Photoinduced fluidity Mechanical behavior in Ge-Se and Te-As-Se glasses

J.-C. Sangleboeuf
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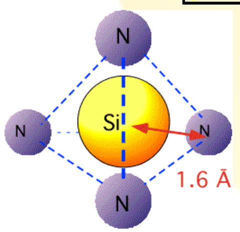
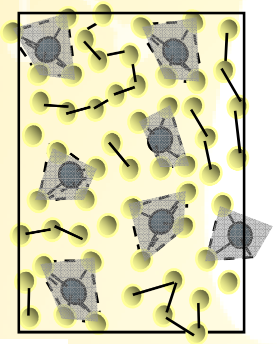
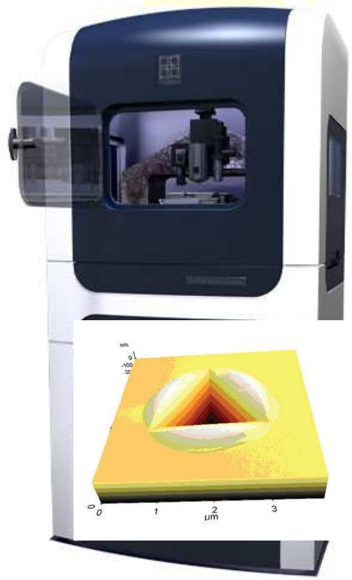
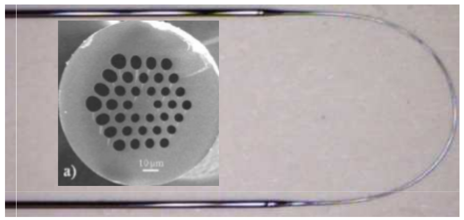
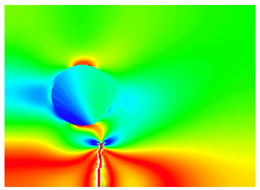
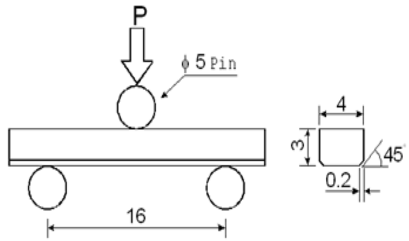
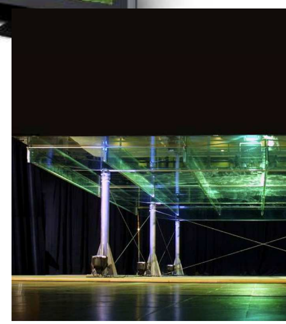
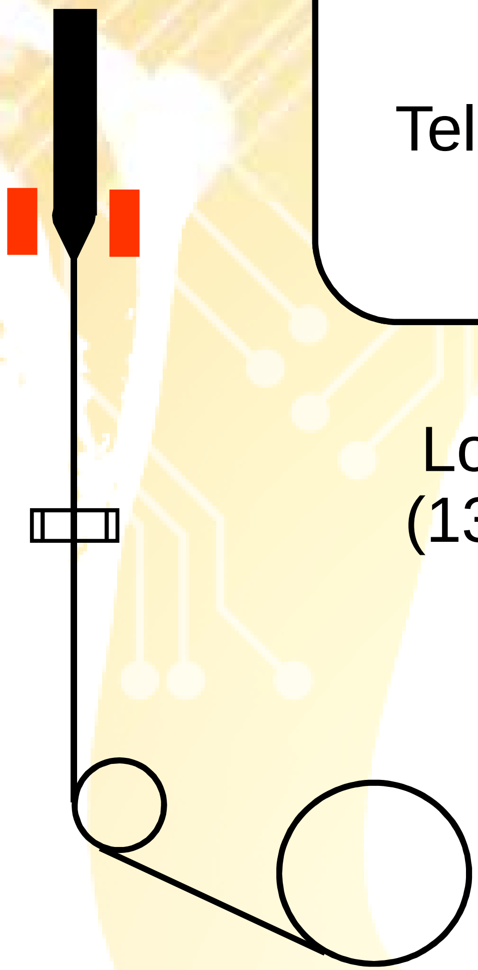
University of Rennes 1, France

Fiber drawing



TAS glass

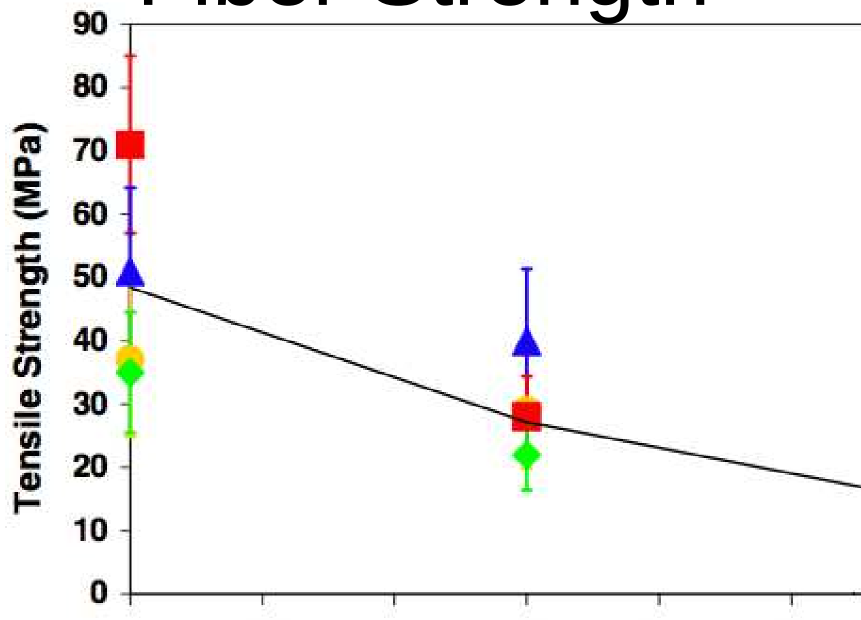
Tellurium	Arsenic	Selenium	
20%	30%	50%	(mol%)

Low T_g (137°C) ⇒ Viscoelastic behaviour at room temperature

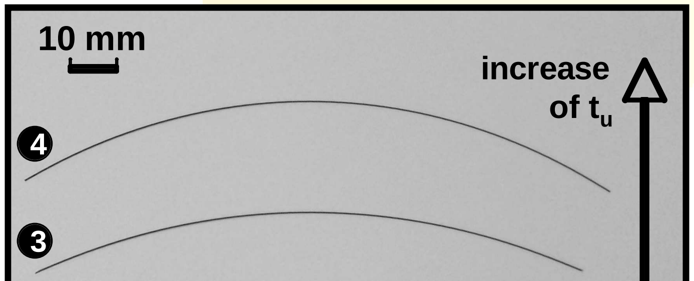
Cutting

Air Quenched

Fiber Strength

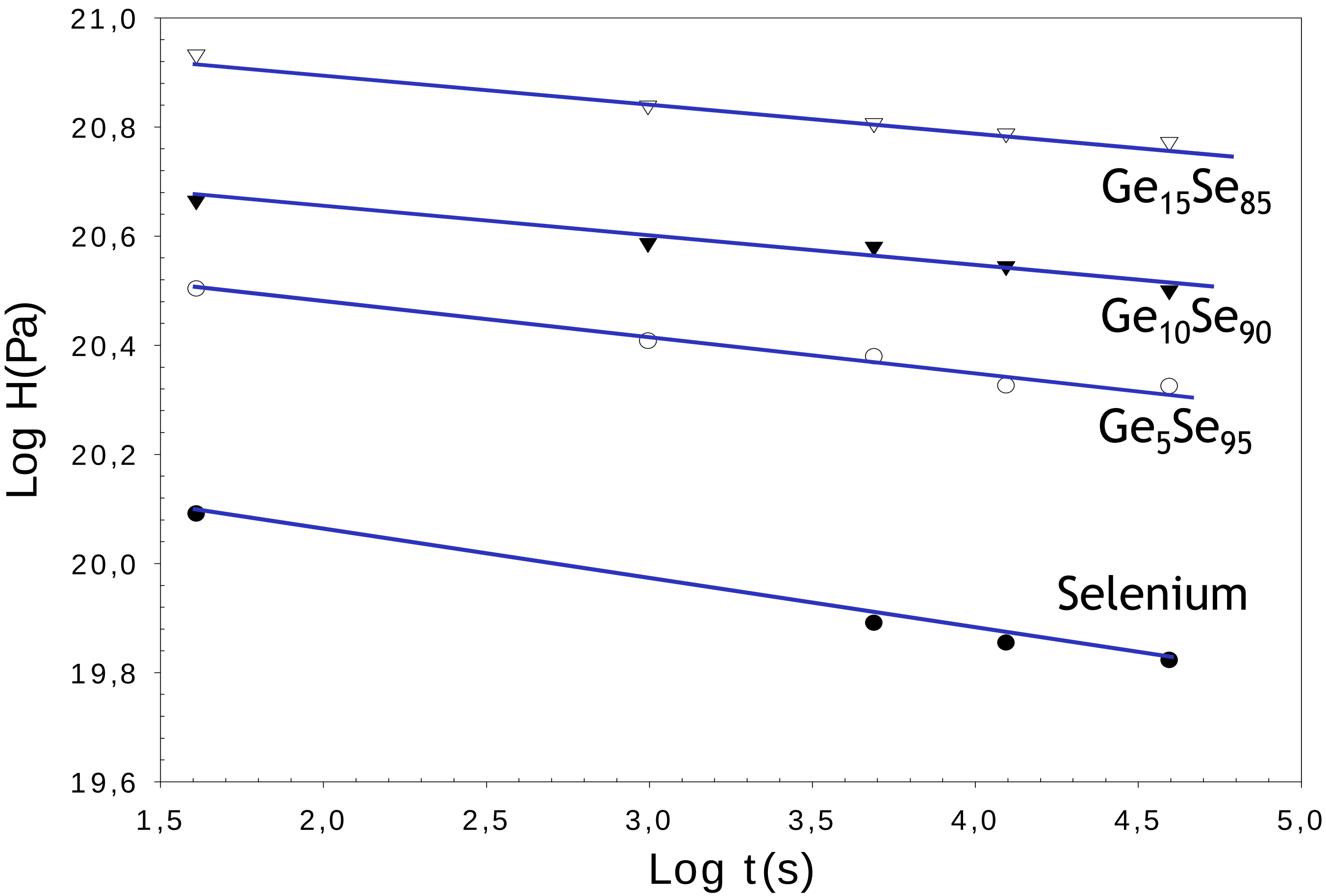


Fiber Curvature



behavior

log H (Pa)



Time dependence of the Meyer's hardness

low Tg => visco-elastic behaviour at ambiant temperature

N·H
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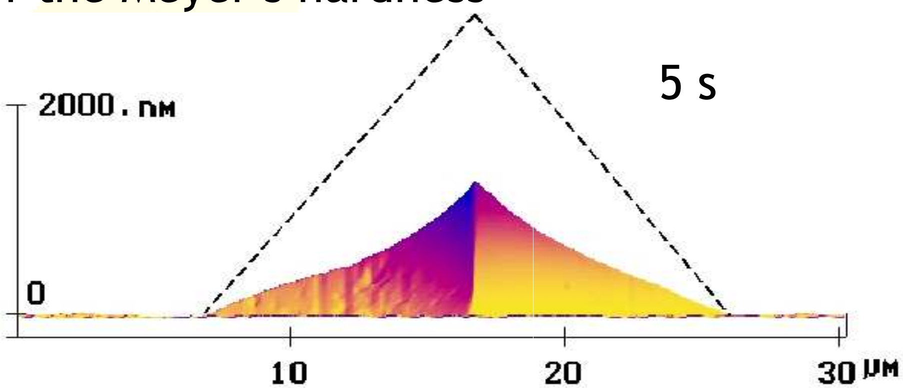
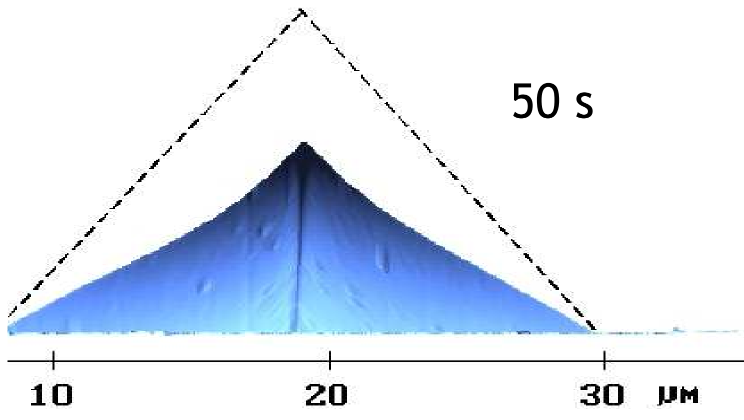
Journal of Non-Crystalline Solids 298 (2002) 260–269
www.elsev

