International Year of CHEMISTRY 2011

polimeri europa

Espansi polistirenici per l'isolamento termico

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Riscaldamento di una casa non coibentata:

- 29000 kWh/Anno (250 kWh/m^2)
- 1600 Euro
- 7.2 ton di CO_2

Tetto:
12120 kWh/a

Pareti:
10100
kWh/a

Finestre:
4700
kWh/a

Fondazioni:
1800 kWh/a

Fonte: EUMEPS 201

Riscaldam … pentata:

- ~~29000~~ 56…
- ~~1600~~ 312…
- ~~7,2~~ 1,4 t…

Tetto:
~~12120~~

Fonte: EUMEPS 201

Materiali in competizione

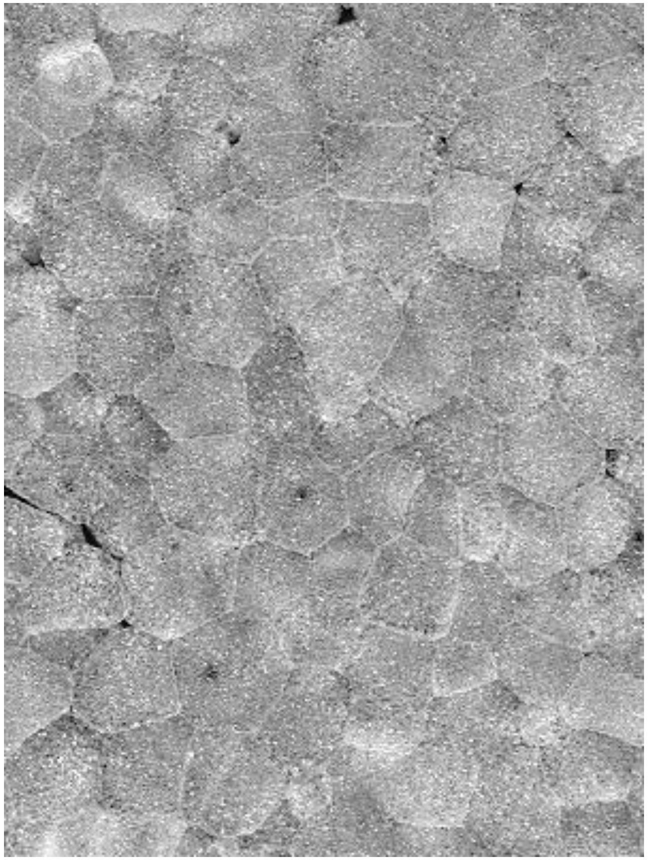
Uso di diversi materiali in:		EPS	XPS	PUR	MW
Tetto	con carico	🔵	🔵	🔵	🟡
	senza carico	🔵	🔵	🟡	🔵
Parete	cavità	🔵	🔵	🔵	🔵
	esterna	🔵	🔴	🔴	🟡
	esterna, ventilata	🔵	🔵	🔵	🔴
	interna	🔵	🔵	🔴	🔵
Pavimento	elastificato	🔵	🔴	🔴	🟡
	rigido	🔵	🔵	🔴	🔴
Fondazioni	parete	🟡	🔵	🔴	🔴
	fondazioni	🟡	🔵	🔴	🔴
	sotto-fondazioni	🔴	🔵	🔴	🔴

