Glass fiber based VIP Study of properties and ageing

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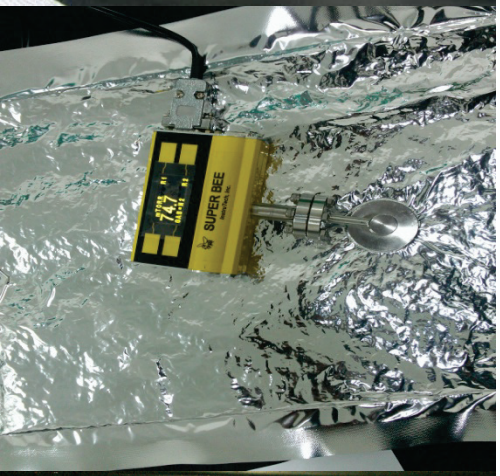
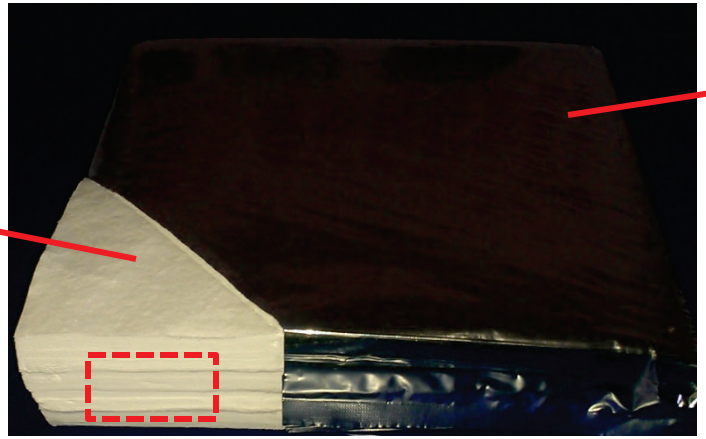


Content

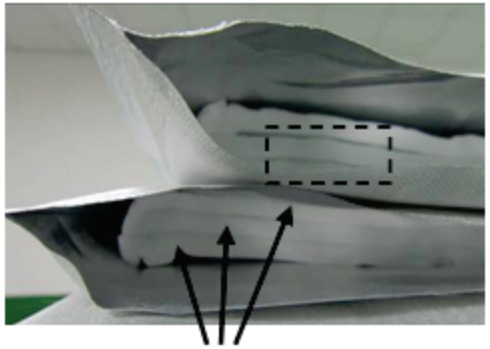
- Background
- Glass fiber & envelope materials
- VIP ageing (dynamic conditions)
- Service life estimation
- Summary & outlook

Background - VIP

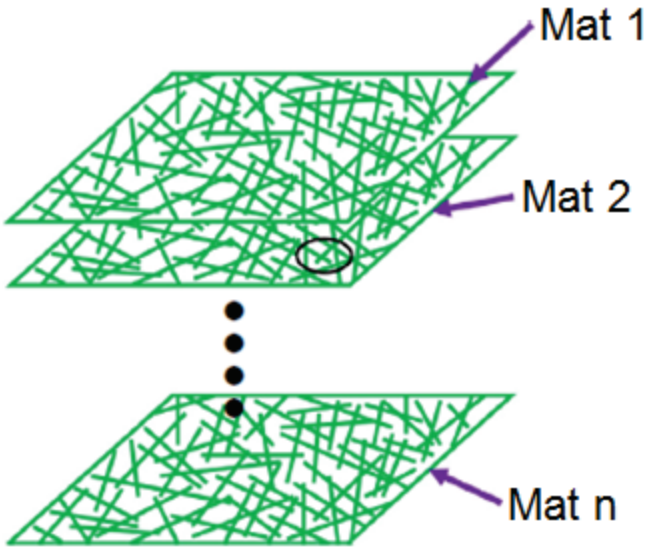


Cross section:

Macroscopic illustration



Layers of glass fiber mats

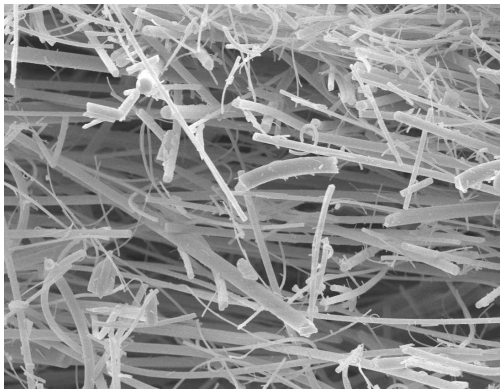


Background - typical application in China

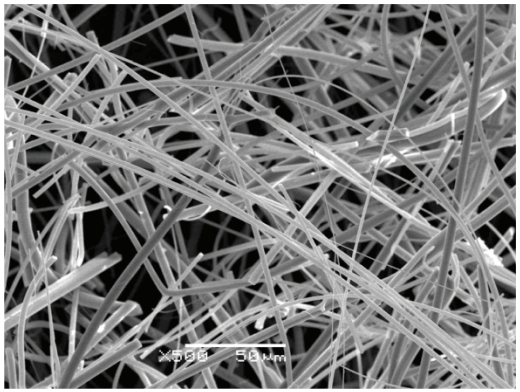
Typical building insulation

Glass fiber core material - properties

Properties	Centrifugal glass fiber with powders (CF)	Aerocor glass fiber (AF)
Mean fiber diameter (μm)	2 ~ 6	1.5 ~ 2
Mean fiber length (mm)	20 ~ 35	5 ~ 10
Pore size (nm)	100	< 50
Porosity	≥ 90 %	≥ 92 %
Mat thickness (mm)	3	1
Composition (EDS, at.%)		
O	37.39	40.79
Na	11.18	8.99
Mg	1.92	1.76
Al	0.48	1.00
Si	42.93	38.96
Ca	6.10	8.50



SEM - Centrifugal



SEM - Aerocor

Envelope material - composition & properties

AL 1

PA	Polyamine (15 µm)
PU	Polyurethane glue (2 µm)
VMPET	Metalized polyethylene terephthalate (12 µm)
PU	Polyurethane glue (2 µm)
Al foil	Aluminium foil (7 µm)
PU	Polyurethane glue (2 µm)
LDPE	Low density polyethylene (50 ~ 55 µm)

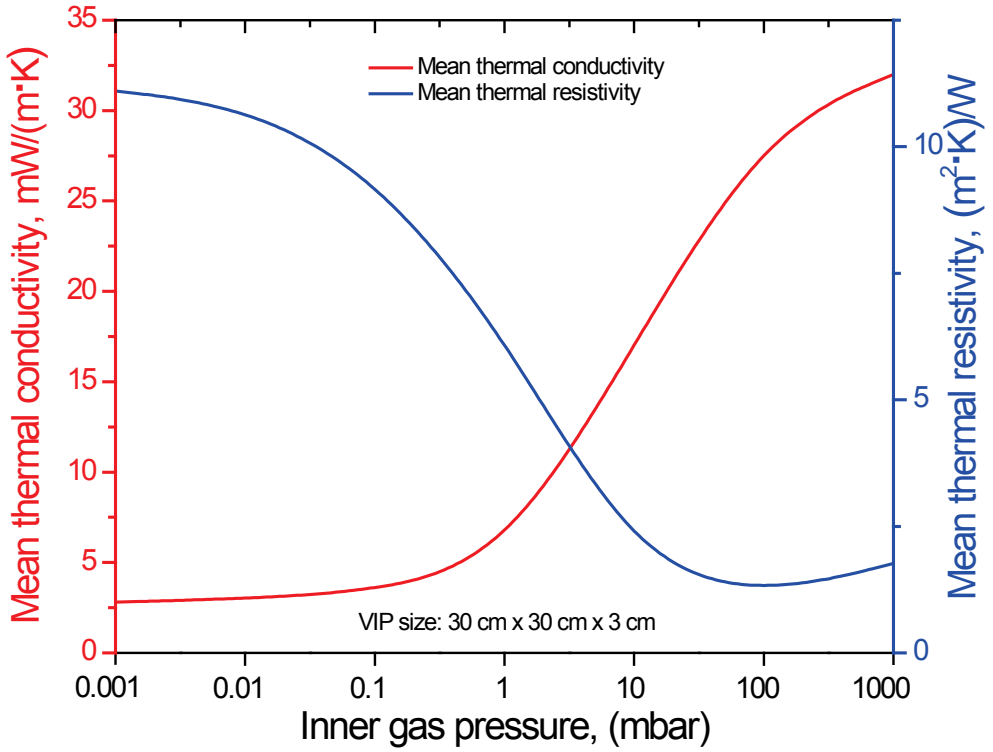
AL 2

FGC	Fiberglass cloth (340 ~ 350 µm)
PU	Polyurethane glue (2 µm)
PET	Polyethylene terephthalate (12 µm)
PU	Polyurethane glue (2 µm)
Al foil	Aluminium foil (7 µm)
PU	Polyurethane glue (2 µm)
PA	Polyamine (15 µm)
PU	Polyurethane glue (2 µm)
mLLDPE	Metallocene linear low density PE (80 µm)