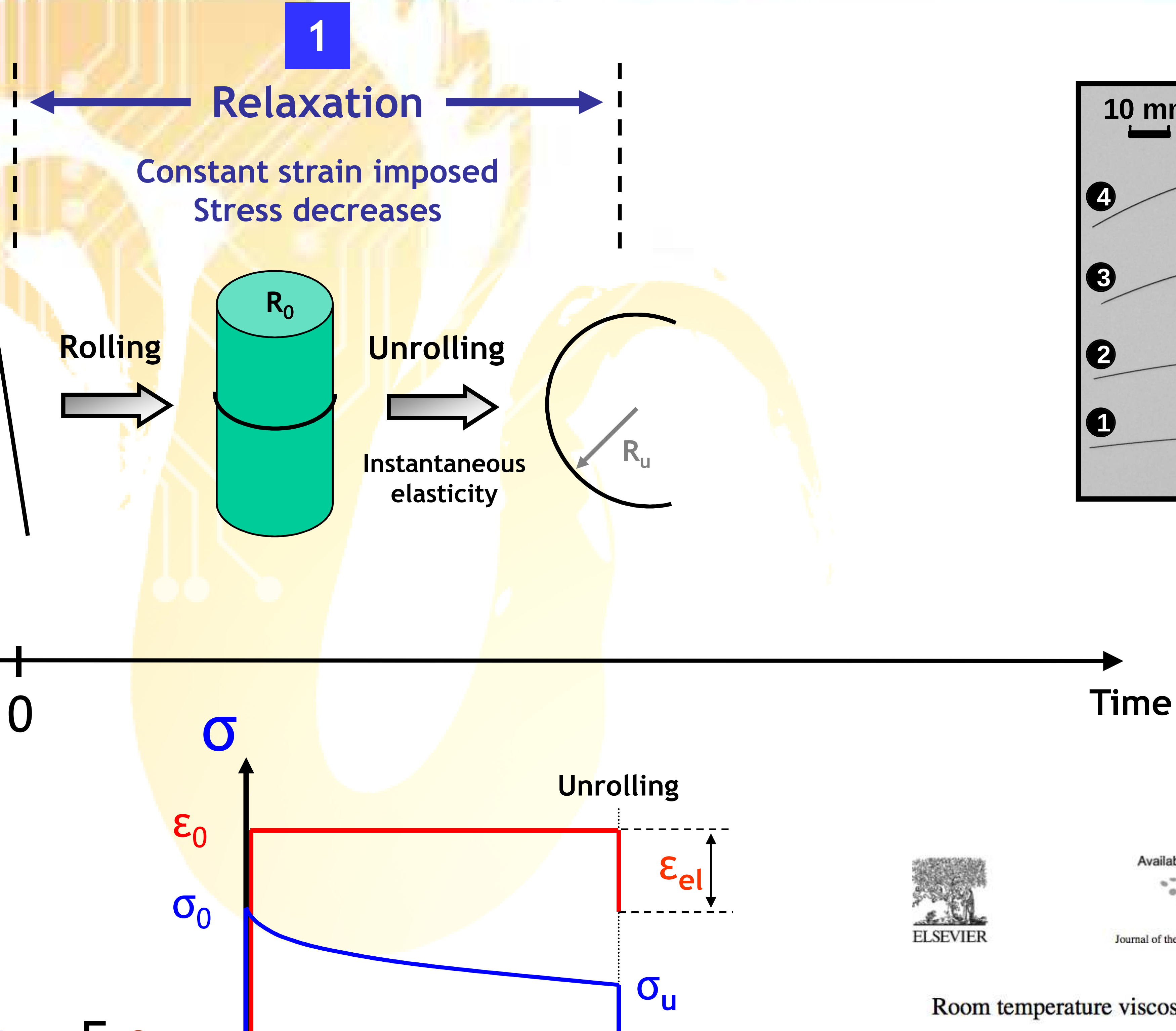
Indentation creep of Ge–Se chalcogenide glasses
elastic recovery and non-Newtonian flow

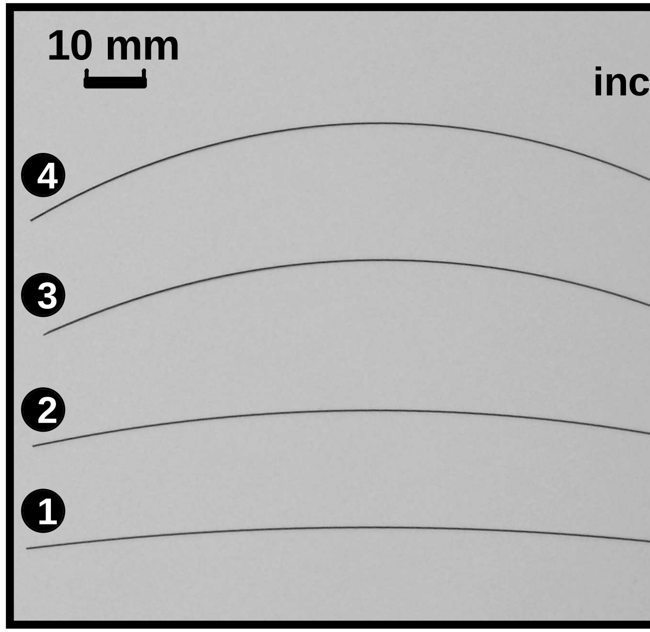
Jean-Pierre Guin [a], Tanguy Rouxel [a,*], Vincent Keryvi
Jean-Christophe Sanglebœuf [a], Ingrid Serre [a], Jacques L

A.F.M profile
Selenium
0.1 N (5-50 s)
21 □ 2 °C









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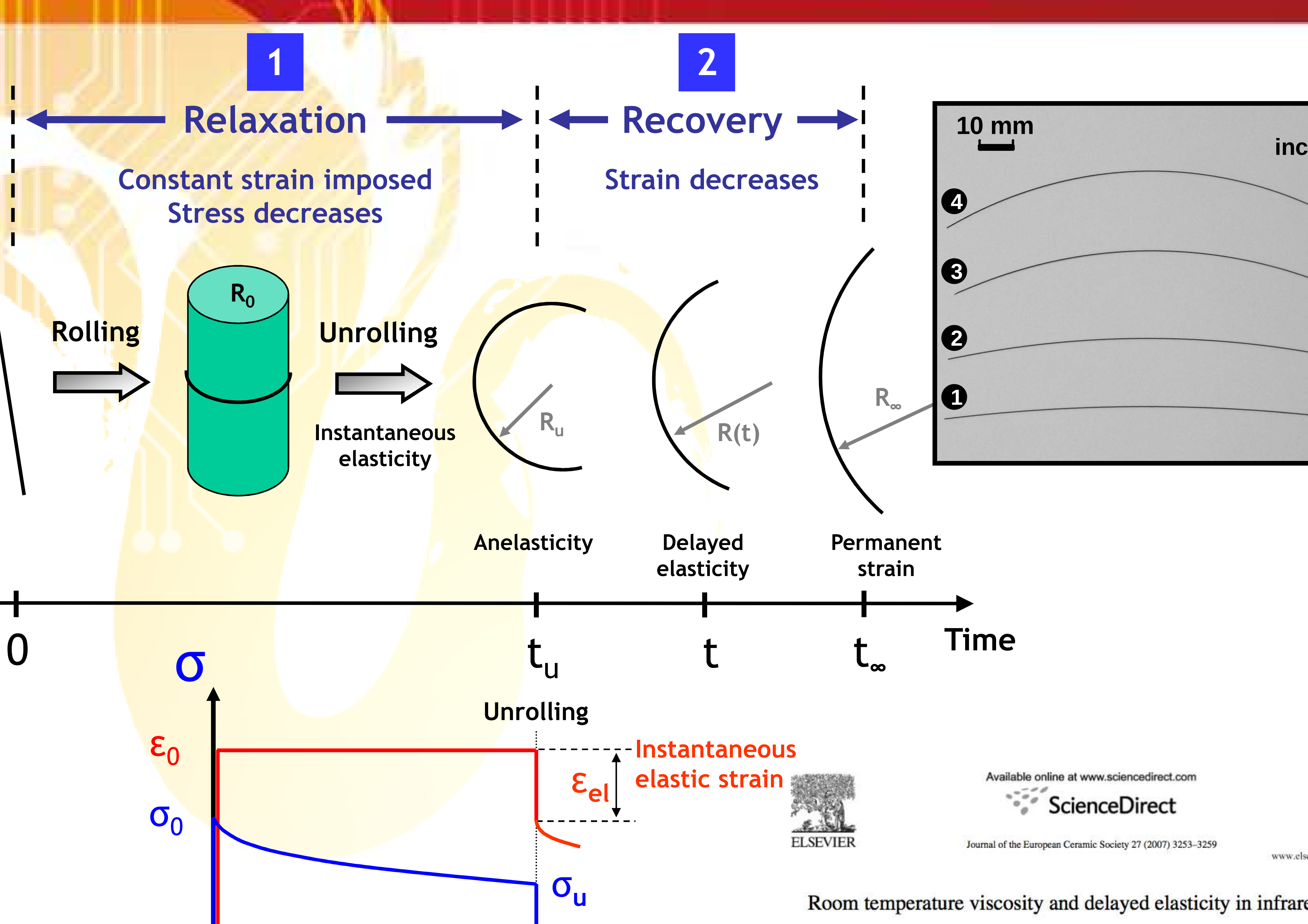
www.els

Room temperature viscosity and delayed elasticity in infrare


1
Relaxation
Constant strain imposed
Stress decreases
2
Recovery
Strain decreases
10 mm
inc
4
3
2
1
Rolling
R_0
Unrolling
Instantaneous elasticity
R_u
R(t)
R_∞
Anelasticity
Delayed elasticity
Permanent strain
0
t_u
t
t_∞
Time
σ
Unrolling
ε_0
σ_0
ε_{el}
Instantaneous elastic strain
σ_u
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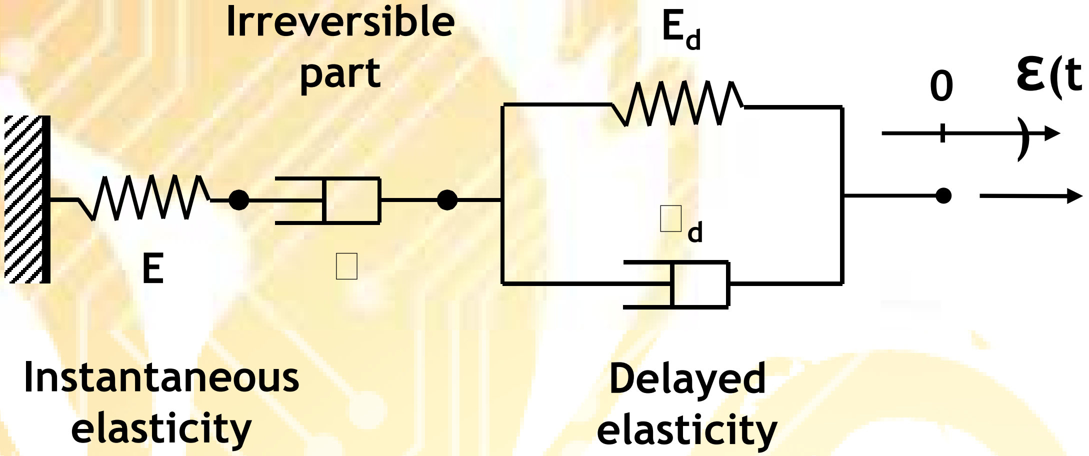
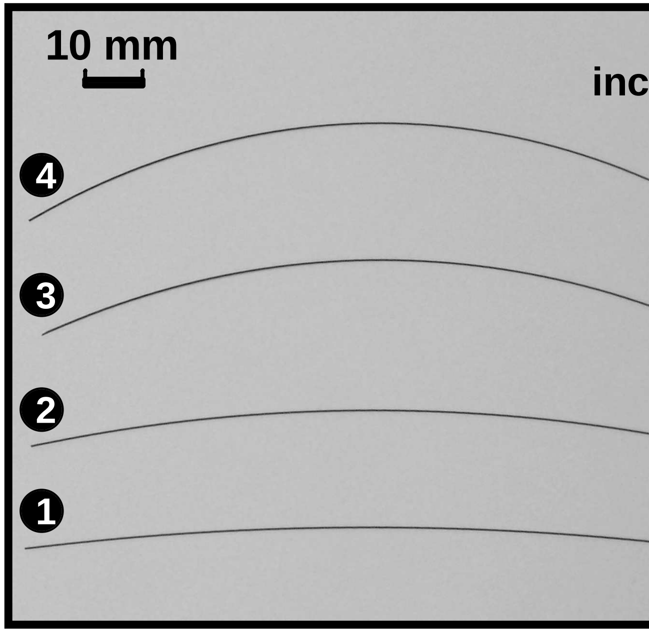
Room temperature viscosity and delayed elasticity in infrare

