数据比较—Hot Disk精度

一篇源自**Torbjorn Log***教授的文献

列举比较5种不同标准材料的Hot Disk测试结果

- ***T.Log, S.E.Gustafsson, Transient Plane Source (TPS) Technique for Measuring Thermal Transport Properties of Building Materials, *Fire and Materials* 19, 43-49 (1995)**

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To cover a range of thermal conductivity from good insulators to good conductors the following five materials were chosen to test the TPS method over a thermal conductivity range of about 0.02–200 $W\,m^{-1}\,K^{-1}$:

(1) Extruded polystyrene (ASTM C 578 Round Robin[12])
(2) PMMA (Perspex, ICI, Inc.)
(3) Cecorite 130P (Lafarge Company, France) used for a CODATA measurement program[13]
(4) Stainless steel (SRM 1462, NIST, Gaithersburg, MD, USA)[14]
(5) Aluminium (Grade ALMG4.5MN (DIN.1745, DIN.59600), Nordisk Metal A/S, Haugesund, Norway)

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小数点后第四位

Table 1. Test specimens, test specimen dimensions and thermal transport properties from other sources

Test specimen	Dimensions (mm)	k ($W m^{-1} K^{-1}$)	a ($mm^2 s^{-1}$)
Extruded polystyrene	100 × 100 × 50	0.028[12]	0.75[a]
PMMA	100 × 100 × 20	0.19[17]	0.11[17]
Cecorite 130P	31 × 35 × 20	1.45[13]	0.96[13]
Stainless steel (NIST)	Dia. 32, L 50	14.20[14]	3.74[18]
Aluminium	100 × 100 × 30	166[b]	68.5[c]

[a] Calculated from $\rho = 31$ kg m^{-3} and $C_p \approx 1200$ J Kg^{-1} K^{-1}.[17]

[b] From diffusivity measurements*, $(\rho C_p) = 2.43$ MJ m^{-3}.

[c] Measured in the present work using a photoflash technique.[18]

数据源自不通技术的测试结果

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Table 2. Sensor diameter, r, measurement time, t, and τ_{max} for the five materials studied.

Test specimen	r (mm)	t (s)	τ_{max} ()
Extruded polystyrene	15.0	250	0.9
PMMA	10.0	500	0.7
PMMA	6.83	250	0.8
Cecorite 130P	10.0	30	0.5
Stainless steel	6.83	12	1.0
Aluminium	15.0	5	1.2

使用的Hot Disk探头半径，测试功率和时间

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Table 5. Thermal properties of the XPS test specimen measured in the present work using the TPS technique

Run #	k ($W\,m^{-1}\,K^{-1}$)		α ($mm^2\,s^{-1}$)
1	0.0268		0.714
2	0.0281		0.513
3	0.0269		0.704
4	0.0270		0.757
5	0.0277		0.642
Average	0.0273	0. 028	0.666
St. dev.	0.0006		0.095
St. dev.	2.1%		14.2%

Table 6. Thermal properties of the PMMA test specimen measured in the present work using the TPS technique (r=10.0 mm)

Run #	k ($W\,m^{-1}\,K^{-1}$)	a ($mm\,s^{-1}$)
1	0.1955	0.133
2	0.1939	0.125
3	0.1954	0.130
4	0.1919	0.125
5	0.1955	0.128
Average	0.194	0.128
St. dev.	0.002	0.003
St. dev.	0.8%	2.7%

PMMA取值0.19

Table 7. Thermal properties of the PMMA test specimen measured in the present work using the TPS technique (r=6.83 mm)

小探头，短测试时间

Run #	k ($Wm^{-1}K^{-1}$)	a (mm^2s^{-1})
1	0.1943	0.114
2	0.1933	0.122
3	0.1935	0.121
4	0.1982	0.143
5	0.2010	0.134
Average	0.196	0.127
St. dev.	0.003	0.012
St. dev.	1.7%	9.1%

相同结果！

Table 8. Thermal properties of Cecorite test specimen measured in the present work using the TPS technique

Run #	k ($Wm^{-1}K^{-1}$)		a (mm^2s^{-1})
1	1.476		1.024
2	1.478		1.045
3	1.474		1.042
4	1.473		1.042
5	1.480		1.069
Average	1.476	1.45	1.044
St. dev.	0.003		0.016
St. dev.	0.2%		1.5%

这种材料具有很轻的吸湿性，一般不作为标准材料

Table 9. Thermal properties of the stainless steel test specimen measured in the present work using the TPS techniques

