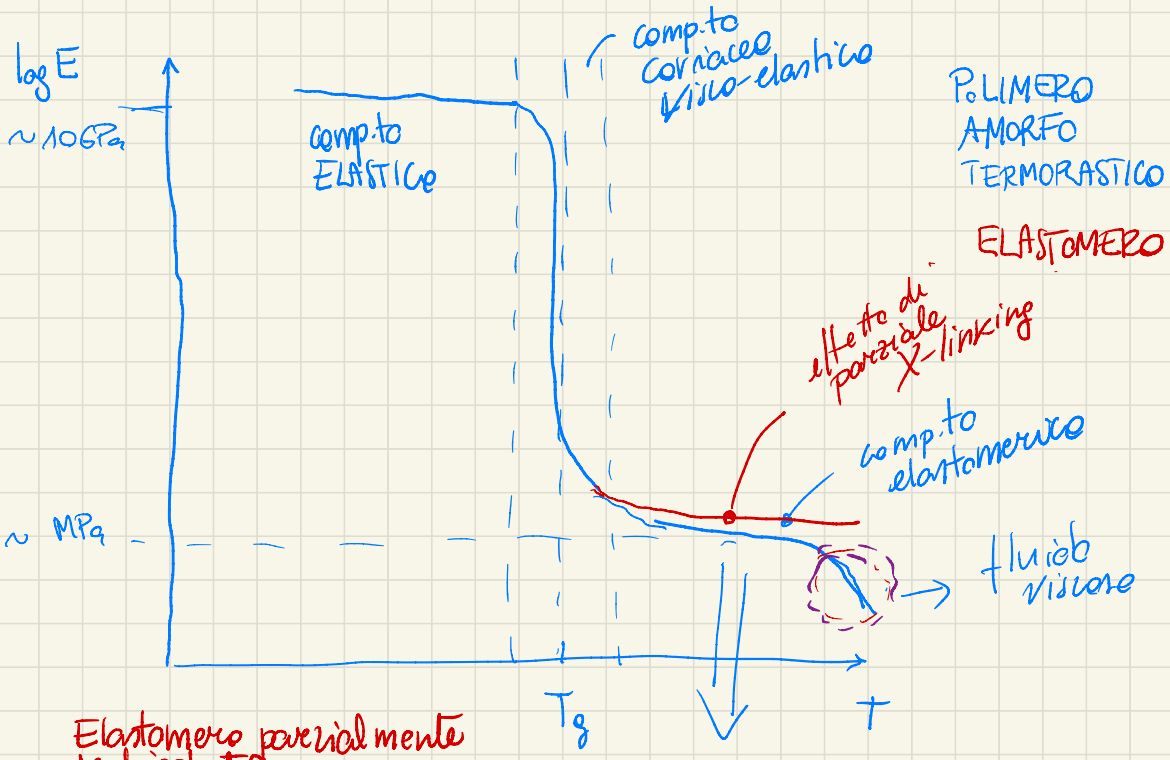
Lezione 16 09.11.2022

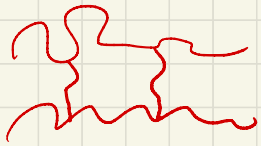
Proprietà meccaniche dei polimeri:

- Effetto della temperatura sulla rigidità (modulo elastico)
- Solidi a comportamento entalpico e solidi a comportamento entropico
- Principio di Equivalenza t-T
- Curve sforzo-deformazione