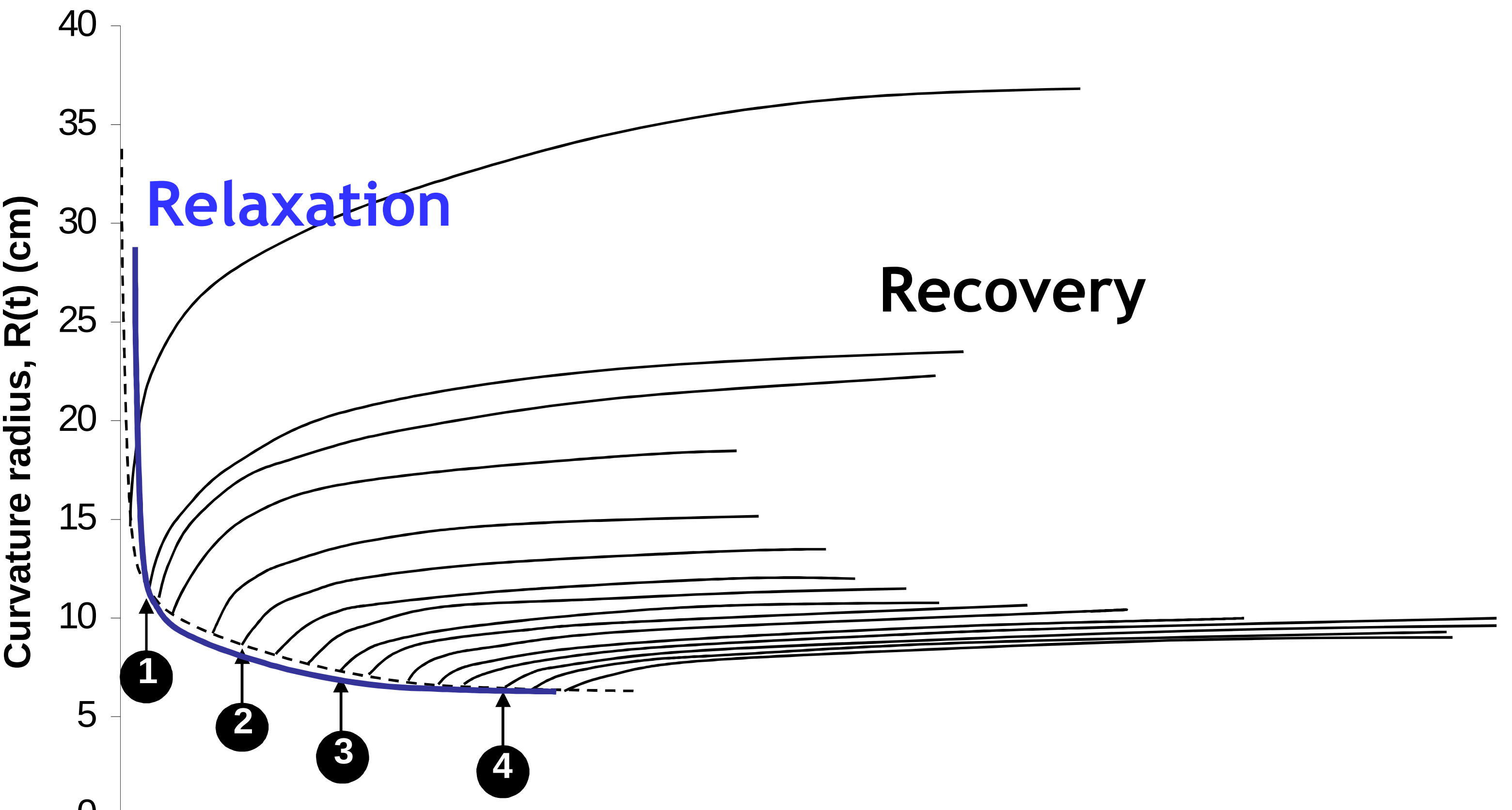
Viscoelastic model : Burger's cell

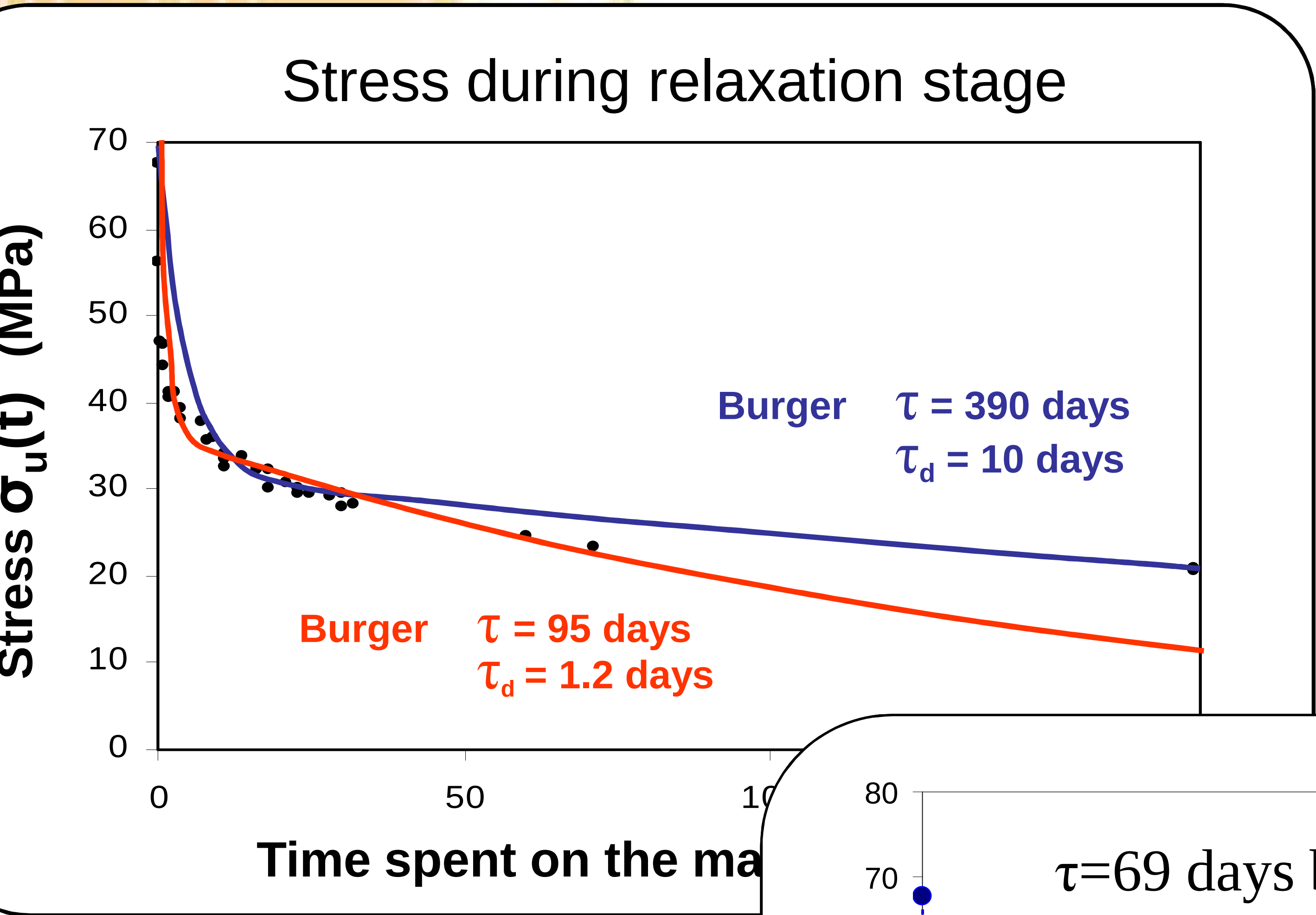


Time constant:

$$\tau = \frac{\eta}{E}$$



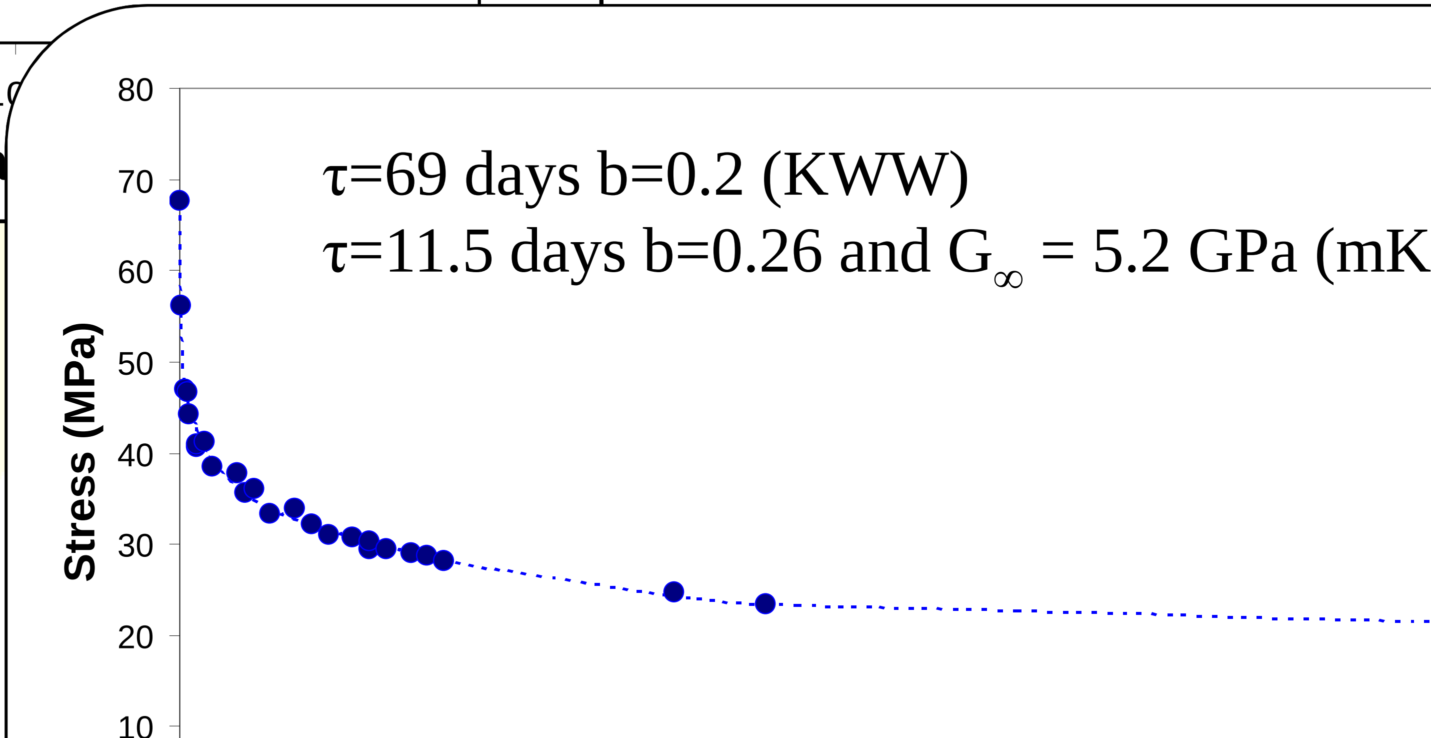




Burger's cell

⇩

Problem to model for both short and long periods

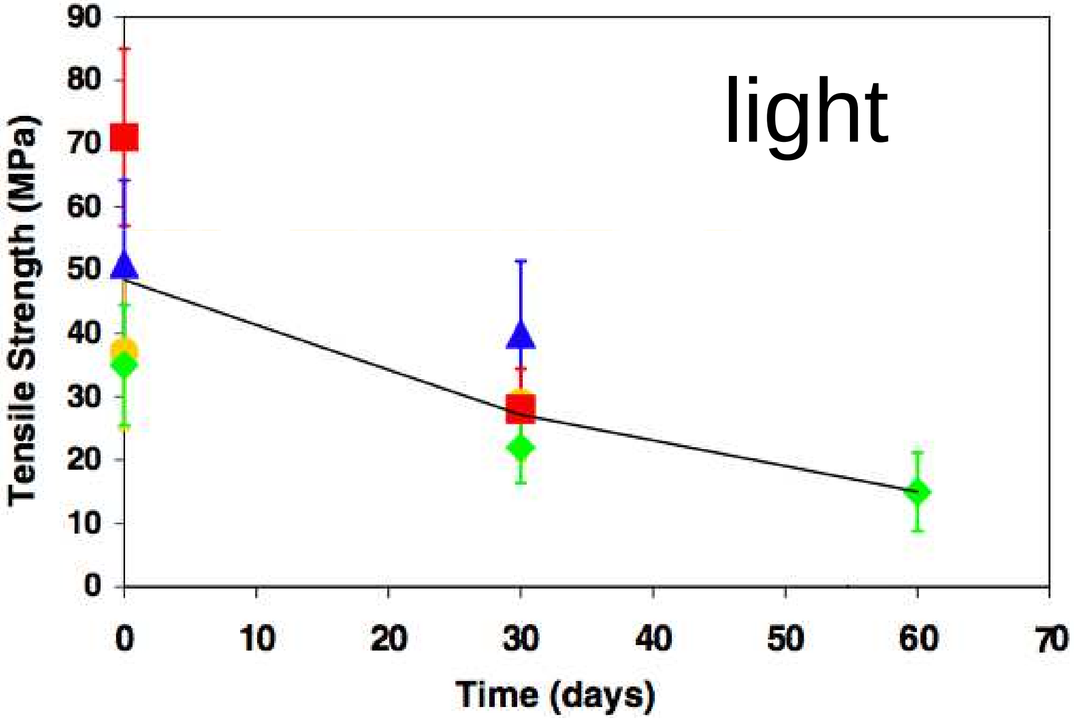


ed stretched exponential equation

lraush-Williams-Watt equation (KWW):

ensile test

Gaelle Delaizir[1], Jean-Christophe Sangleboeuf[2], Ellyn A King[3], Yann Gueguen[2]
Xiang-Hua Zhang[4], Catherine Boussard-Pledel[4], Bruno Bureau[4] and Pierre
Lucas[3]