🔵 *= utilizzato frequentemente*

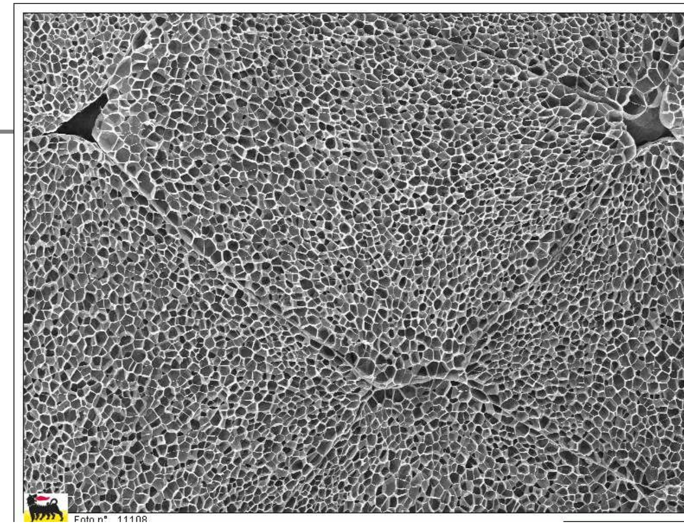
🟡 *= utilizzato raramente*

🔴 *= non utilizzato*

EPS

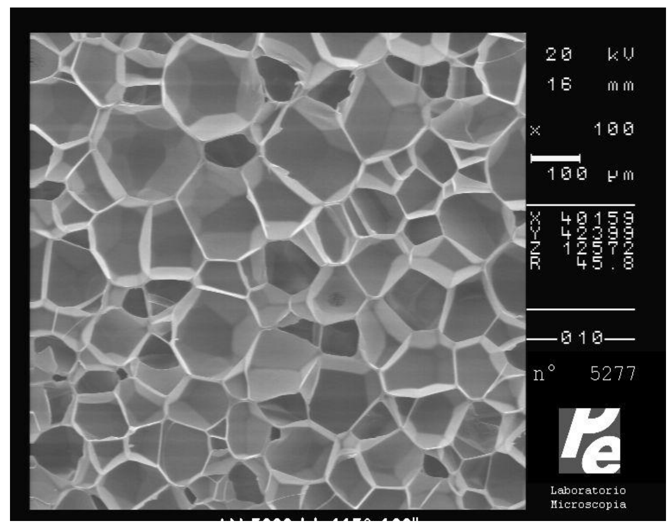


Microscopio Ottico



SEM

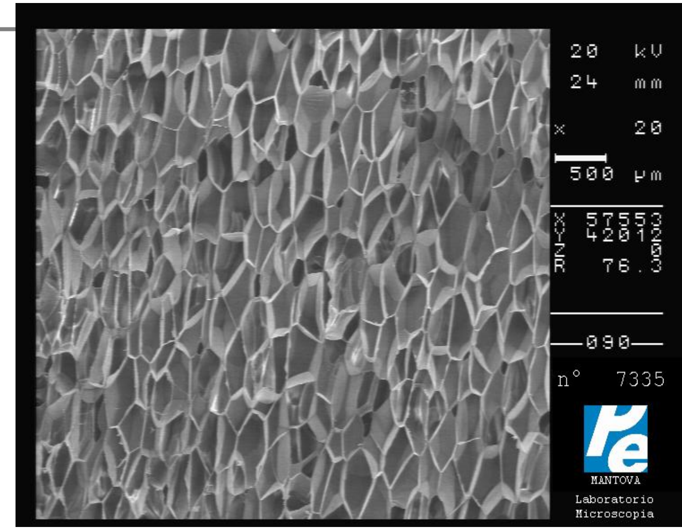
1 mm



SEM

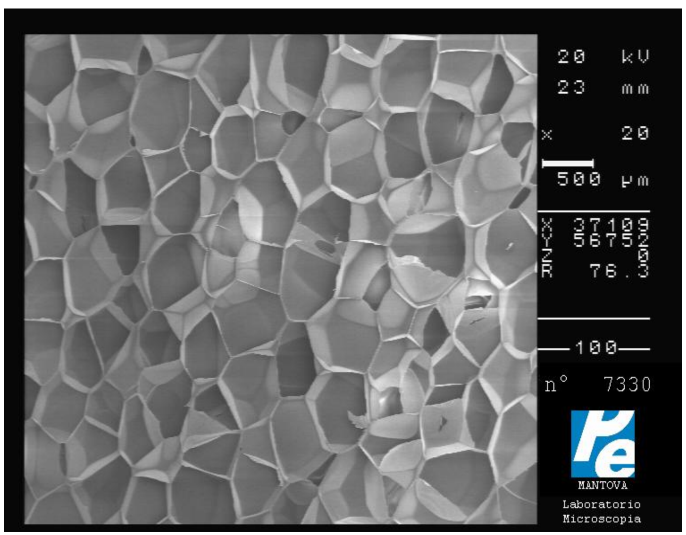
200 µm

XPS



SEM

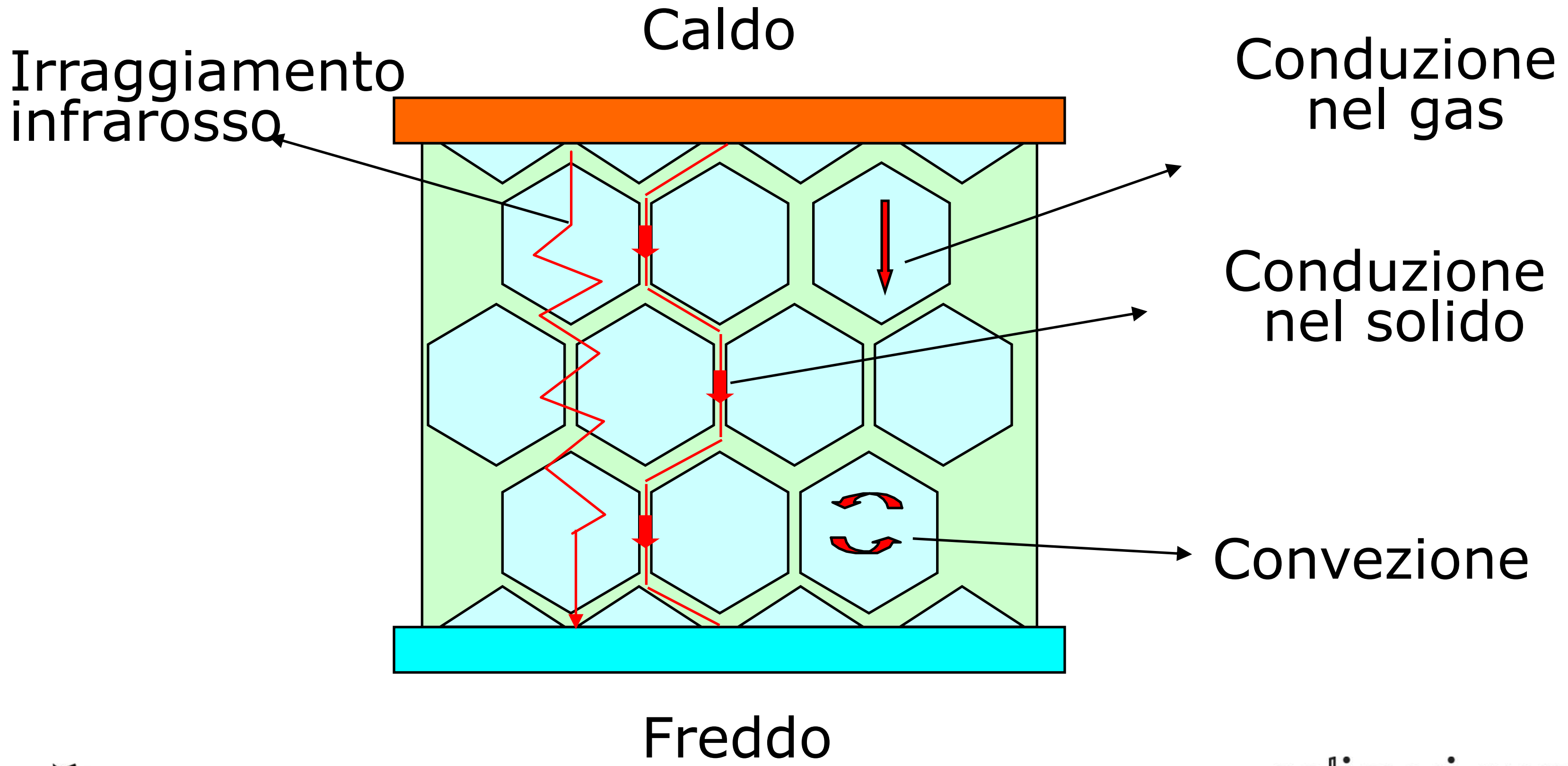
1 mm



SEM

1 mm

Meccanismi di trasporto del calore nelle schiume polimeriche



Meccanismi di trasporto del calore nelle schiume polimeriche

I contributi del solido (λ_s^*) e del gas (λ_g^*) alla conducibilità termica totale sono proporzionali alle rispettive conducibilità moltiplicate per le rispettive frazioni volumetriche