Elastomero parzialmente reticolato

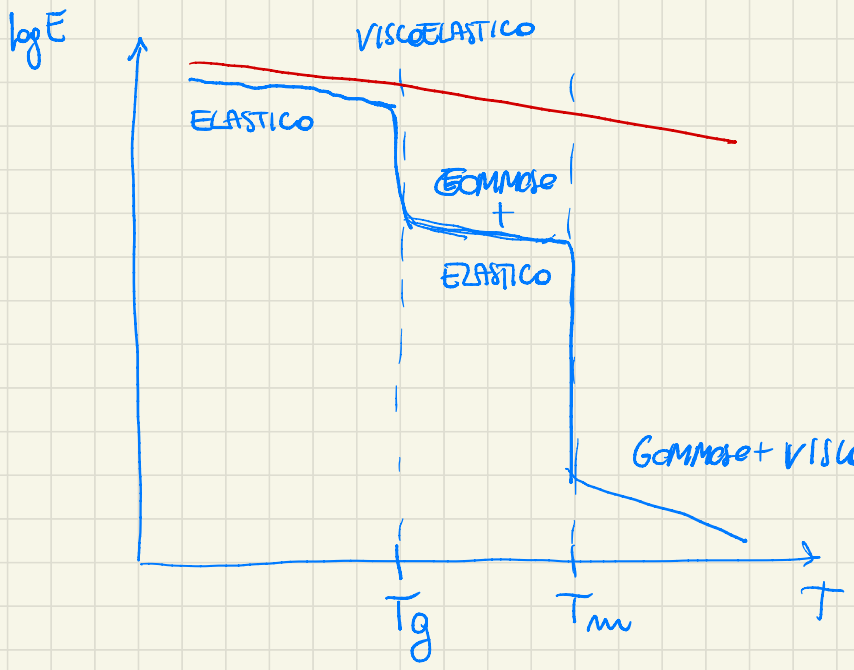
X-linking



TP AMORFO

Entanglments
PUNTI di Aggancio fisico tra le macromolecole

punti di aggancio fisico entanglments



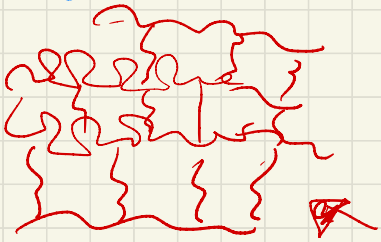
P. LIMERO
TP
Semi Cristallino

P. LIMERO
Termo
Indurente
TI

Polimero TP
Semicristallino

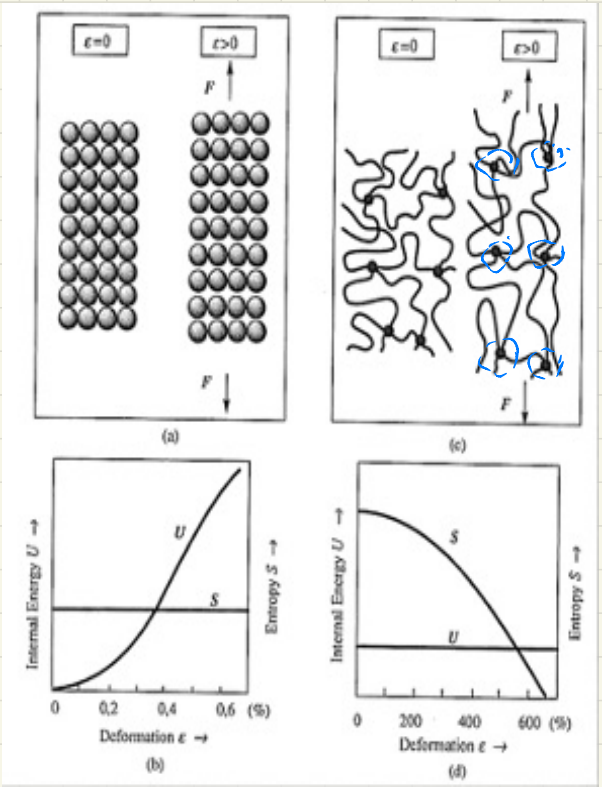
RANDOM COIL
+
SFERULITI

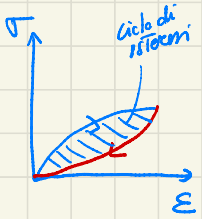
Polimeri TI



STRUTTURA
AMORFA
RIGIDA

SOLIDO CRISTALLINO SOLIDO ELASTOMERICO (POLIMERI @ $T \gg T_g$)





INTERPRETAZIONE TERMODINAMICA del COMP.TO ELASTOMERICO

U : energia interna del sistema

$$dU = dQ - dW$$

$$dW = -f\,dl + P\,dV$$

elastomeri $\nu = 0.5$ $dV = 0$

$$dQ = T\,dS$$

$$f\,dl = dU - T\,dS$$

$A = U - TS$

↳ Energia libera di Helmoltz

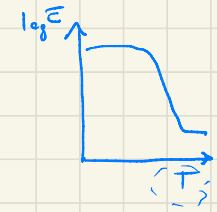
$T = cost$

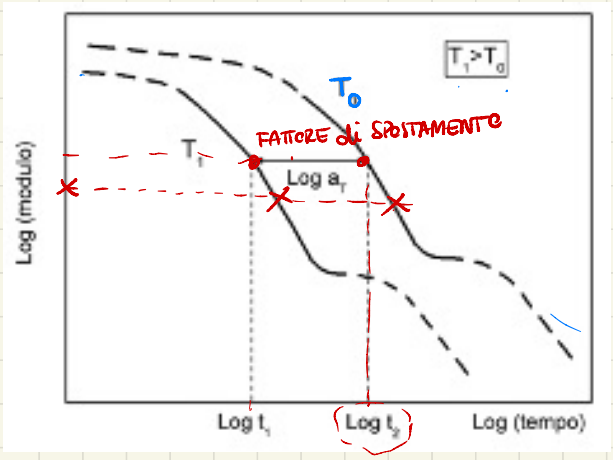
$\Rightarrow dA = dU - TdS - SdT$ $\quad T = cost$