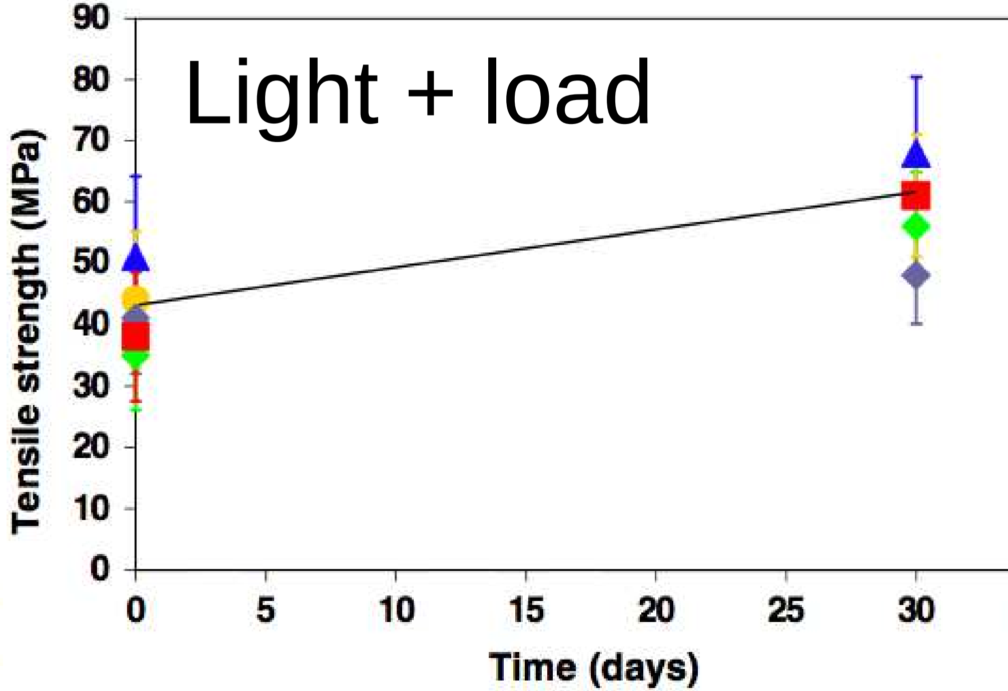
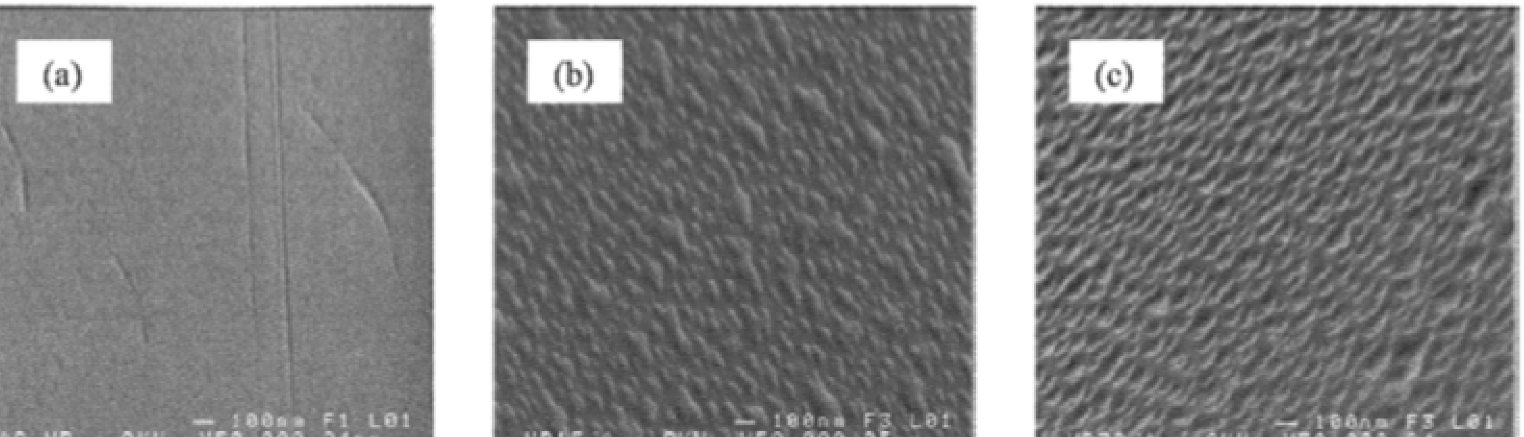
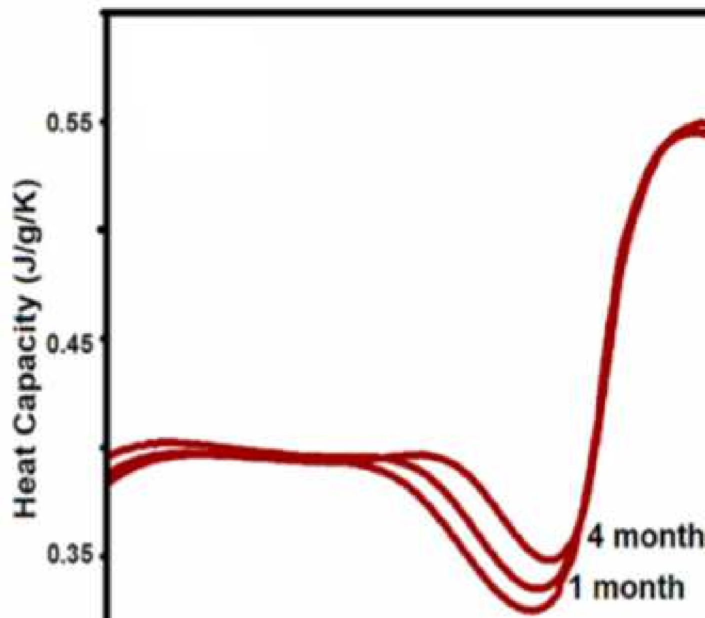


Photo-oxydation





- **Ge-Se: $GeSe_9$ - $GeSe_4$**

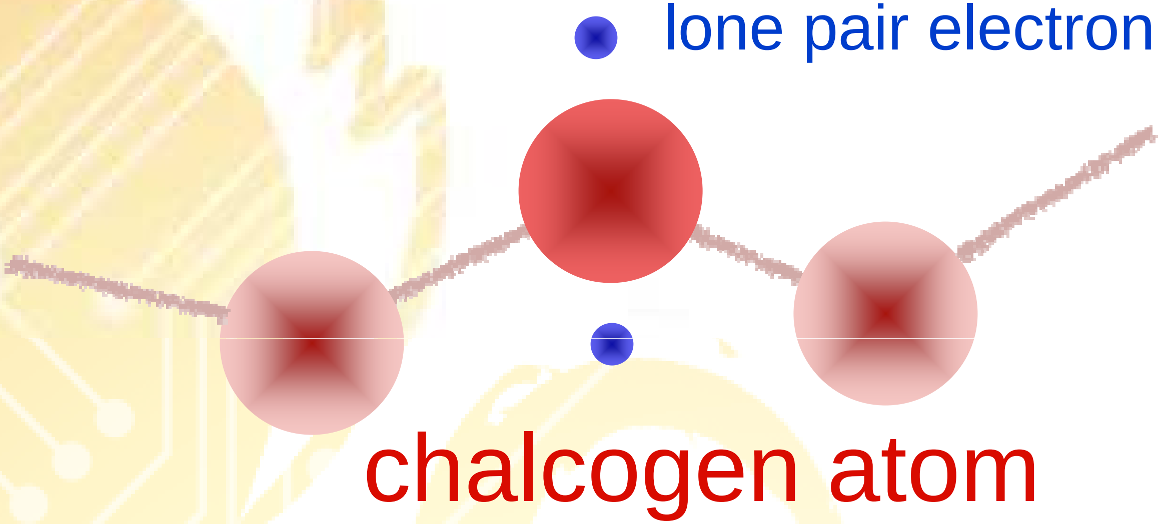
  fragile strong

- **Te-As-Se: $Te_2As_3Se_5$ (TAS)**

Infrared spectroscopy for biology

	Tg (°C)	μ (GPa)
$GeSe_9$	92	4.6
$GeSe_4$	162	5.7

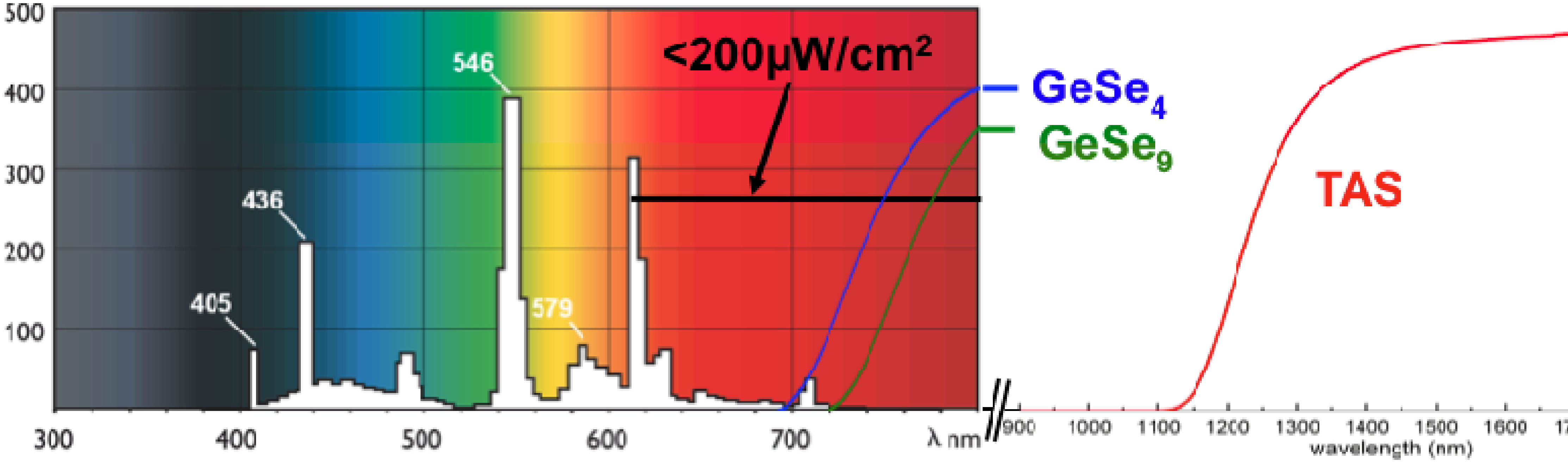
effects?



- ☑ photoinduced refractive index change
- ☑ photoamorphisation
- ☑ photodarkening
- ☑ photopolymerization
- ☑ photoexpansion
- ☑ photocrystallization
- ☑ photofluidity
- ☑ photo-oxydation
- ☑ photobleaching

Condition

- Common fluorescente light bulbs



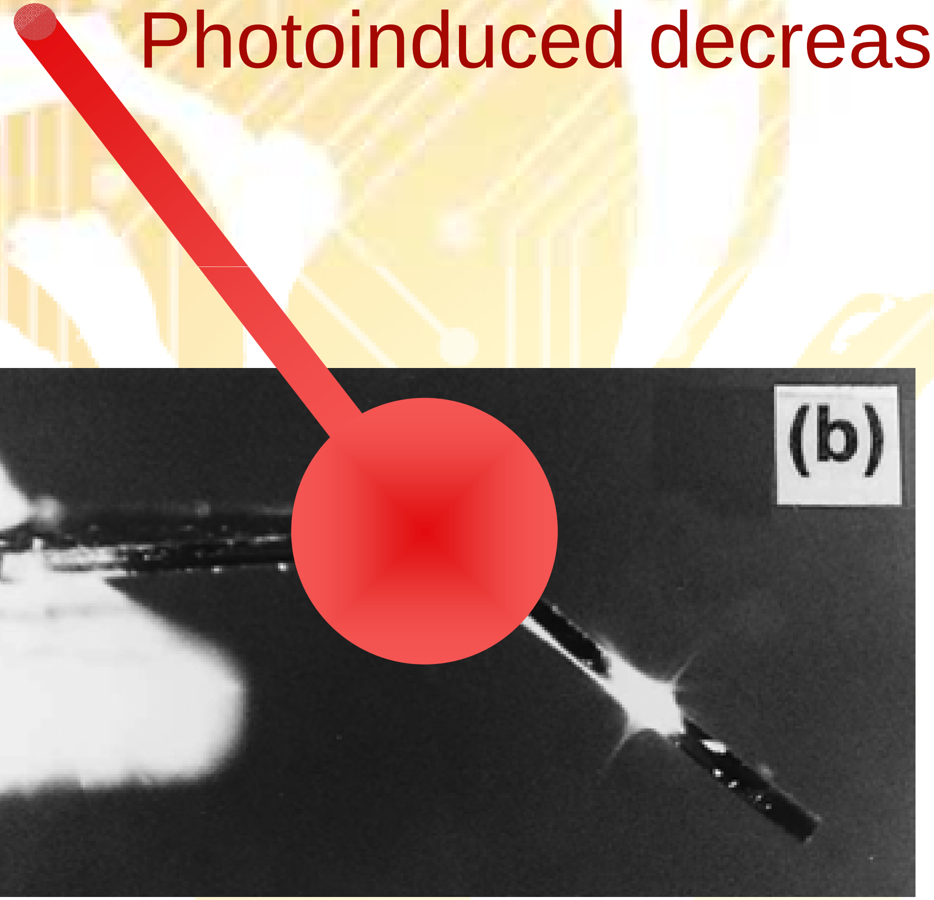
Ge-Se: suband-gap light corresponds to low light intens

