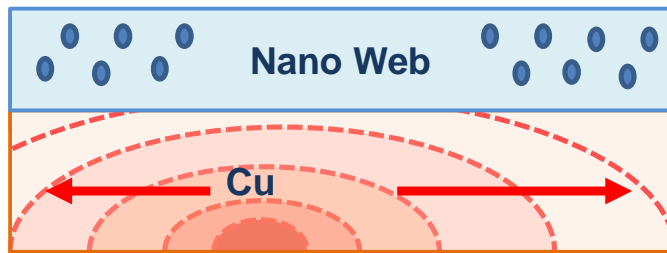
(In plan : 400 W/mK, Through plan : 0.3 W/mK)



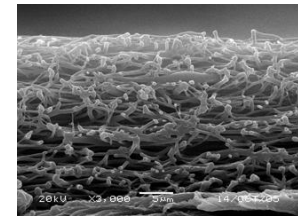
Customer needs for heat dissipation(insulation)



◆ HTF (Hybrid Thermal Film) structure



(plane)



(cross section)

Cu + Nano Web structure

- Heat dissipation through fast horizontal heat conduction by Cu (400 W / mK)
- Superior vertical insulation property by Nano Web (0.3 W / mK)
- Surface temperature is lowered by "heat dispersion layer + heat insulating layer"
- Price competitiveness compared to existing heat-insulating sheet

➔ **Hybrid structure with thin thickness satisfies customer's demand**

Features

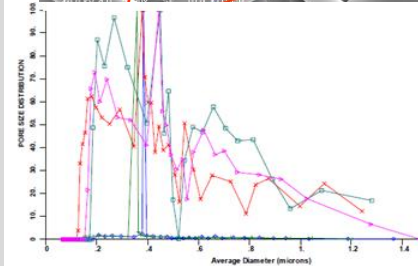
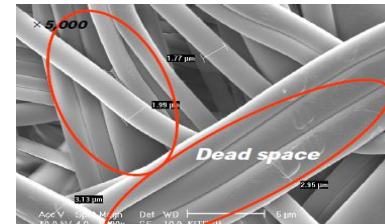
- Narrow pore size distribution
- High Porosity (70~80%)
- Perfect 3D Open pore structure (No blinded pore)
- Excellent uniformity
- Fixed pore construction

Benefits

- Excellent removal efficiency
- Very low pressure drop
- Longer filter service life
- Lower energy costs
- Reduced equipment downtime
- Reduced investment costs due to compact size of filter systems
- Customize design & manufacturing

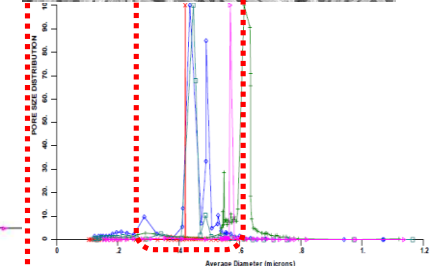
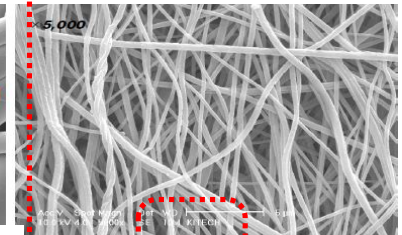
Nano filter Advantage