$$\lambda_s^* = f\,\lambda_s \frac{\rho^*}{\rho_s}$$

$$\rho^* = \text{densità della schiuma}$$

$$\rho_s = \text{densità del solido}$$

$$\lambda_g^* = \lambda_g (1 - \frac{\rho^*}{\rho_s})$$

L.J. Gibson, M.F. Ashby; “Cellular Solids”, Pergamon Press 1988

- La conduzione per convezione è trascurabile per dimensioni delle celle inferiori a ~ 10 mm.
- La conduzione per irraggiamento (λ_r^*)dipende dall'assorbimento della radiazione infrarossa nella fase solida e si può scrivere :

$$\lambda_r^* = 4\beta\sigma \bar{T}^3 t \exp\left(-K_s \frac{\rho^*}{\rho_s} t\right)$$

$t = \text{spessore}$

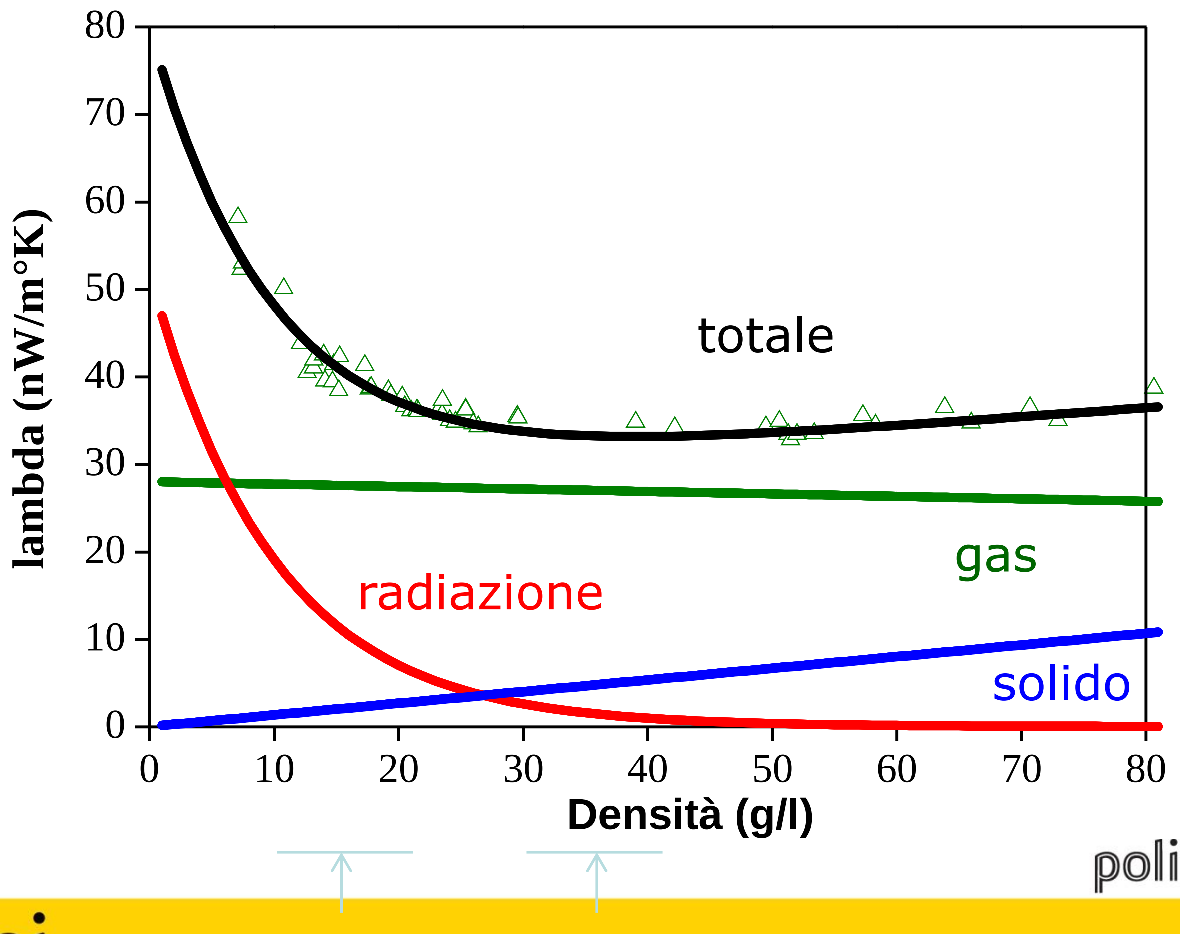
$K_s = \text{coefficiente di estinzione}$