low absorption, volumic effects

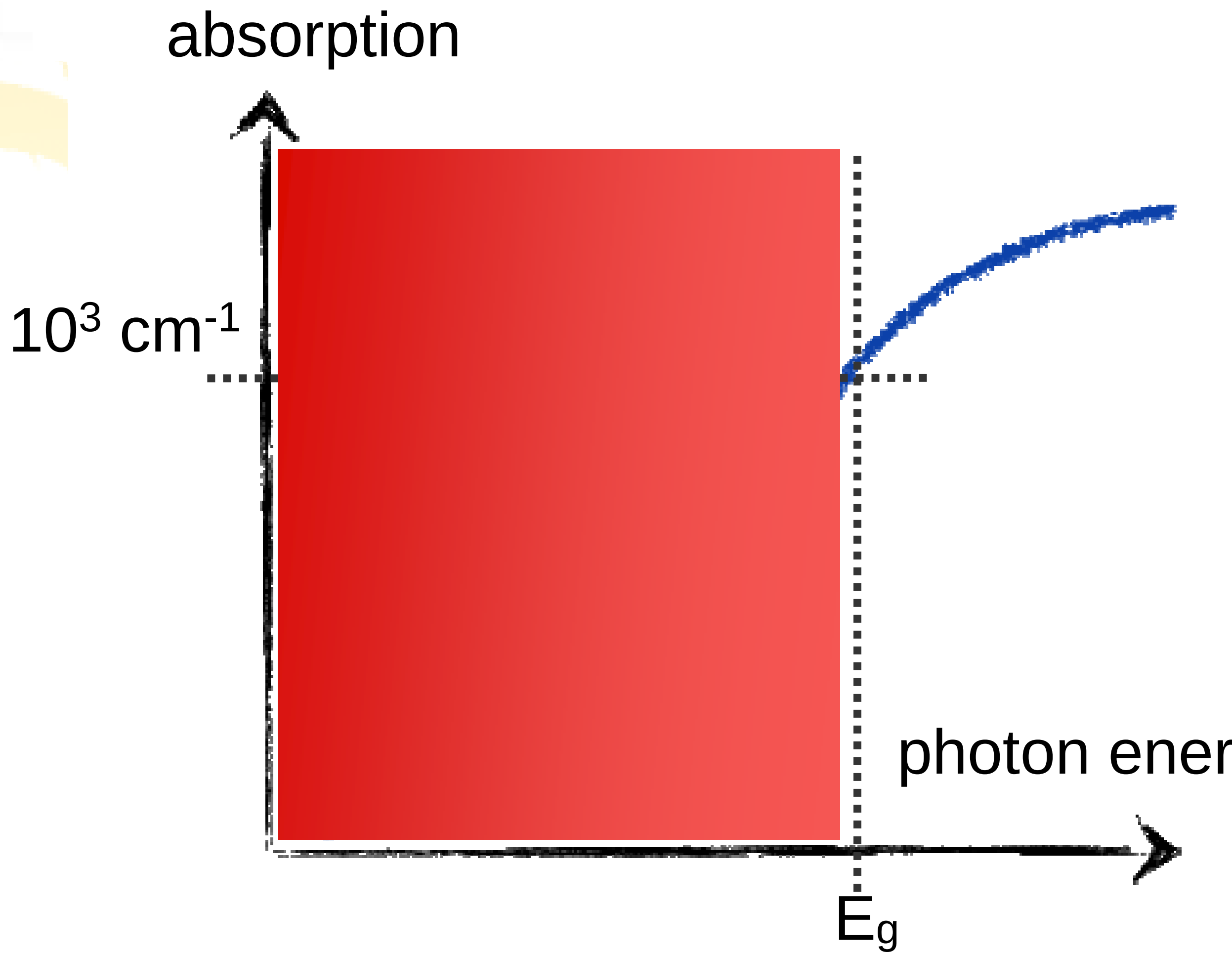
TAS: no suband-gap light, E>Eg,

high absorption, effects limited to the surfa

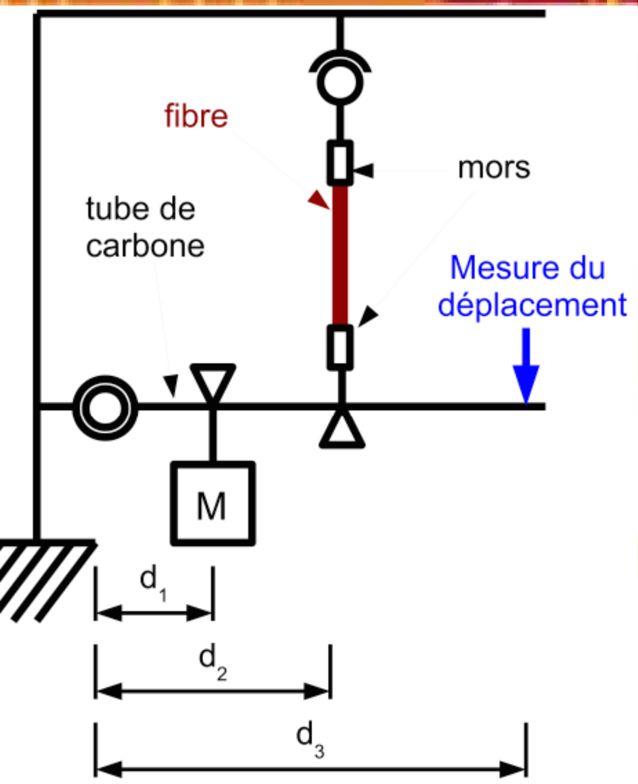
Photoinduced decrease of the viscosity (in chalcogenide gla

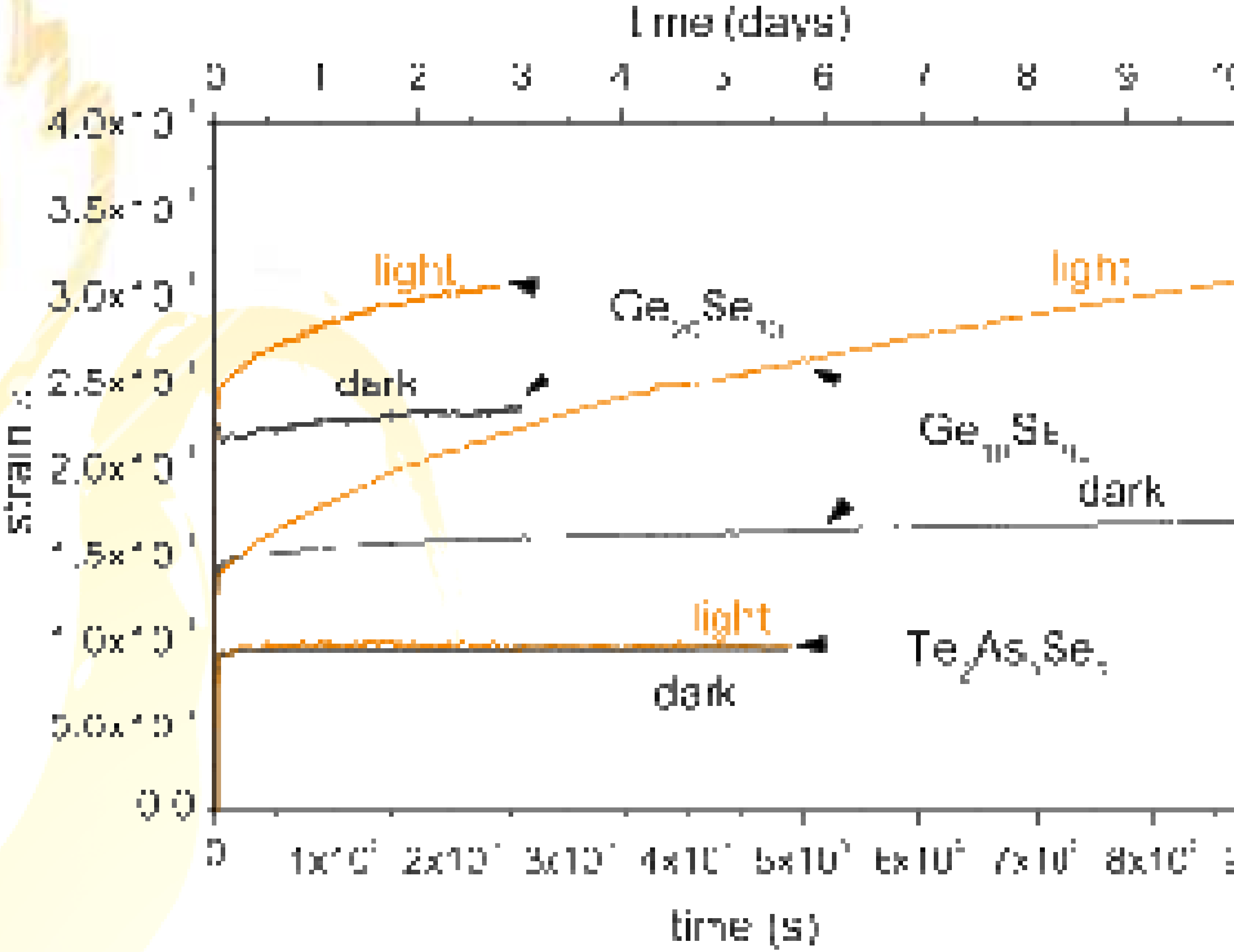


akuni, H. & Tanaka, K.
ical Microfabrication of Chalcogenide Glasses
ence, **1995**, *270*, 974-975



- Low absorption: few photons absorbed
- No temperature increase due to laser heating





tensile creep
ests on fibers

300 µm

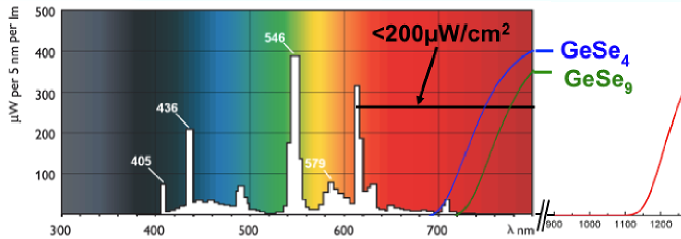
TAS: no photoinduced effects even for high absorption

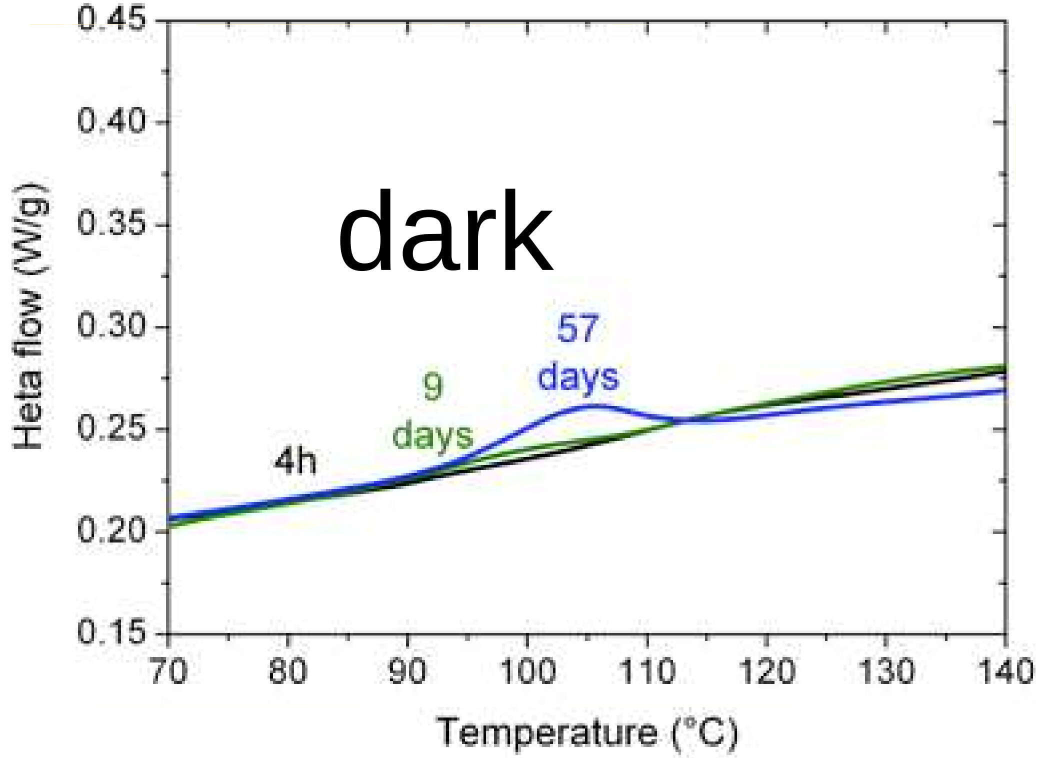
effects limited to the surface, no macroscopic flu