Micro membrane
Diameter of fiber :
1~ 3 μ m
Porosity : 20~ 35%



Wide distribution: range of pore size distribution : 0.1~1.2 μ m

Amogreentech
Diameter of fiber :
0.1~ 0.3 μ m
Porosity : 65~ 70%



Narrow distribution: range of pore size distribution : 0.4~0.6 μ m

Water/Air treatment system using Nanofiber membrane

Powerless water purification system

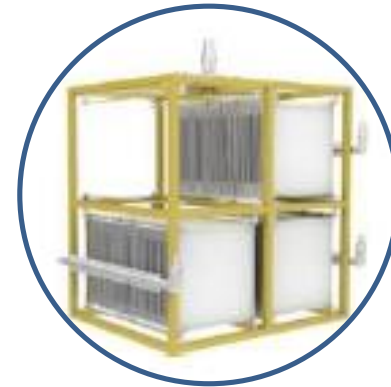
3 layer membrane filtration module



Portable Water Bag

Membrane for sewage / waste water

Flat membrane filtration module system for sewage / waste water

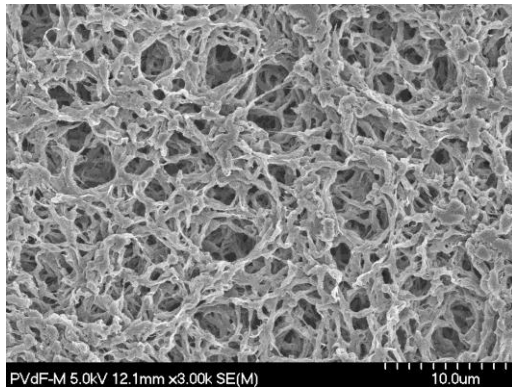


Ultrafine dust filter

Automatic Ventilation Products

Commercial VS Electrospin PVDF membrane

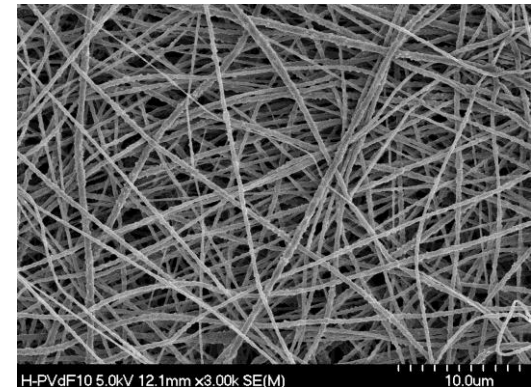
Commercial PVDF Membrane



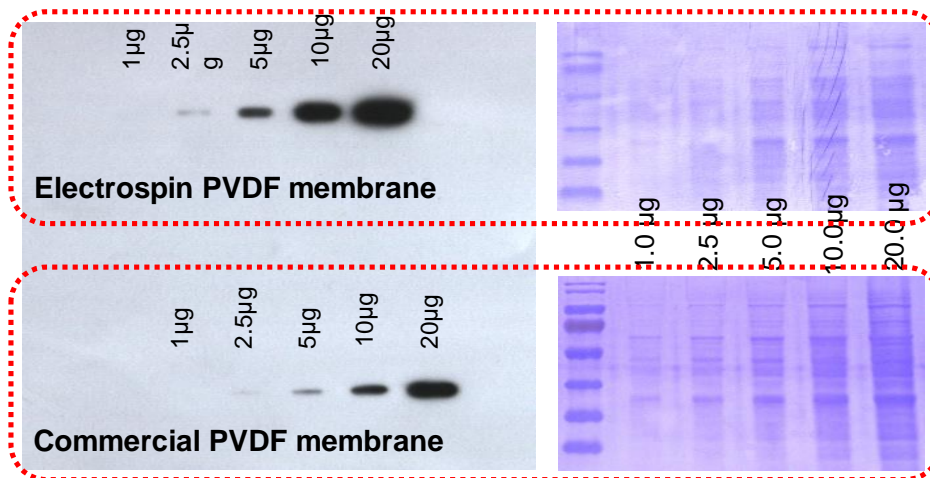
◆ Low uniformity

	Commercial	Nanofiber
Pore Size (μm)	0.45	0.2~0.45
Thickness (μm)	165	60~150
Porosity (%)	67.7	73.3

Electrospin PVDF Membrane



◆ High uniformity



Electrospin PVDF membrane is **“more sensitive”** than commercial PVDF membrane.