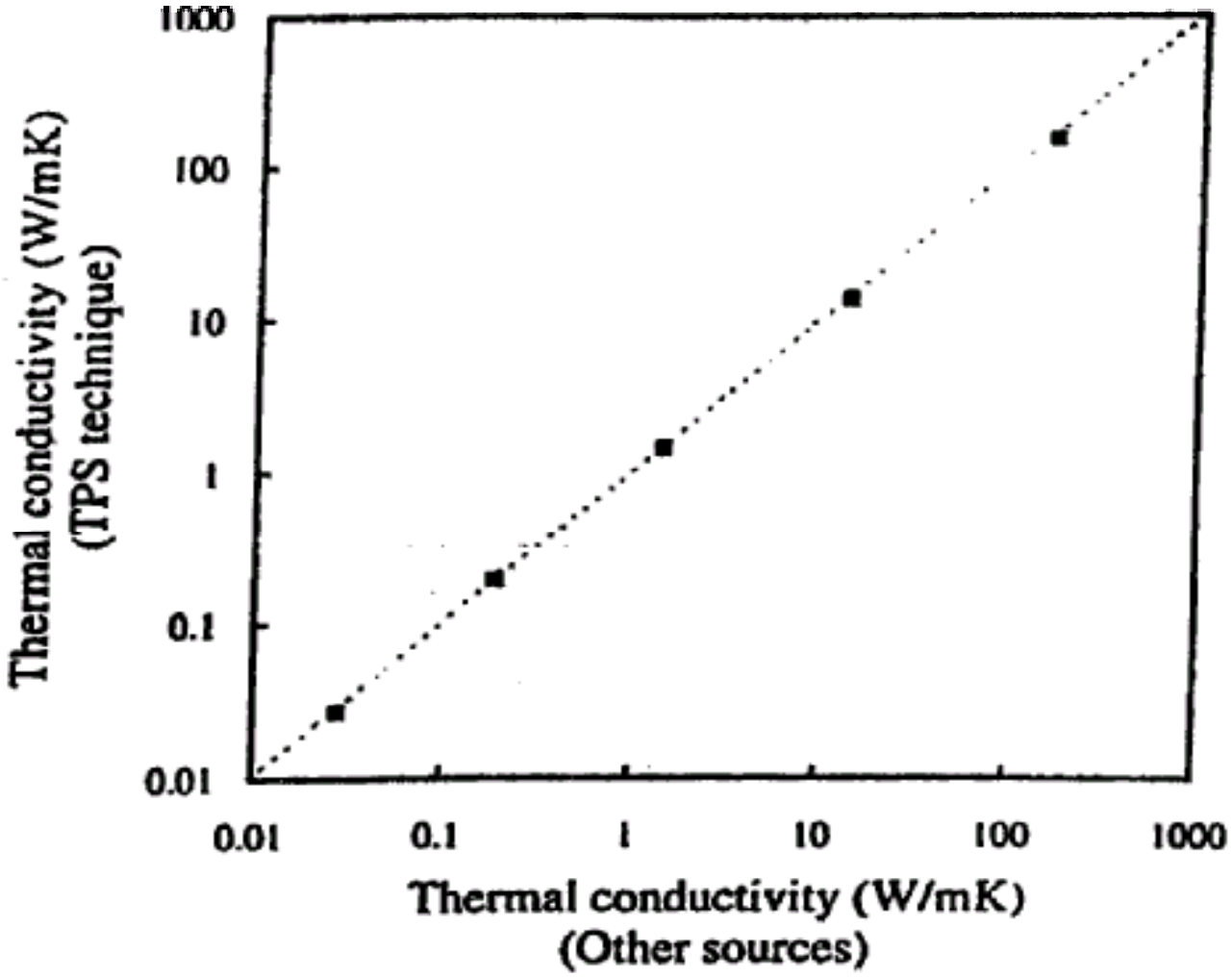
Run #	$\overset{k}{(W m^{-1} K^{-1})}$	$\overset{a}{(mm^2 s^{-1})}$
1	13.94	3.67
2	13.89	3.64
3	13.93	3.61
4	13.88	3.75
5	13.96	3.63
Average	13.92 *14. 20*	3.66
St. dev.	0.03	0.06
St. dev.	0.2%	1.5%

Table 4. Thermal properties of the aluminium test specimen measured in the present work using the TPS technique