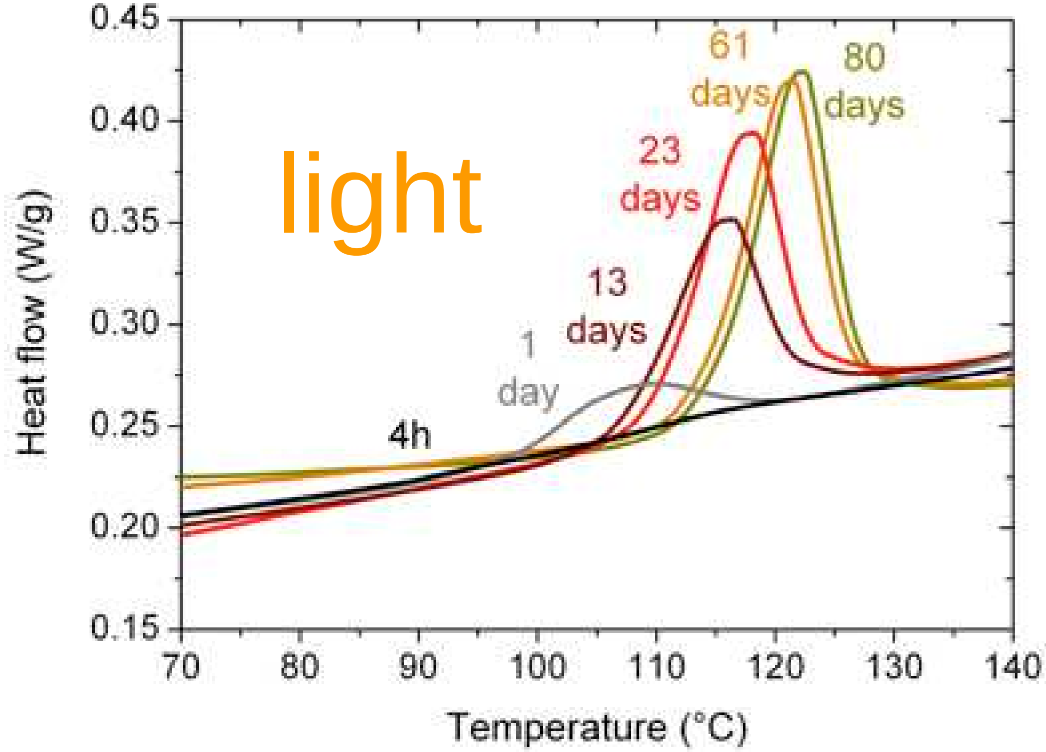
Ageing: evolution of mechanical/physical properties du
structural relaxation

- **Evidence of photorelaxation at low light intensit**
- **Relaxation-recovery tests**
- **Evidence of photoageing**
- **A model for photofluidity**

$GeSe_9$ fibers (| 300 µm)

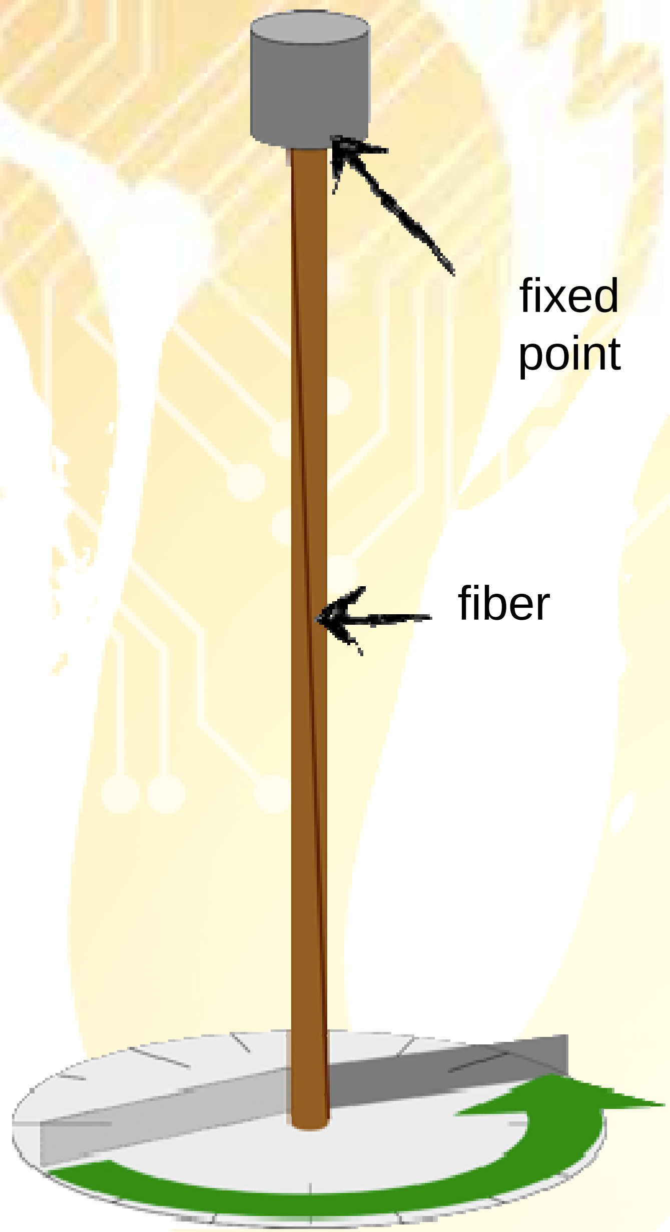


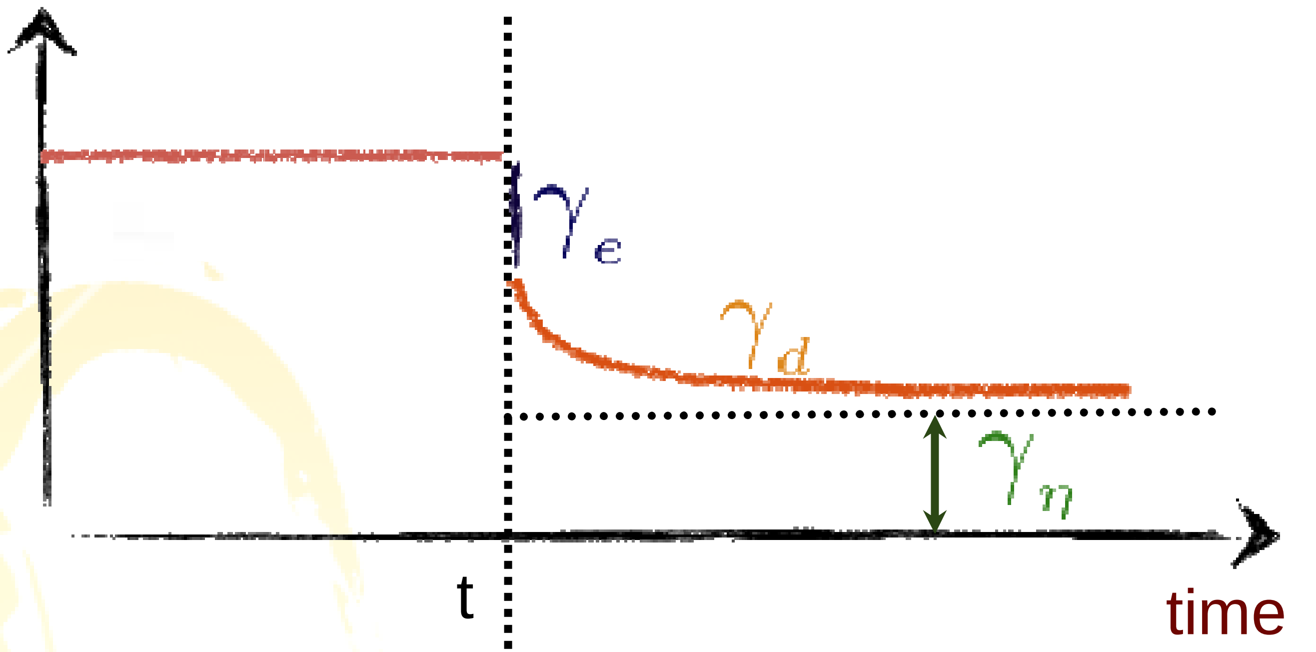


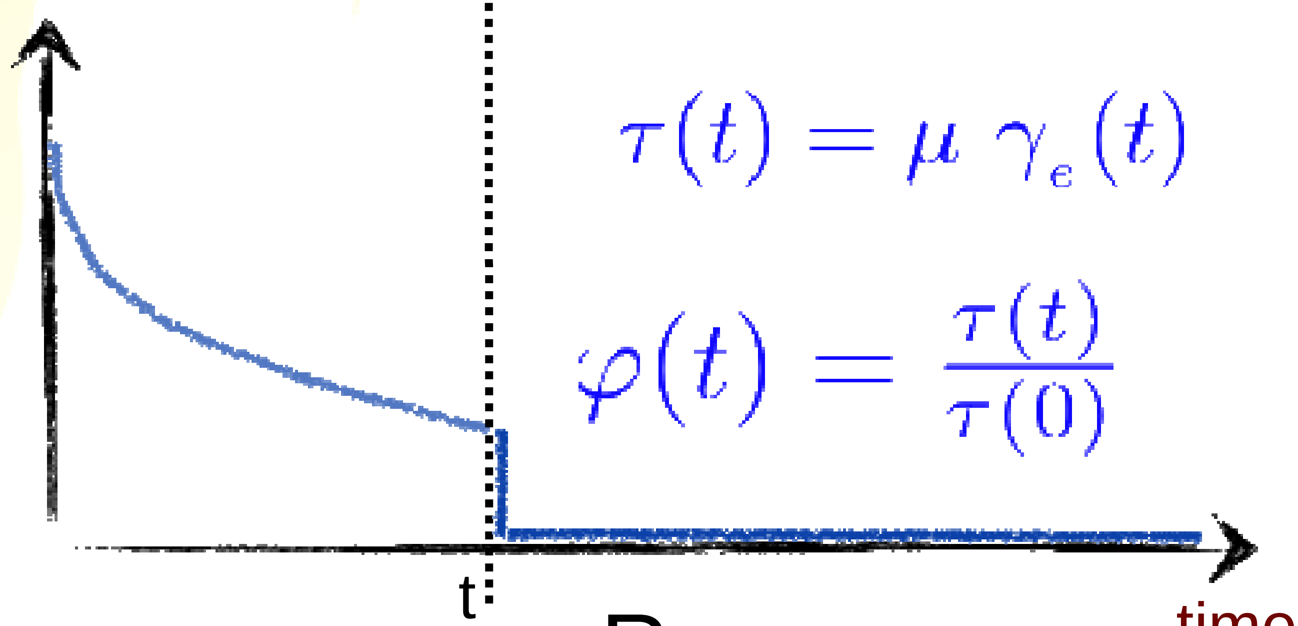


Fast relaxation under irradiation

Relaxation time
~35 days under irradiation
>10 years (estimated) in the dark





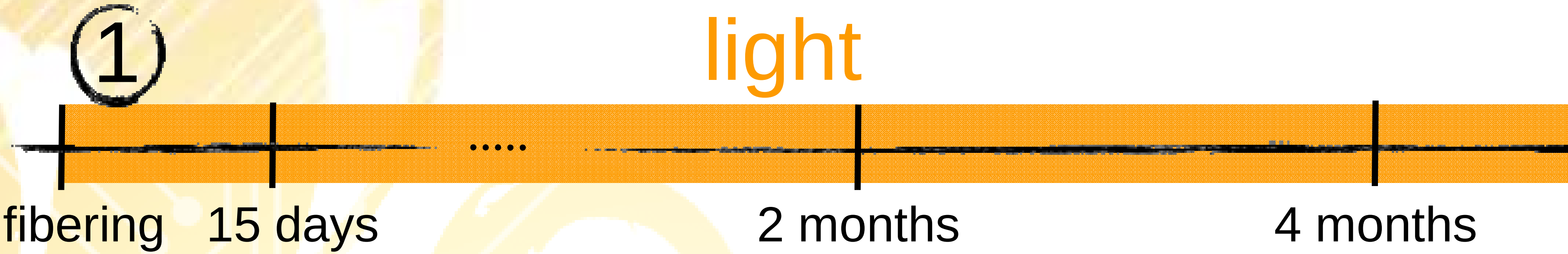


$$\tau(t) = \mu\,\gamma_e(t)$$

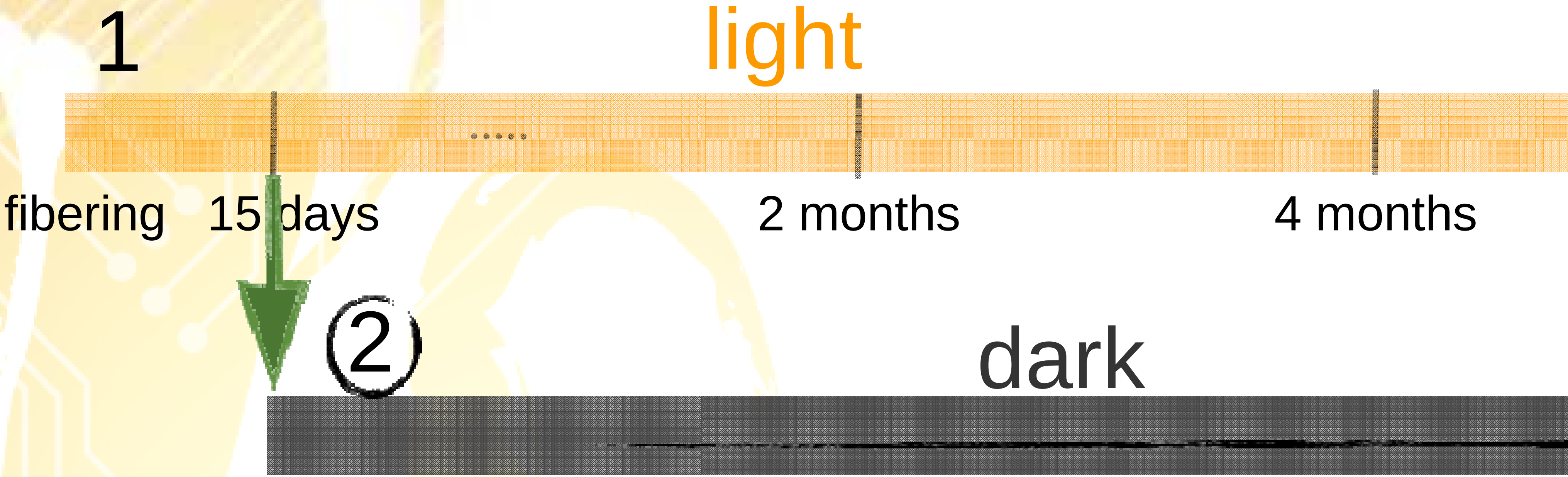
$$\varphi(t) = \frac{\tau(t)}{\tau(0)}$$