Filters



<Liquid Filter>



<Filter module>



<Fuel filter>

Battery



<ESS(UPS)>



<Flexible Battery>



<Super Capacitor>



<Separator for LIB>

Electronic materials



<Acoustic vents film>



<Hybrid thermal film>

Bio & Medical



<Culture system>



<Patch>



<Western membrane>

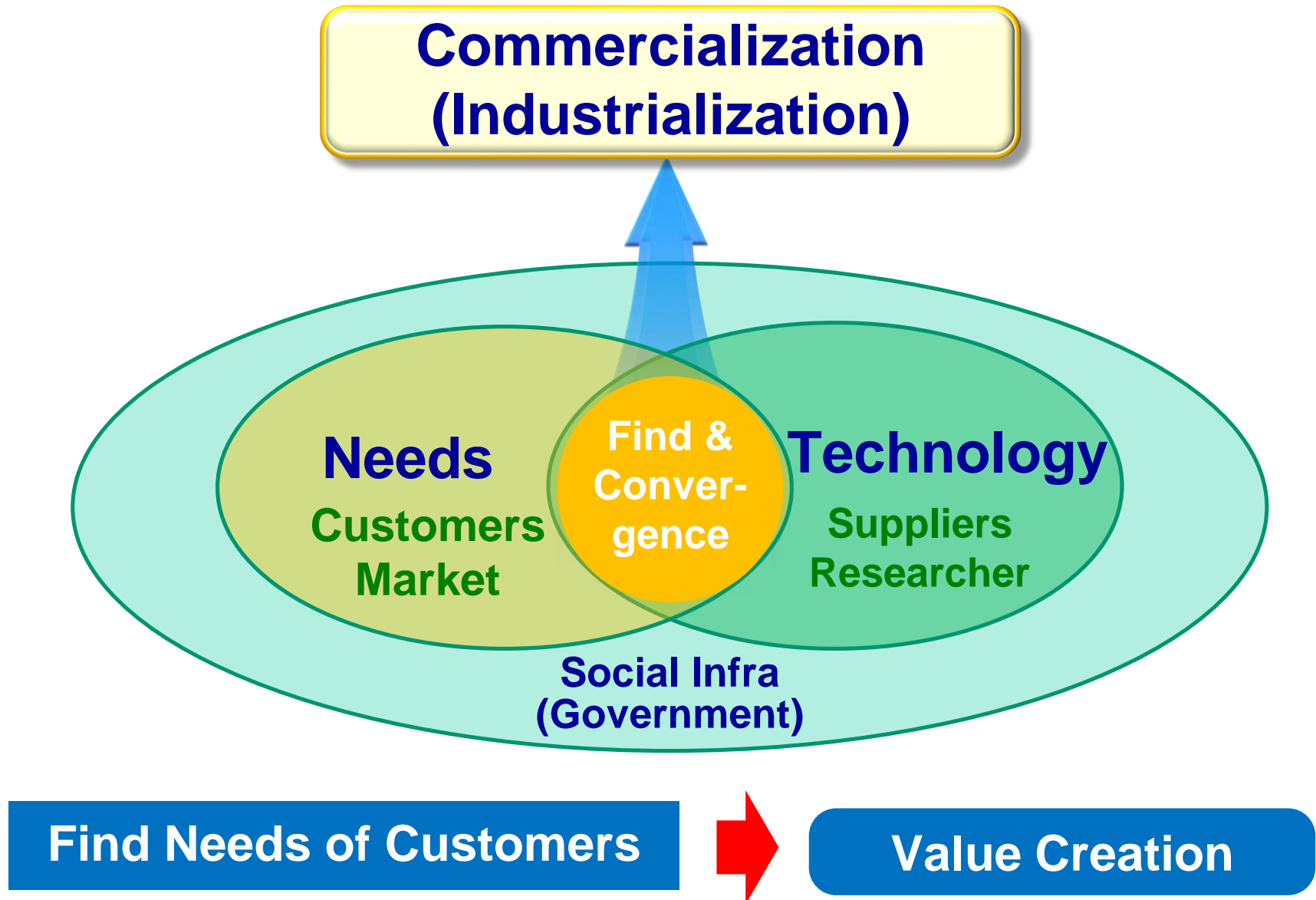


<Mask pack>

Textile



<AMOTEX>





Challenging the world with advanced material products

yssong@amogreentech.co.kr