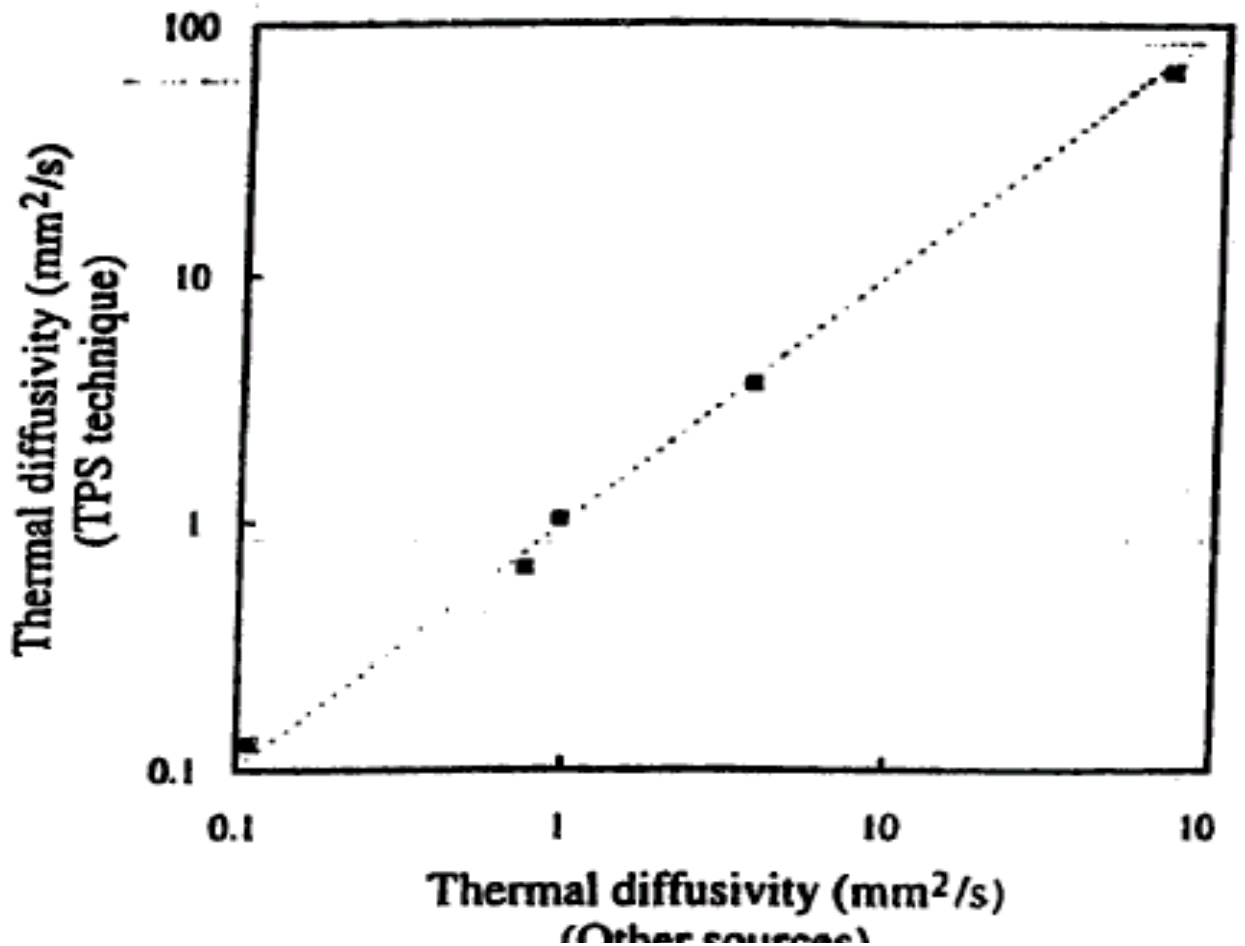
Run #	(W m^{-1} K^{-1})	(mm^2 s^{-1})
1	159.1	63.8
2	154.6	67.2
3	154.8	70.5
4	158.0	66.1
5	160.2	60.6
Average	157.3	65.6
St. dev.	2.5	3.7
St. dev.	1.6%	5.7%

166

导热性能结果 - 完全吻合


Thermal conductivity (W/mK)
(TPS technique)
1000
100
10
1
0.1
0.01
0.01
0.1
1
10
100
1000
Thermal conductivity (W/mK)
(Other sources)

热扩散系数 - 几乎吻合


100
10
1
0.1
Thermal diffusivity (mm²/s)
(TPS technique)
0.1
1
10
10
Thermal diffusivity (mm²/s)