La conducibilità termica totale è quindi

$$\lambda^* = \lambda_s^* + \lambda_g^* + \lambda_r^*$$

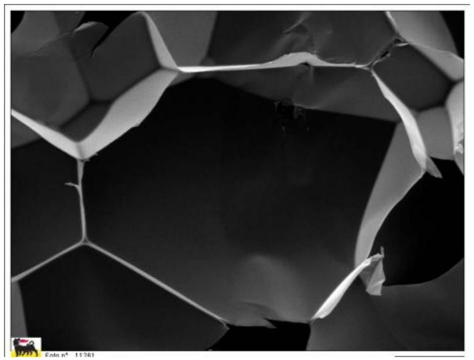
ed è illustrata nella prossima slide

Conducibilità termica vs. Densità

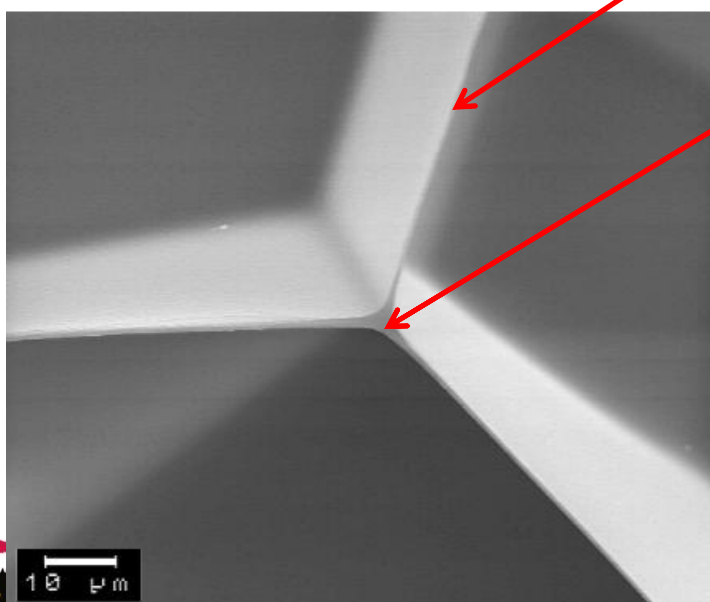


$$\lambda_r^* = 4\beta\sigma \bar{T}^3 t \exp\left(-K_s \frac{\rho^*}{\rho_s} t\right)$$

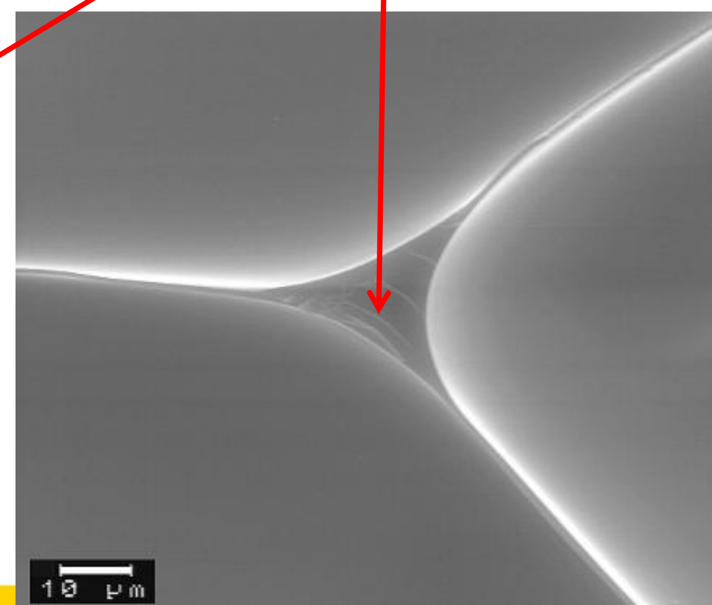
K_s = coefficiente di estinzione



struttura cellulare: pareti e spigoli



EPS

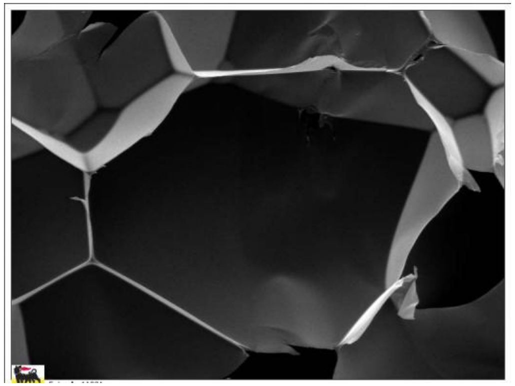


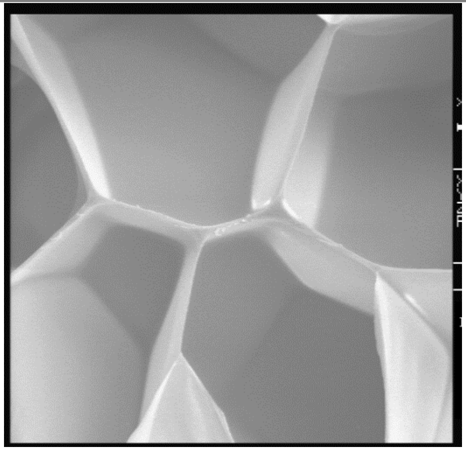
PU

PU

EPS

XPS





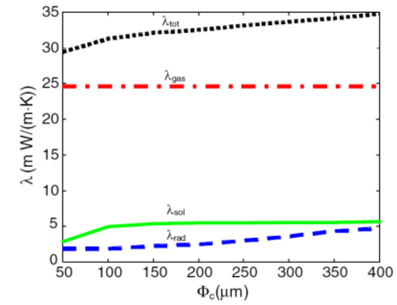


Fig. 23. Total thermal conductivity of PUR foams versus cell diameter ($\rho_f = 35$ kg/m^3, $\Phi_s = 3.0$ μm, $T_m = 300$ K).

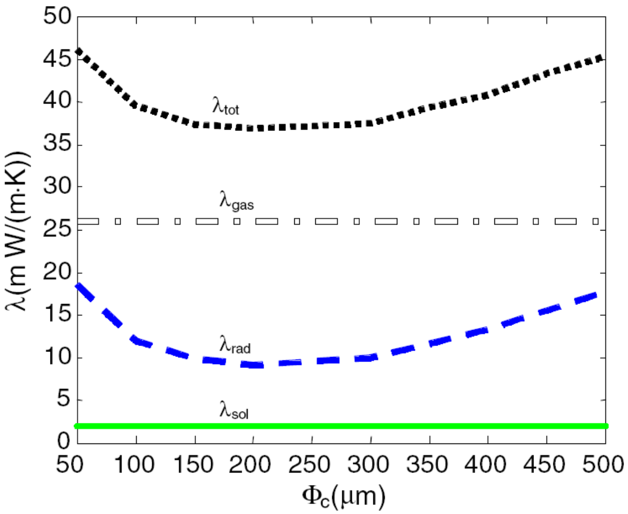


Fig. 19. Total thermal conductivity of EPS foams versus cell diameter ($\rho_f = 15$ kg/m^3, $T_m = 300$ K).