Recovery

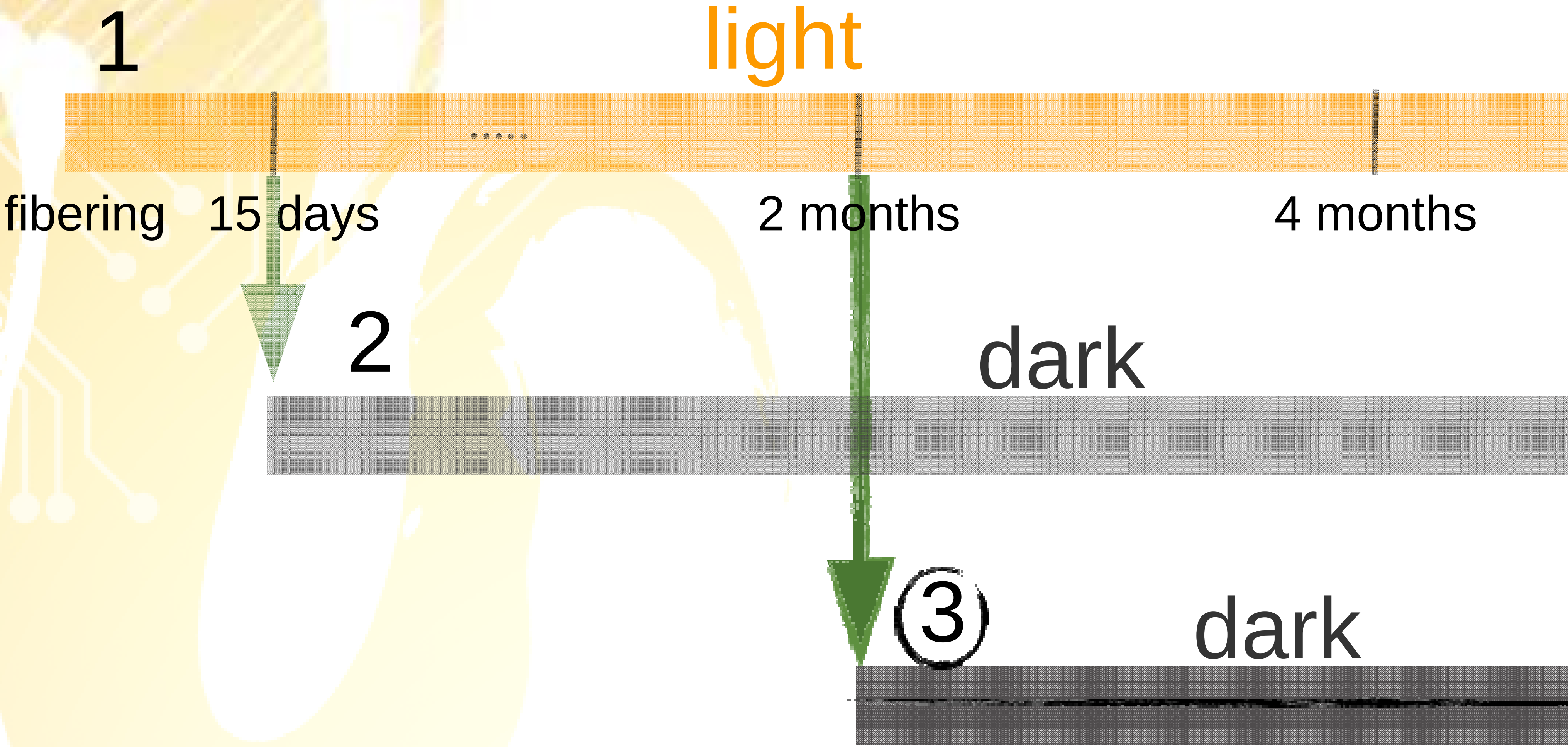
$Ge_{10}Se_{90}$ fibers, | 300 µm



$Ge_{10}Se_{90}$ fibers, | 300 µm



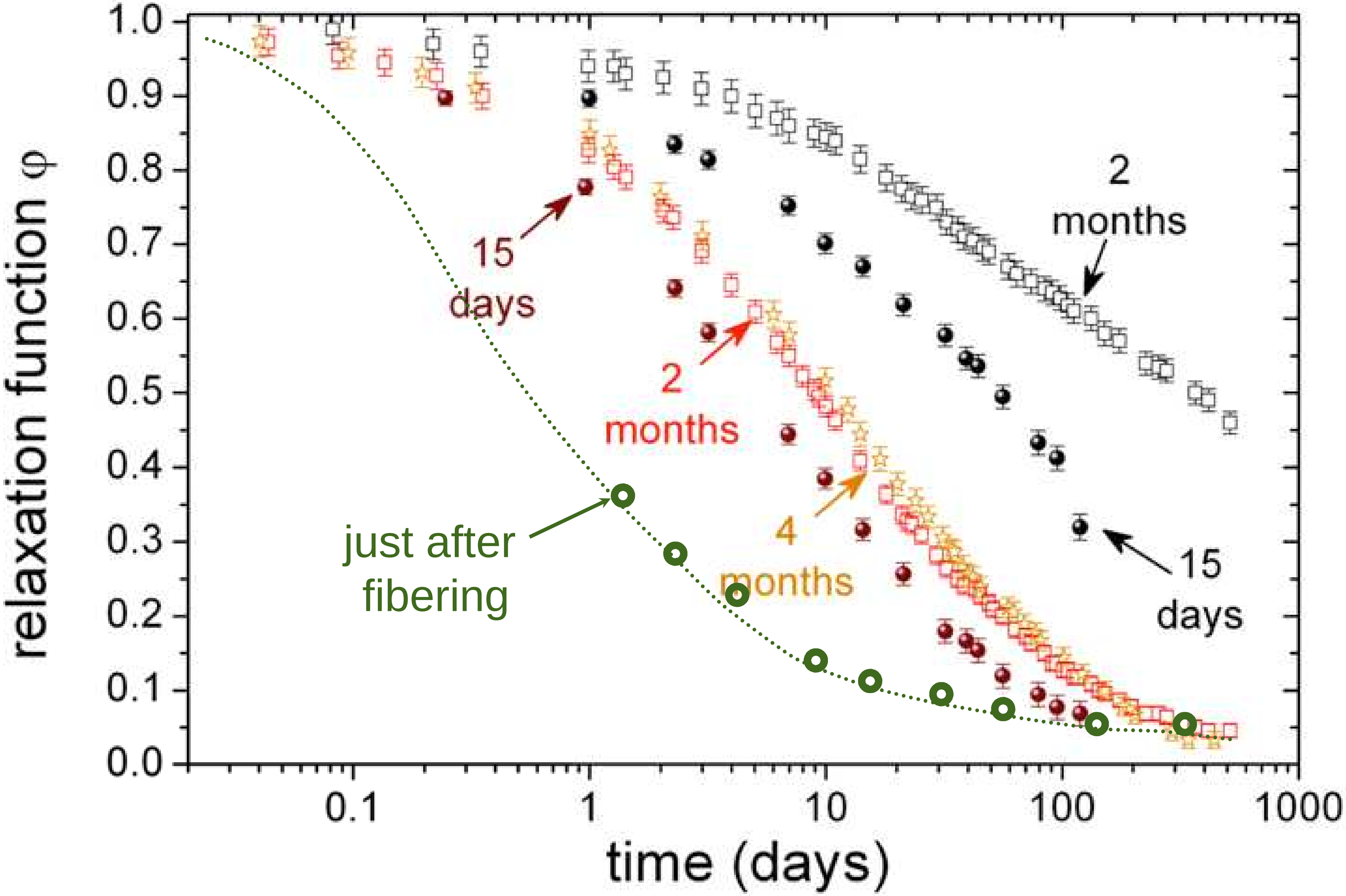
$Ge_{10}Se_{90}$ fibers, | 300 µm



shear relaxation tests

shear relaxation-recovery tests

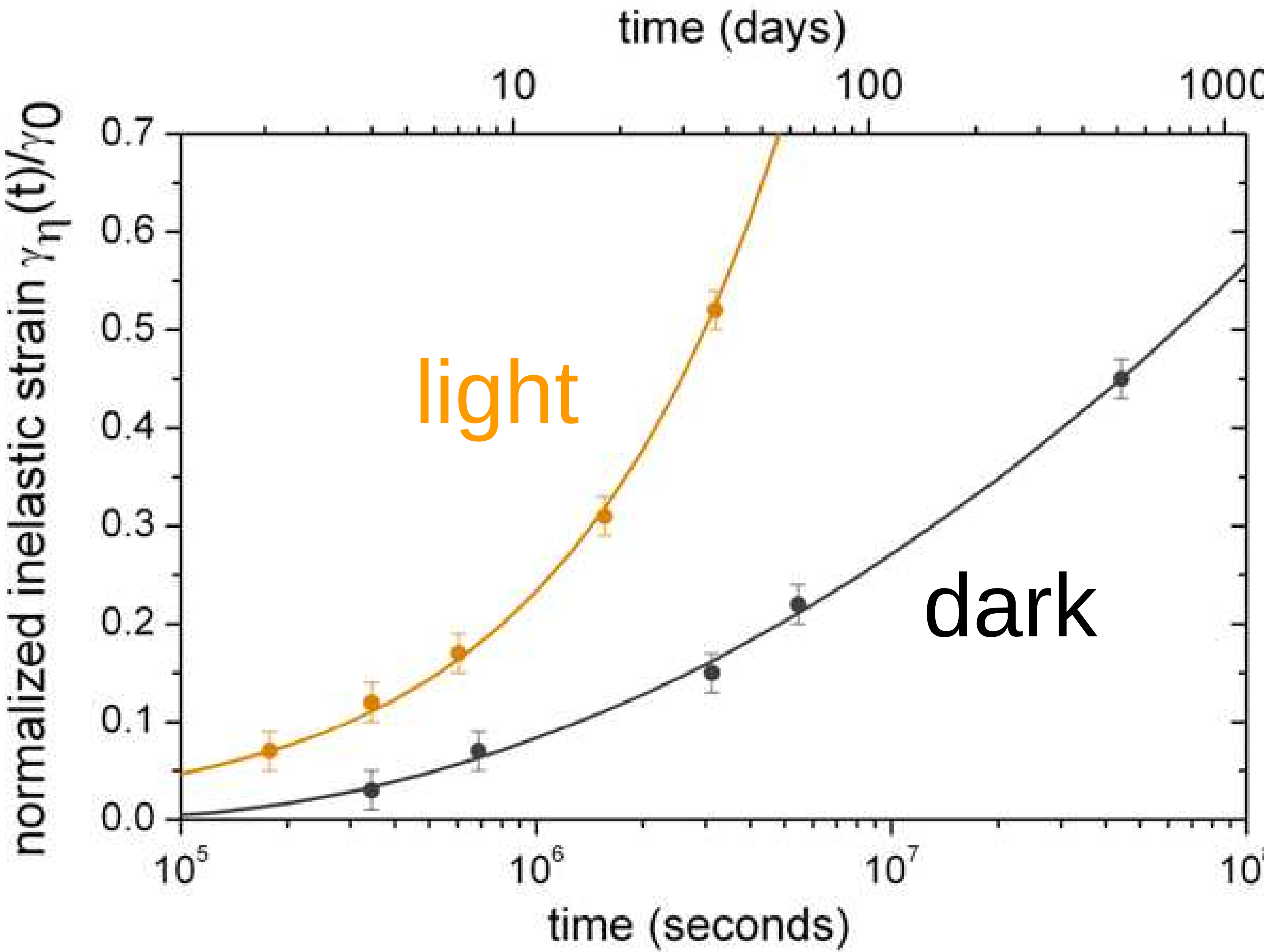
Photofluidity



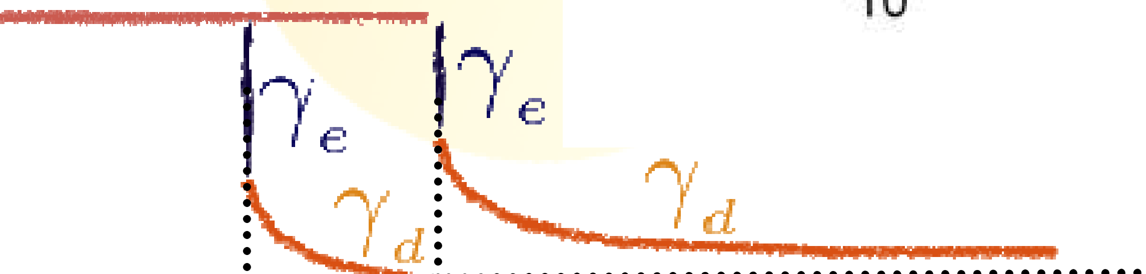
- photofluidity
- ageing

$Ge_{10}Se_{90}$ fibers, aged 2 months under irradiation

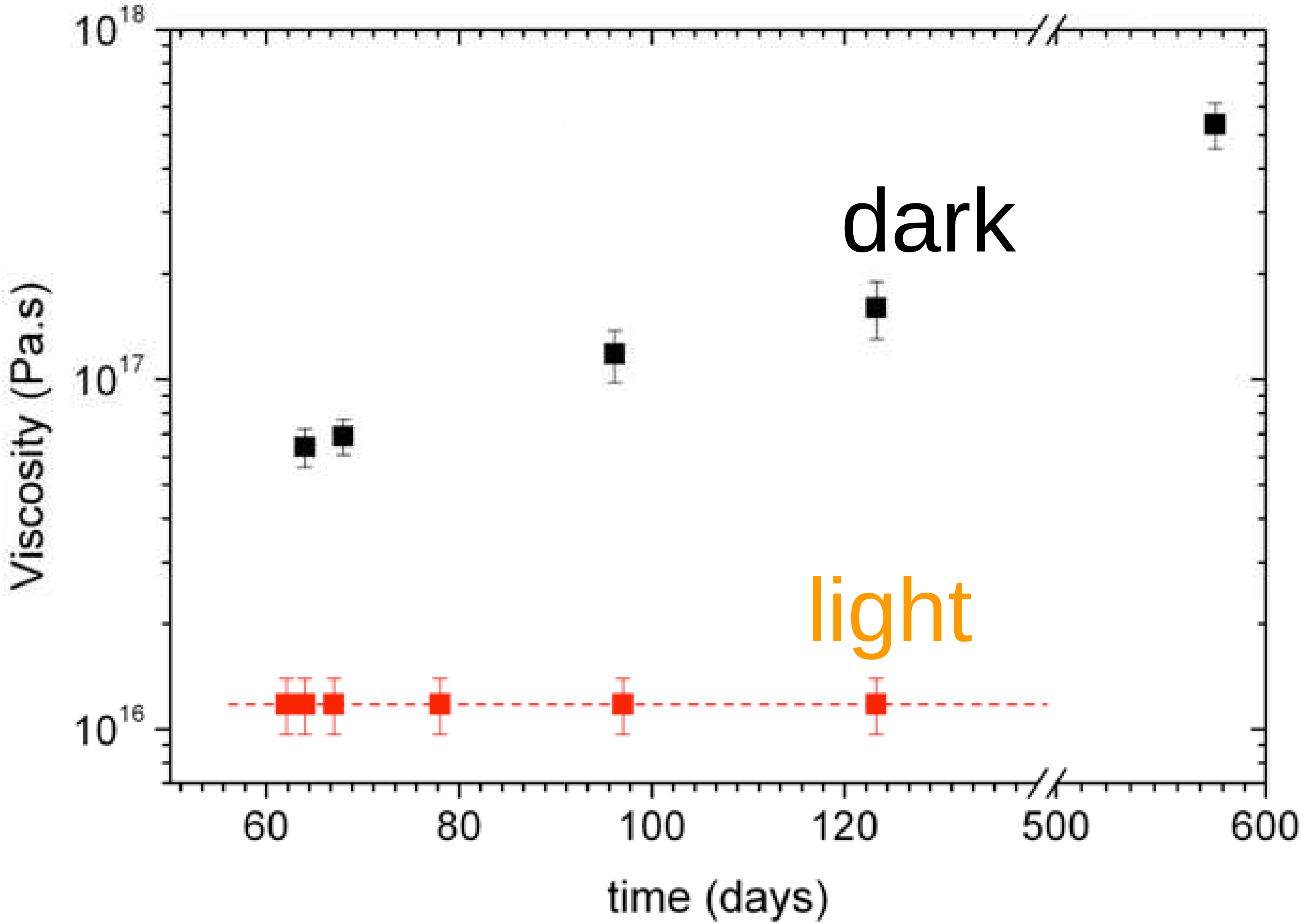
$$(t) = \frac{\tau(t)}{\dot{\gamma}_{\eta}(t)}$$