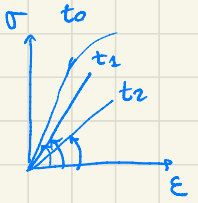
$\underline{f\,dl} = dA$

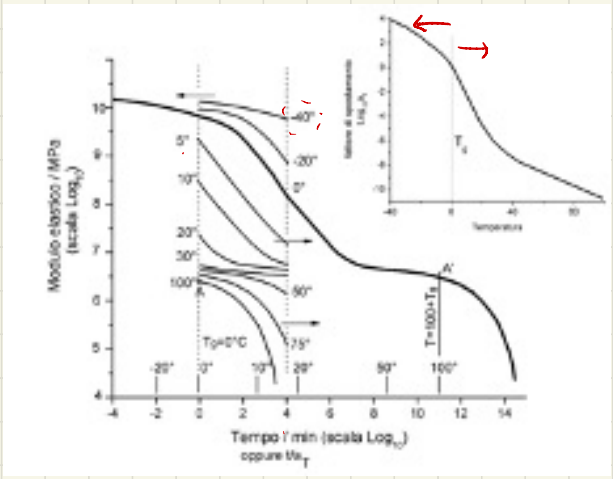
$f = \left(\frac{\partial U}{\partial l}\right)_T - T\left(\frac{\partial S}{\partial l}\right)_T$

PRINCIPIO di Equivalenza t-T sulla rigidità $E(t)$ $E(T)$









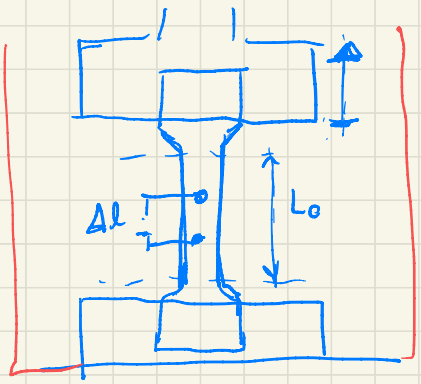
WLF : $\log a_T = \log \frac{t_1}{t_0} = - \frac{c_1 \cdot (T_1 - T_0)}{c_2 + (T_1 - T_0)}$