Parameter	AL 1	AL 2
Water vapour transmission	< 0.05 [g/(m²·24h)]	< 0.05 [g/(m²·24h)]
Oxygen transmission	< 0.005 [cm³(STP)/(m²·d)]	< 0.005 [cm³(STP)/(m²·d)]
Heat seal strength	≥ 60 N	≥ 130 N
Tensile strength	≥ 96 N	≥ 450 N
Puncture strength	> 20 N	> 20 N
Thermal conductivity	0.12 W/(m·K)	0.078 W/(m·K)

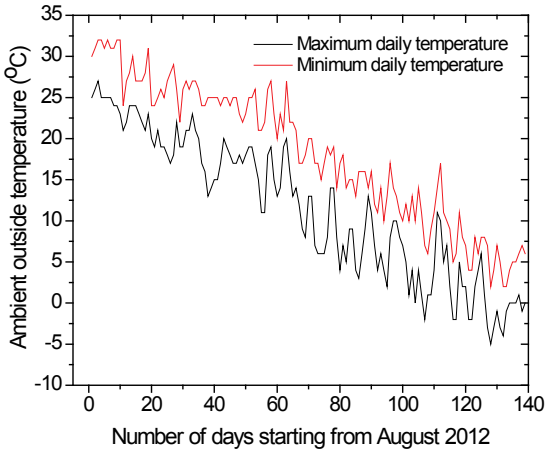
Thermal conductivity & resistivity versus gas pressure

- Thermal conductivity dependence on pressure
- Thermal resistivity dependence on pressure



Ageing - conditions

Sample	Size	Composition (core, laminate)	Inner pressure	Thermal conductivity, λ	R-value, R_{1-dim}
Unit	(cm × cm × cm)		mbar	$mW/m \cdot K$	$m^2 \cdot K/W$
1	30 × 30 × 3	AF, AL2	0.001	3.2	9.2
2	30 × 30 × 3	AF, AL2	0.001	3.1	8.9
3	28 × 28 × 3	CF, AL2	0.01	11.6	2.9
4	28 × 28 × 3	CF, AL2	0.01	11.4	3.0
5	28 × 28 × 3	CF, AL2	0.1	16.5	2.0
6	28 × 28 × 2	CF, AL2	0.1	17.2	1.9
7	30 × 30 × 3	AF, AL1	0.001	3.0	10.3
8	30 × 30 × 3	AF, AL1	0.001	2.5	12.0
9	28 × 28 × 3	AF, AL1	0.01	2.9	11.2
10	28 × 28 × 3	AF, AL1	0.01	2.9	11.1

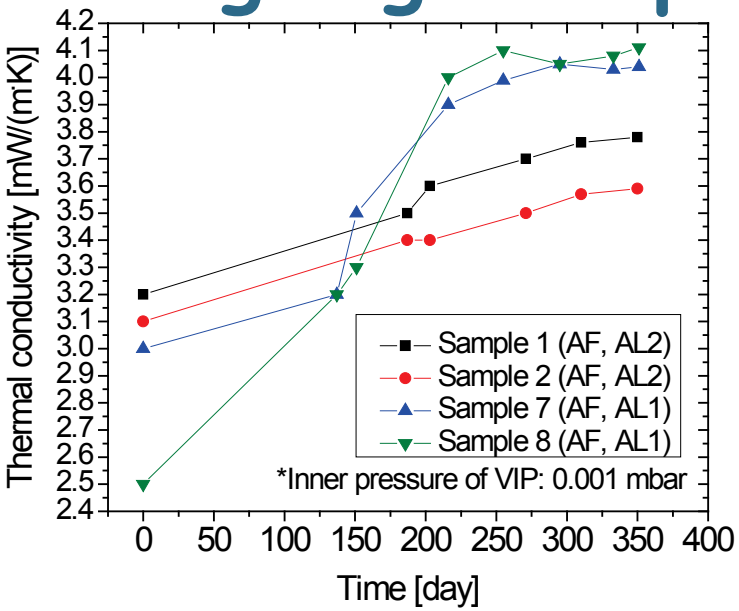


Samples1-4;7-10: partial exposures at 23°C, 50% (for 130-187 days); 80°C, 80% (for 14 days); 23°C, 50% (for 45 days), 80°C, 5% (for 21 days) and 20°C, 45% (for 130 days).

Samples 5 and 6: partial exposures at ambient outdoor conditions for 137 days, and then at 80°C, 80% (for 14 days); 23°C, 50% (for 45 days), 80°C, 5% (for 21 days) and 20°C, 45% (for 130 days).