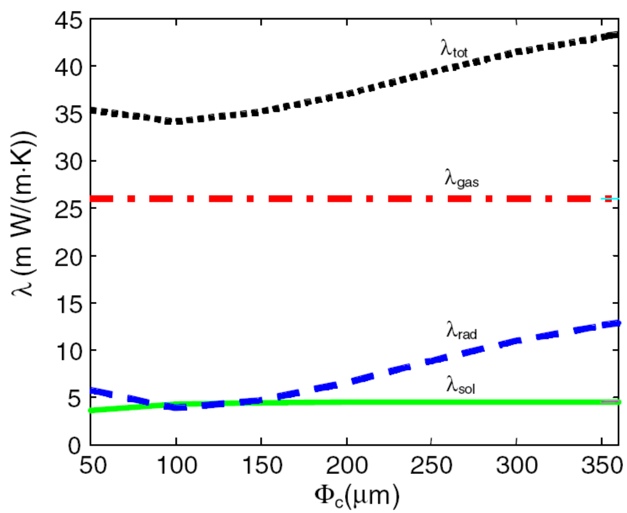


Fig. 21. Total thermal conductivity of XPS foams versus cell diameter ($\rho_f = 35$ kg/m^3, $\Phi_s = 2$ μm, $T_m = 300$ K).

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E. Placido, M.C. Arduini-Schuster, J. Kuhn ; Infrared Physics &Technology 46 (2005) 219-231

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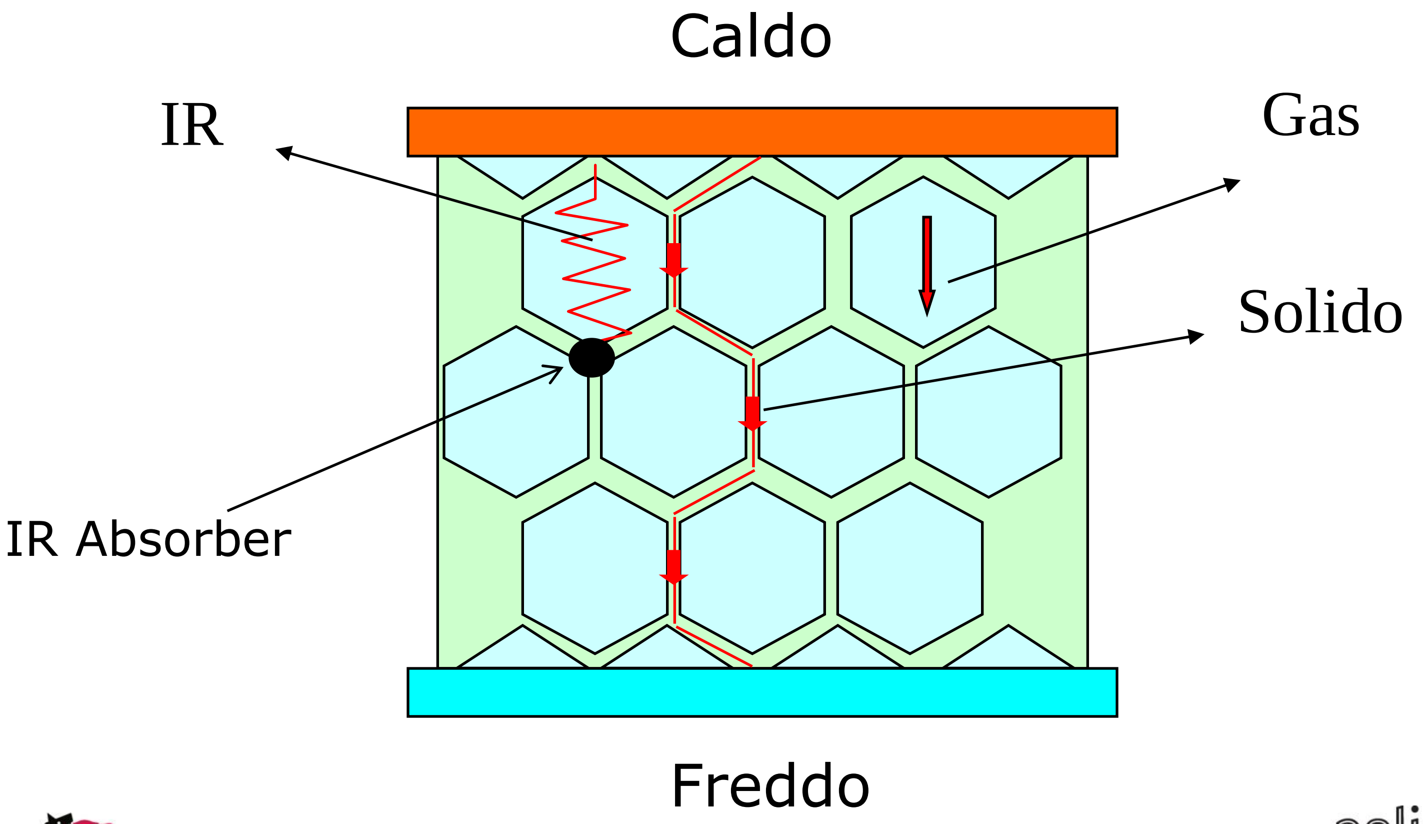
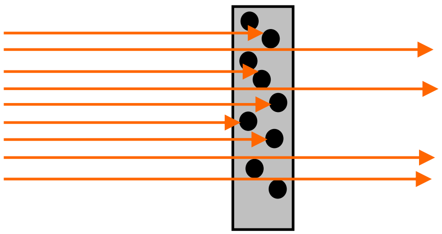
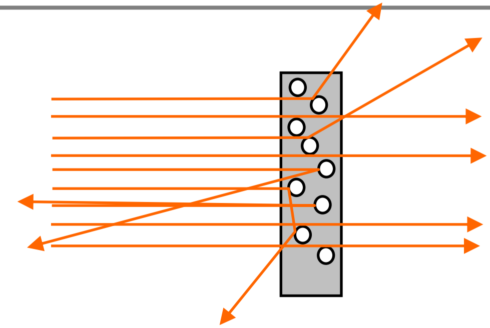
The Bavarian Center for Applied Energy Research (ZAE Bayern)