$T_0 = T_g$

CURVE SFORZO – DEFORMAZIONE

POLIMERO TP AMORFO o SEMICRISTALLINO

$T \sim T_g$



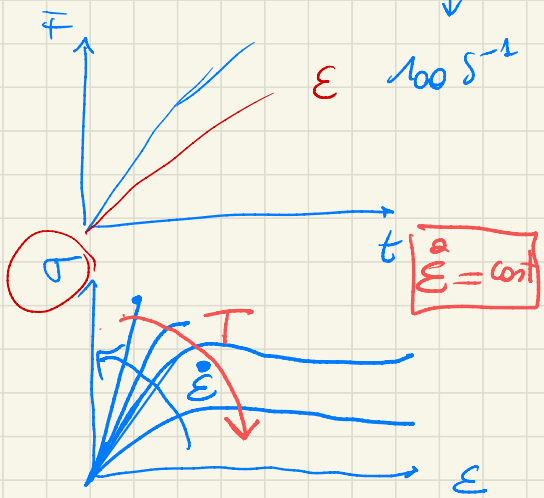
ASSE FISSO

controllo di DEFORMAZIONE

F_{max}

t, F

$\dot{\varepsilon}$ $0.1\,s^{-1}$ ↓ $100\,s^{-1}$

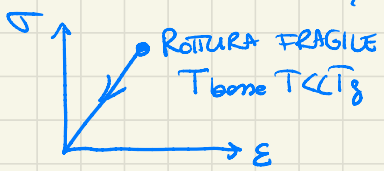


$\dot{\varepsilon} = cost$

T=cost

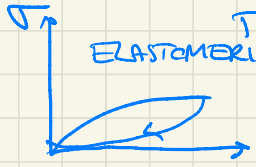
Tamb

$\dot{\varepsilon}$ $[s^{-1}]$, t ↓



ROTTURA FRAGILE

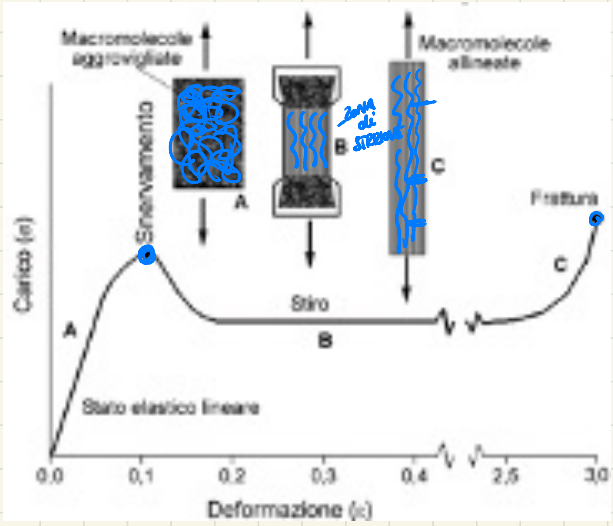
T bone $T < T_g$

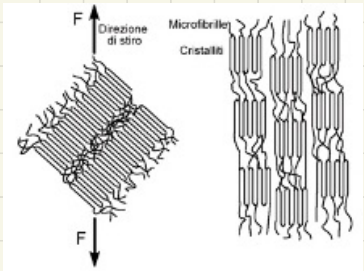


ELASTOMERICO

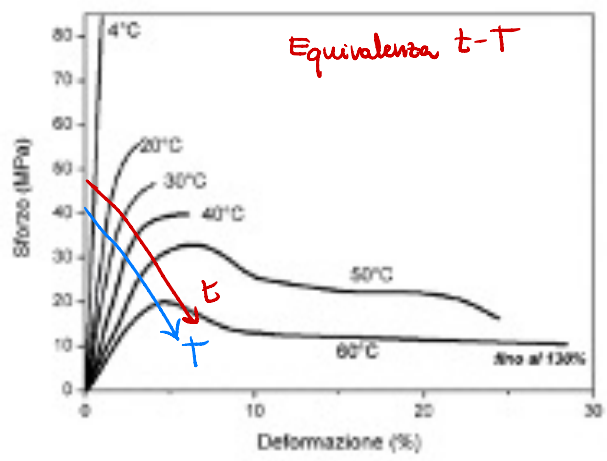
$T > T_g$

COMPTO ENTROPICO



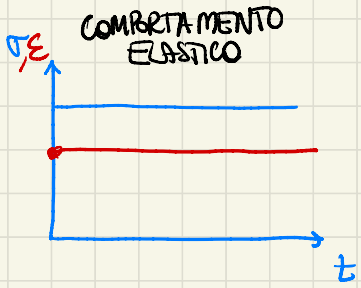


Effetto delle T



- COMPORTAMENTO VISCOELASTICO dei POLIMERI

$\sim T \sim T_g$

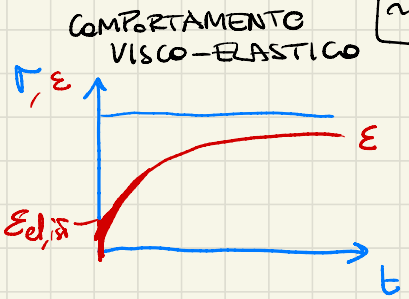


$\sigma = cost.$

$\varepsilon = cost.$

$\sigma = E\,\varepsilon$

$\varepsilon = \frac{\sigma_0}{E}$



CREEP

$\sigma = cost$

$\varepsilon = \varepsilon(t)$

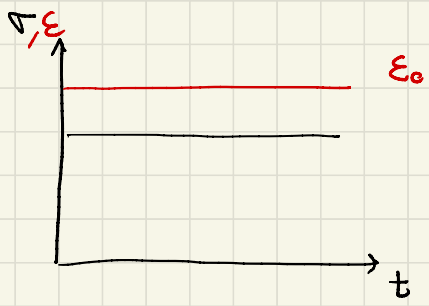
$\varepsilon(t) = \frac{\sigma_0}{E(t)}$

$\frac{1}{E(t)} = J(t)\,,\ D(t),\ C(t)$

MODULO di CREEP o COMPLIANCE MODULE

$[Pa^{-1}]$

COMP.TO ELASTICO



$\sigma = E\,\varepsilon_0$

COMP.TO VISCOELASTICO

$\sigma = E(t)\,\varepsilon_0$

↓

Modulo di rilassamento

[Pa]

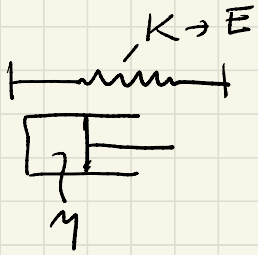
ESEMPI PRATICI

- CREEP → RECIPIENTE in PRESSIONE
- RILASSAMENTO delle TENSIONI → ACCOPPIAMENTO di MATERIALI ATTRAVERSO il SERRAGGIO di VITI

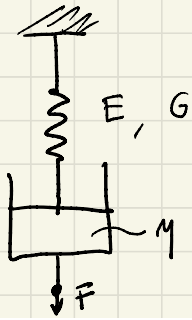
a MODELLI VISCOELASTICI

ACCOPPIAMENTI

- ELASTICA → MOLLA
- VISCOSA → PISTONE



MAXWELL



KELVIN-VOIGT