Ageing - experimental curves

Fig.1 Samples 1, 2, 7, 8.



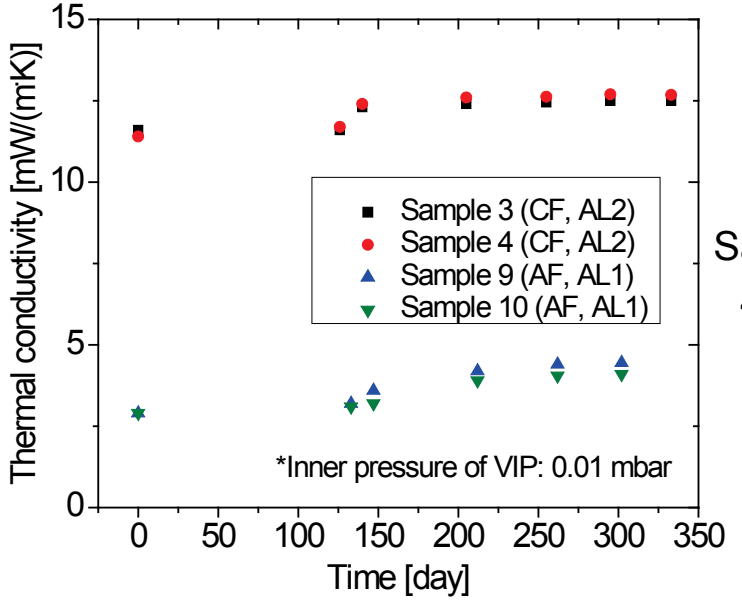
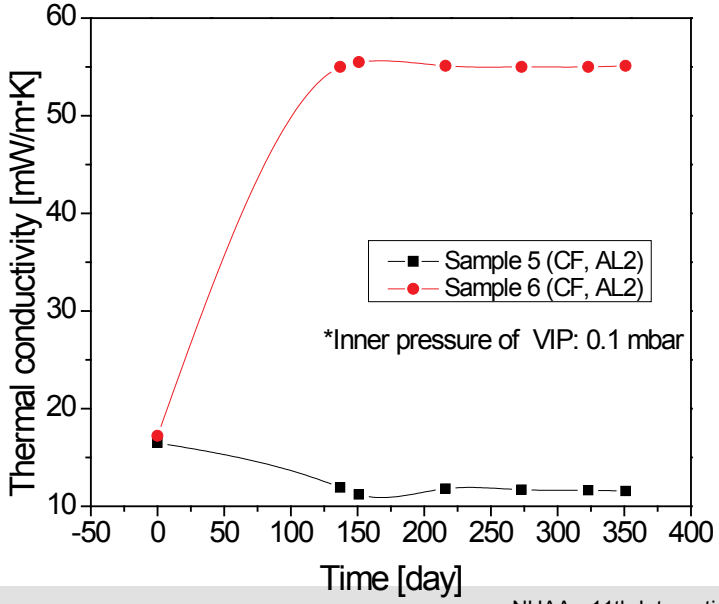


Fig.2 Samples 3, 4, 9, 10.

Fig.4 Samples 5 & 6.



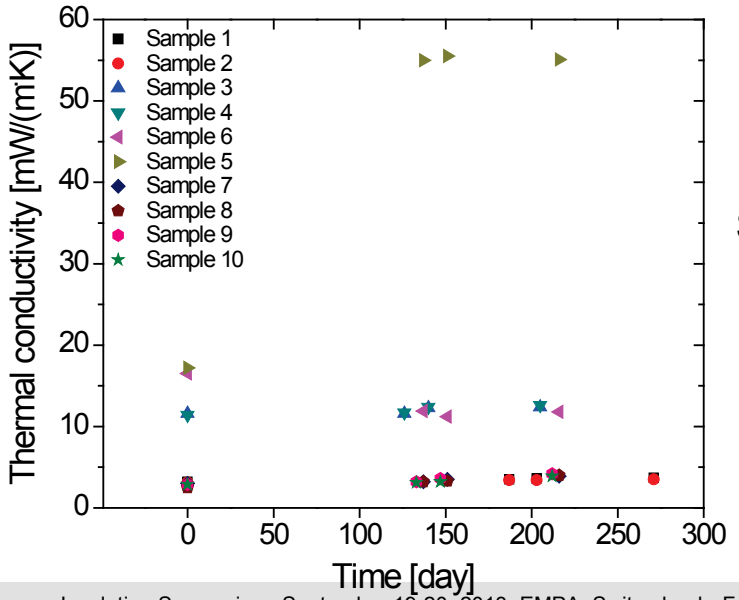


Fig.4 Samples 1-10