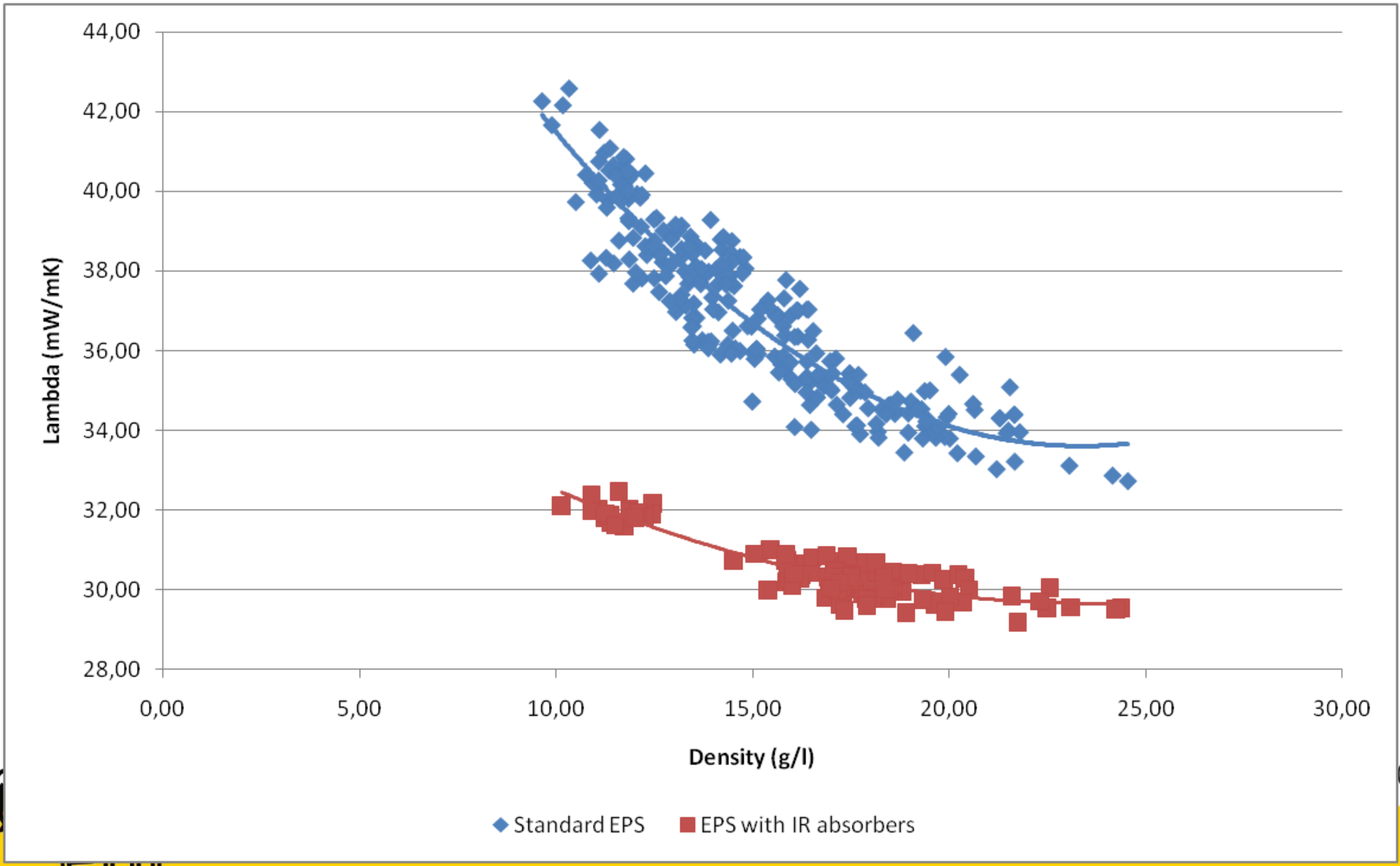
$$\lambda^* = \lambda_s^* + \lambda_g^* + \lambda_r^*$$



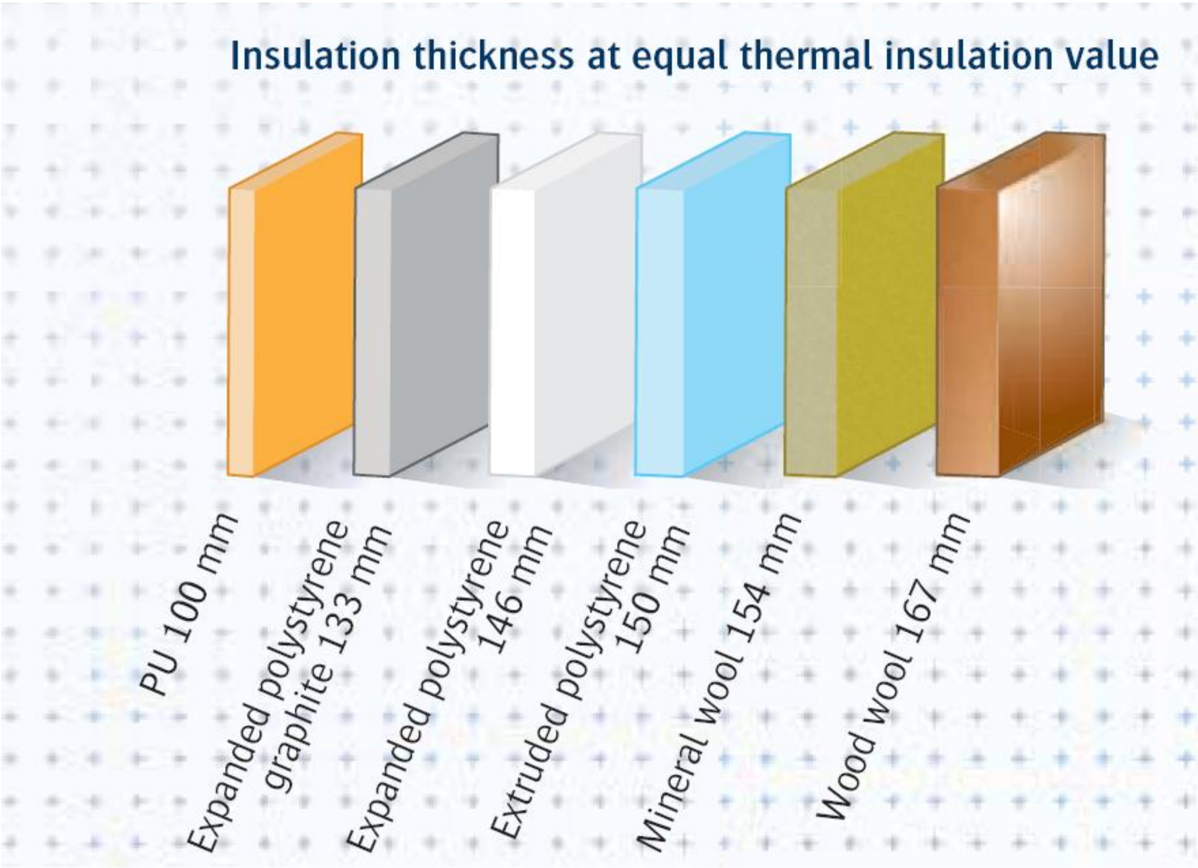
Conducibilità termica: effetto degli "IR Absorbers"