NIST No.1453 聚苯乙烯标准材料的测试

系列NIST No.1453聚苯乙烯材料的信息：

厚度：13.4mm

密度：38 kg/m3 ～46 kg/m3，温度为295K

导热系数：0.0328-0.0338 W/mK

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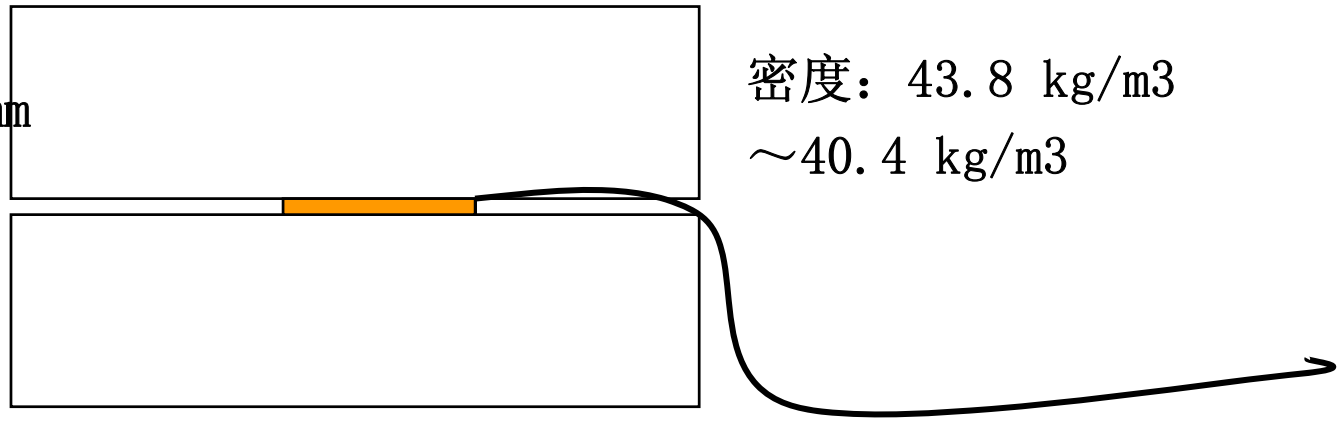
边长：100 mm

厚度：13.4 mm



密度：43.8 kg/m3
～40.4 kg/m3

4组根据两片样品不同面与探头接触的组合数据

不同面的组合	结果(W/mK)	Std %
1-2	0.03394	0.12
2-1	0.03379	0.04
2-2	0.03451	0.08
1-1	0.03346	0.23

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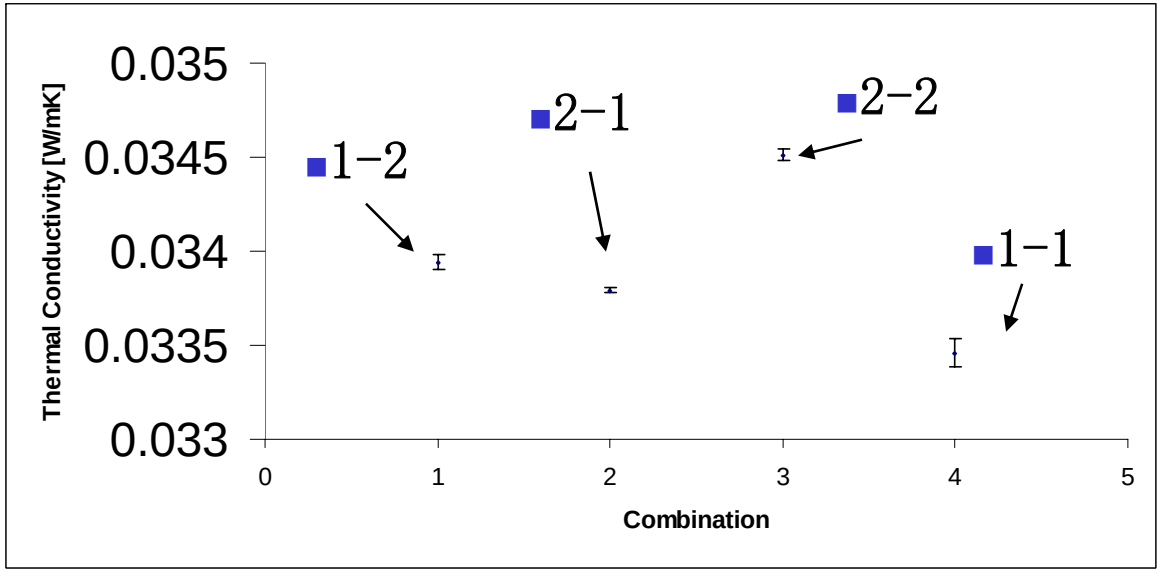
测试结果分布图



最大与最小值之间的误差小于3%!!!

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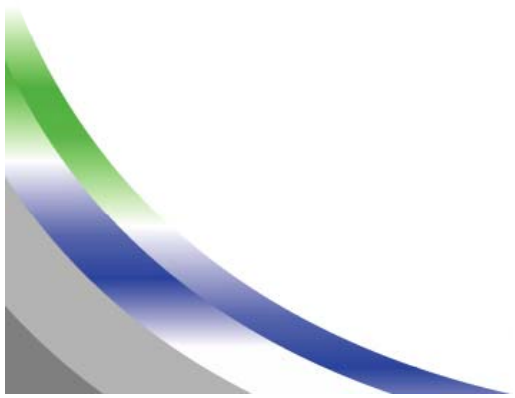
Hot Disk在全量程都有优于3%的精度！

谢谢！



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