Resistenza termica:
prestazioni equivalenti a diversi spessori

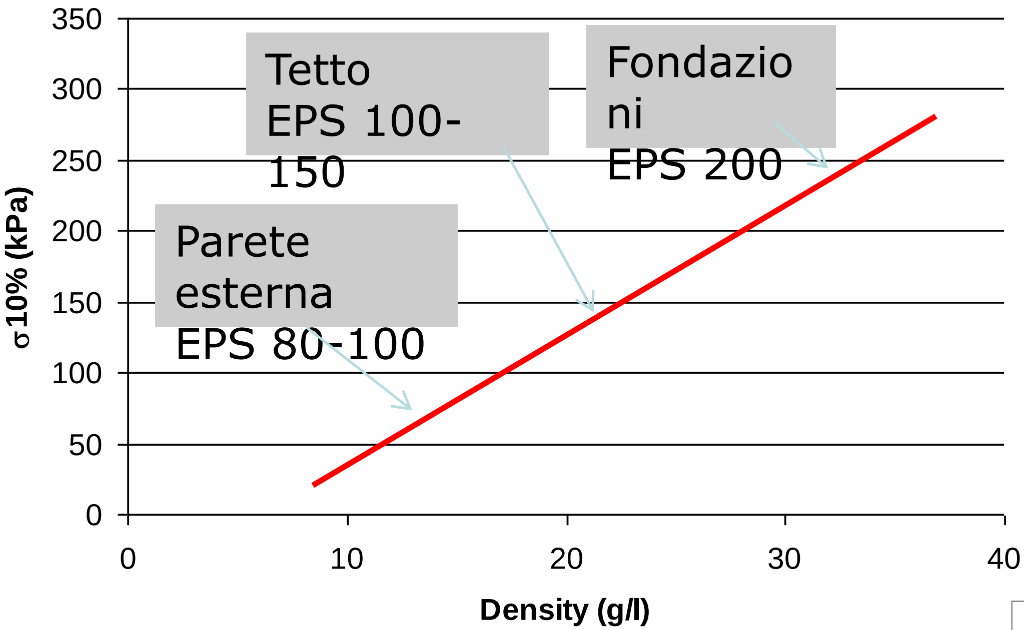


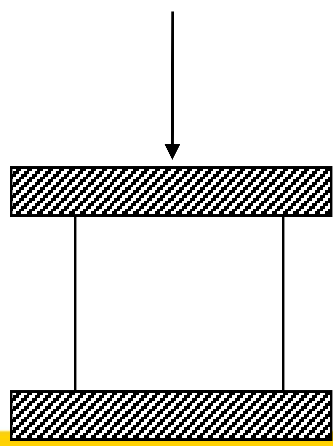
Source:

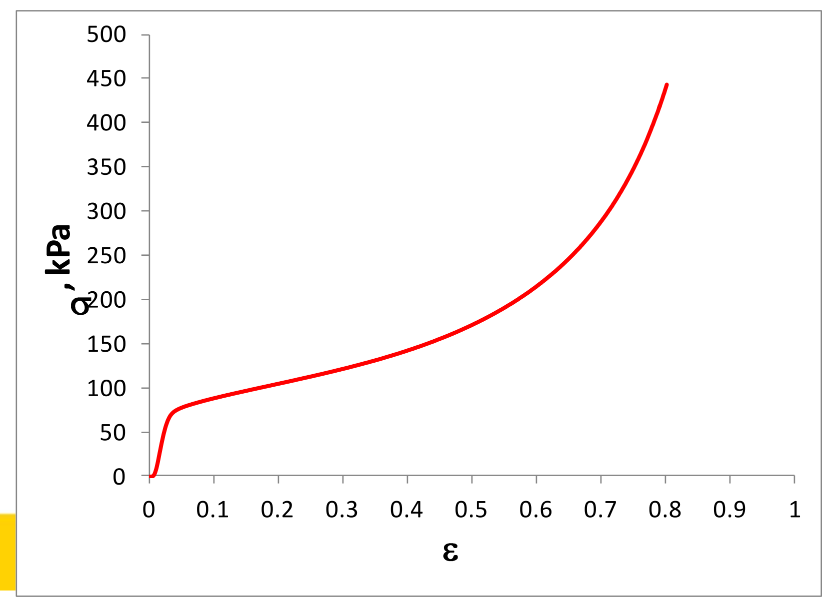
PU EUROPE
EXCELLENCE IN INSULATION

kg/m2	3,5	1,995	2,19	5,25	12,32	20,04

Comportamento meccanico: Compressione



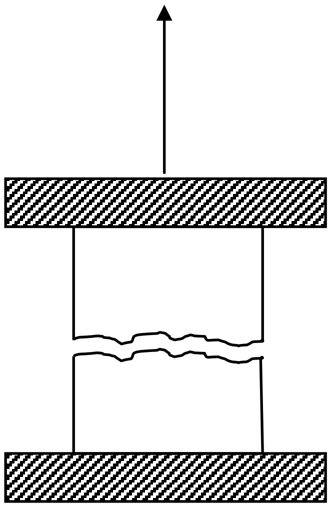


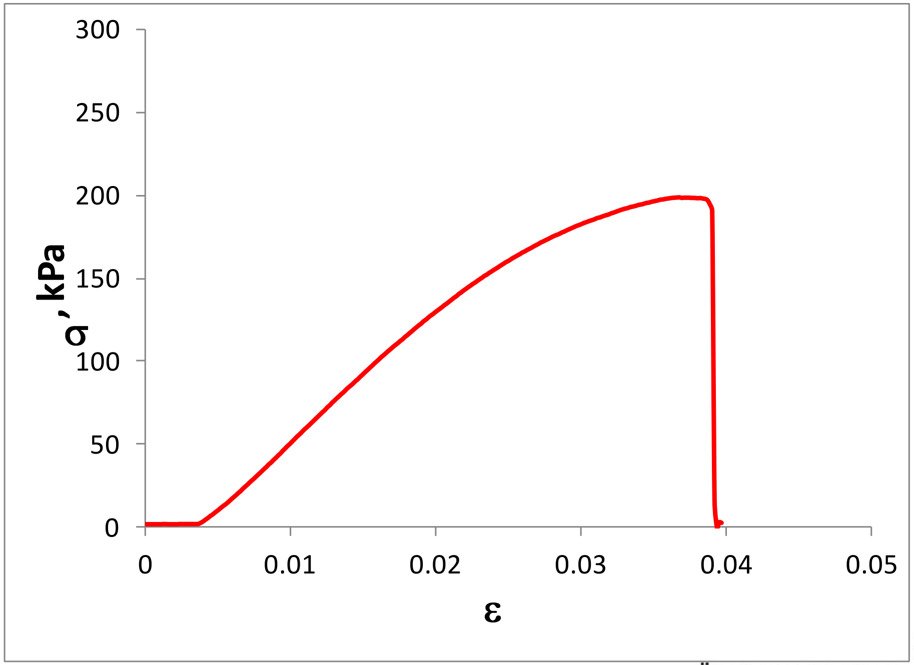


Comportamento meccanico: Trazione

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

EN 13499:2003
Thermal insulation products for buildings – External thermal insulation composite systems (ETICS) based on expanded polystyrene - Specification





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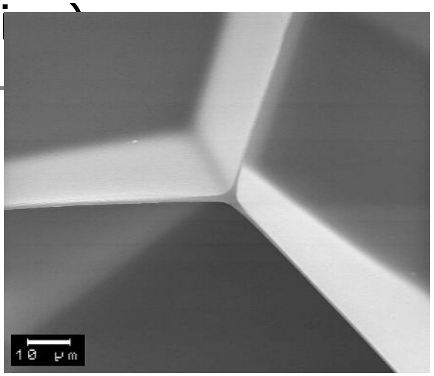
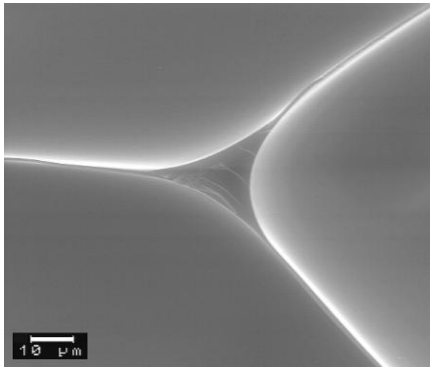
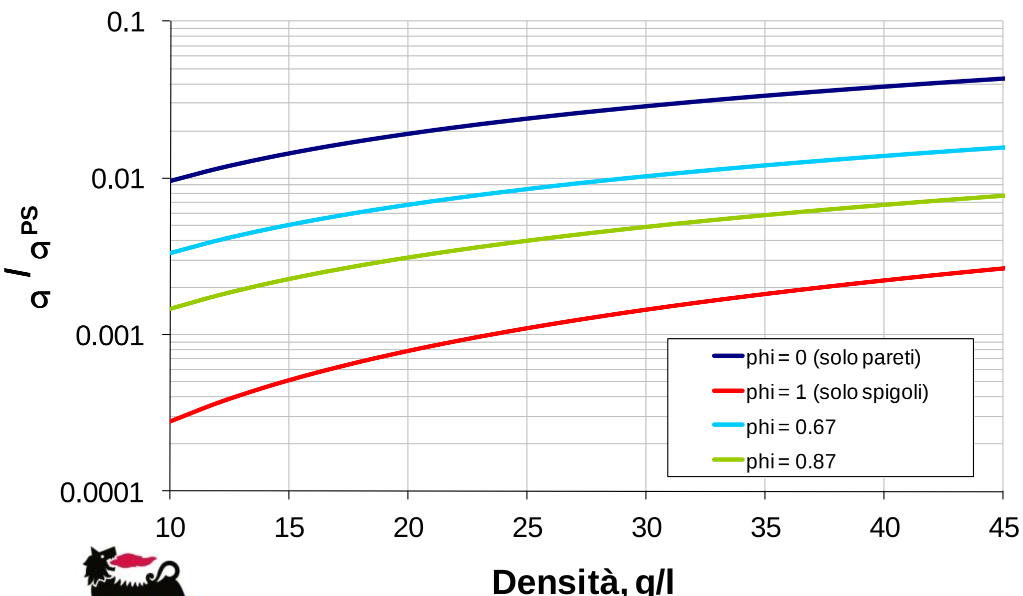
Sforzo a snervamento in compressione (collasso plasti



$$\frac{\sigma_f}{\sigma_S} = 0.3\left(\Phi\frac{\rho_f}{\rho_S}\right)^{3/2} + (1-\Phi)\left(\frac{\rho_f}{\rho_S}\right)$$



σ_f = sforzo a "snervamento" della schiuma
σ_S = sforzo a snervamento del solido
ρ_f = densità della schiuma
ρ_S = densità del solido
Φ = frazione di materiale solido negli "spigoli"



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L.J. Gibson, M.F. Ashby – "Cellular Solids" – Pergamon Press,
F. Ramsteiner, N. Fell, S. Forster – Polymer Testing 20 (2001)

Ottimizzazione della struttura cellulare