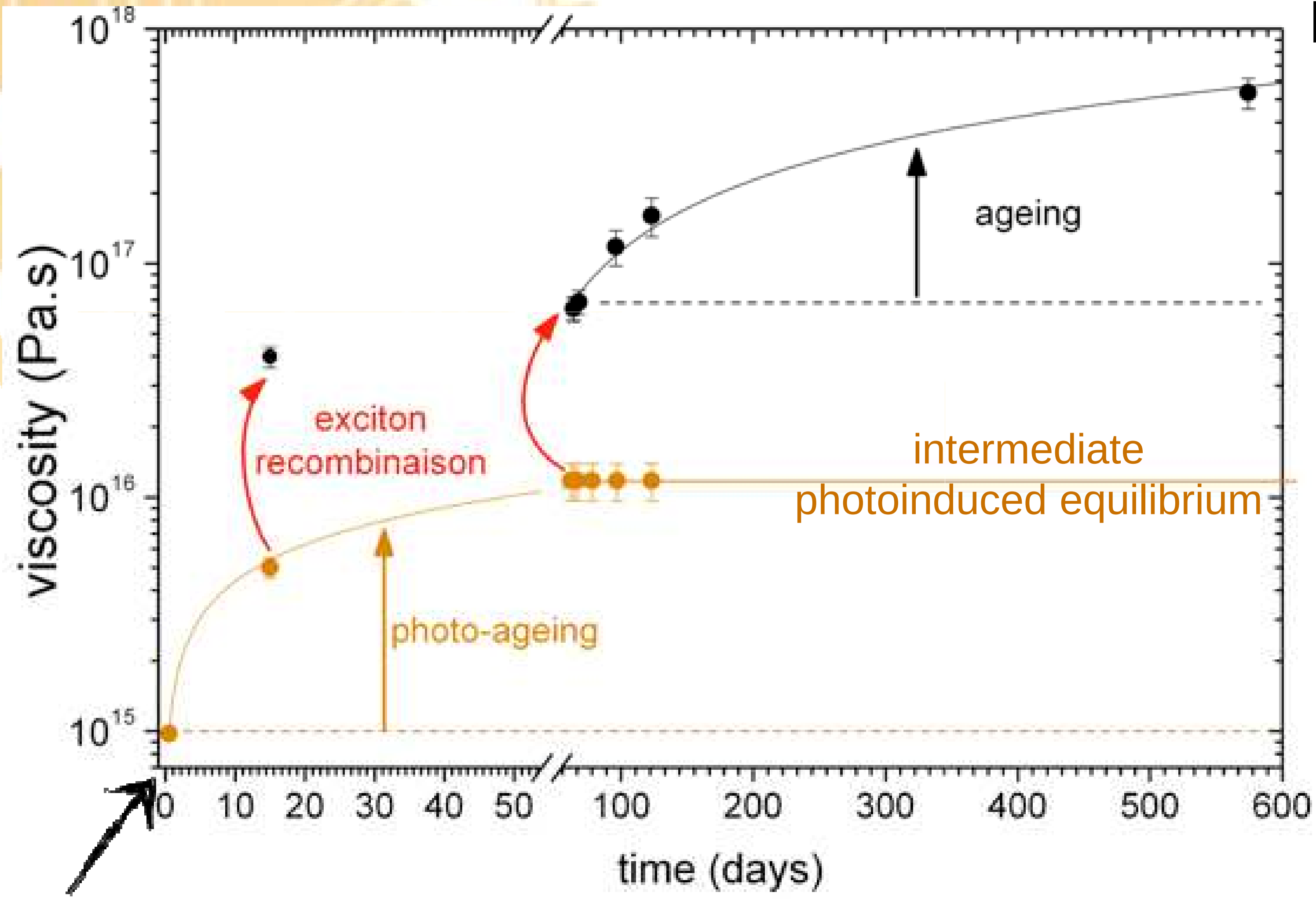
rain



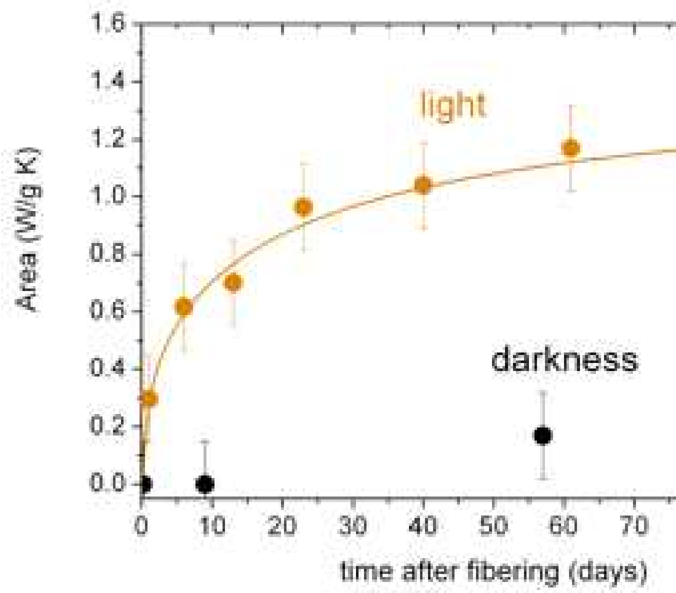
$Ge_{10}Se_{90}$ fibers, aged 2 months under irradiation



$\eta(T_f$ 🖫 20 ⌖ $C) > 10^{19}$



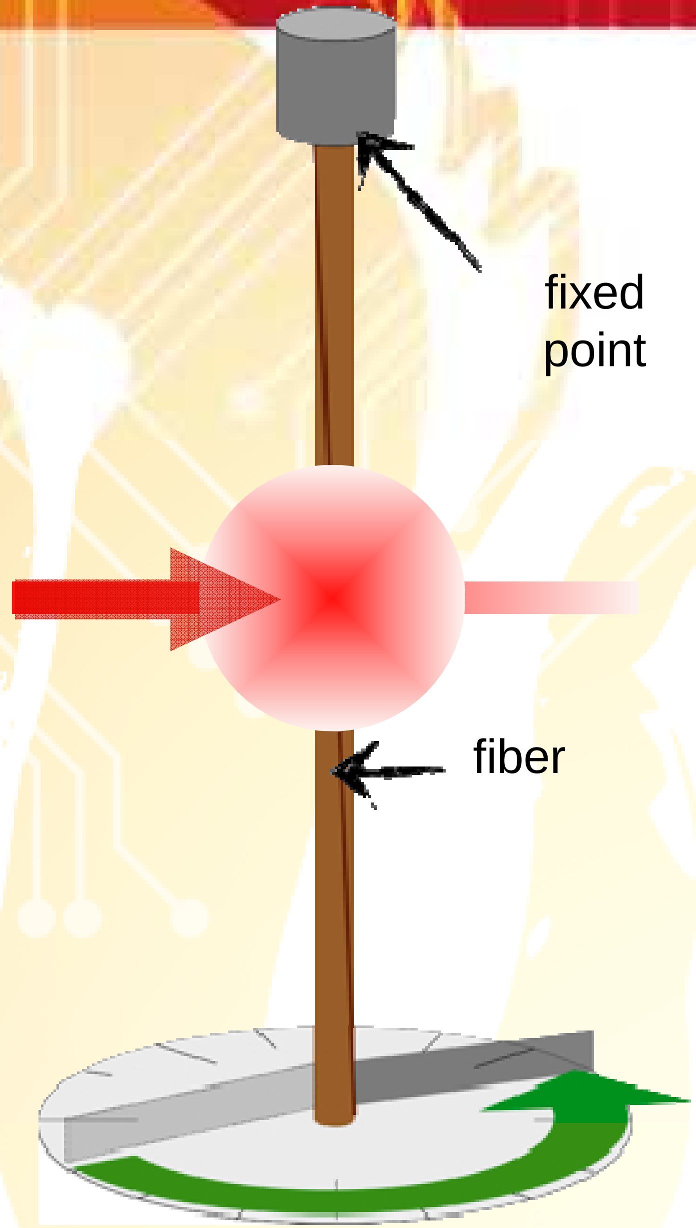
ibering



Structural relaxa

Two processes:

- photoageing due to photorelaxation
- photofluidity due to ?



$$\gamma_i = \frac{r}{L}\,\theta_i$$

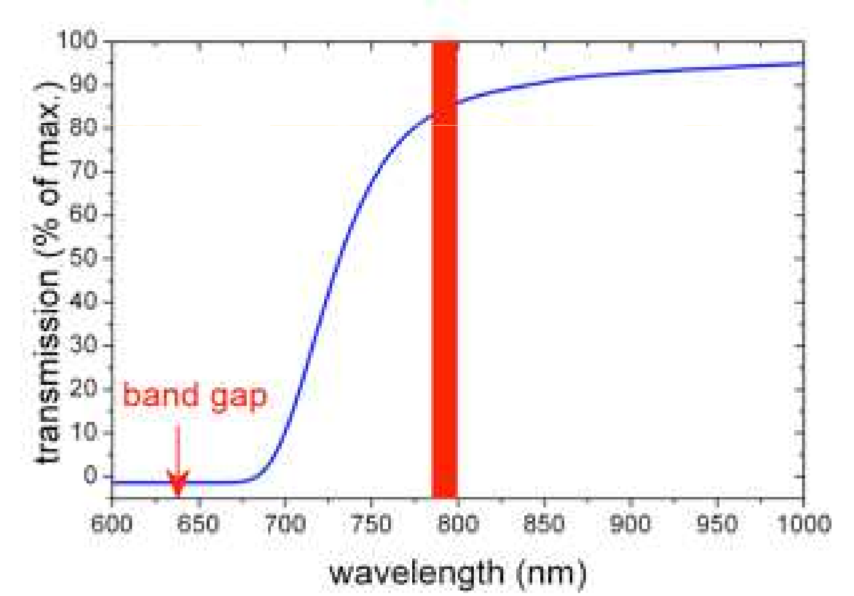
Viscoelastic composite

- unirradiated volume: know
- viscosity of the composi measured

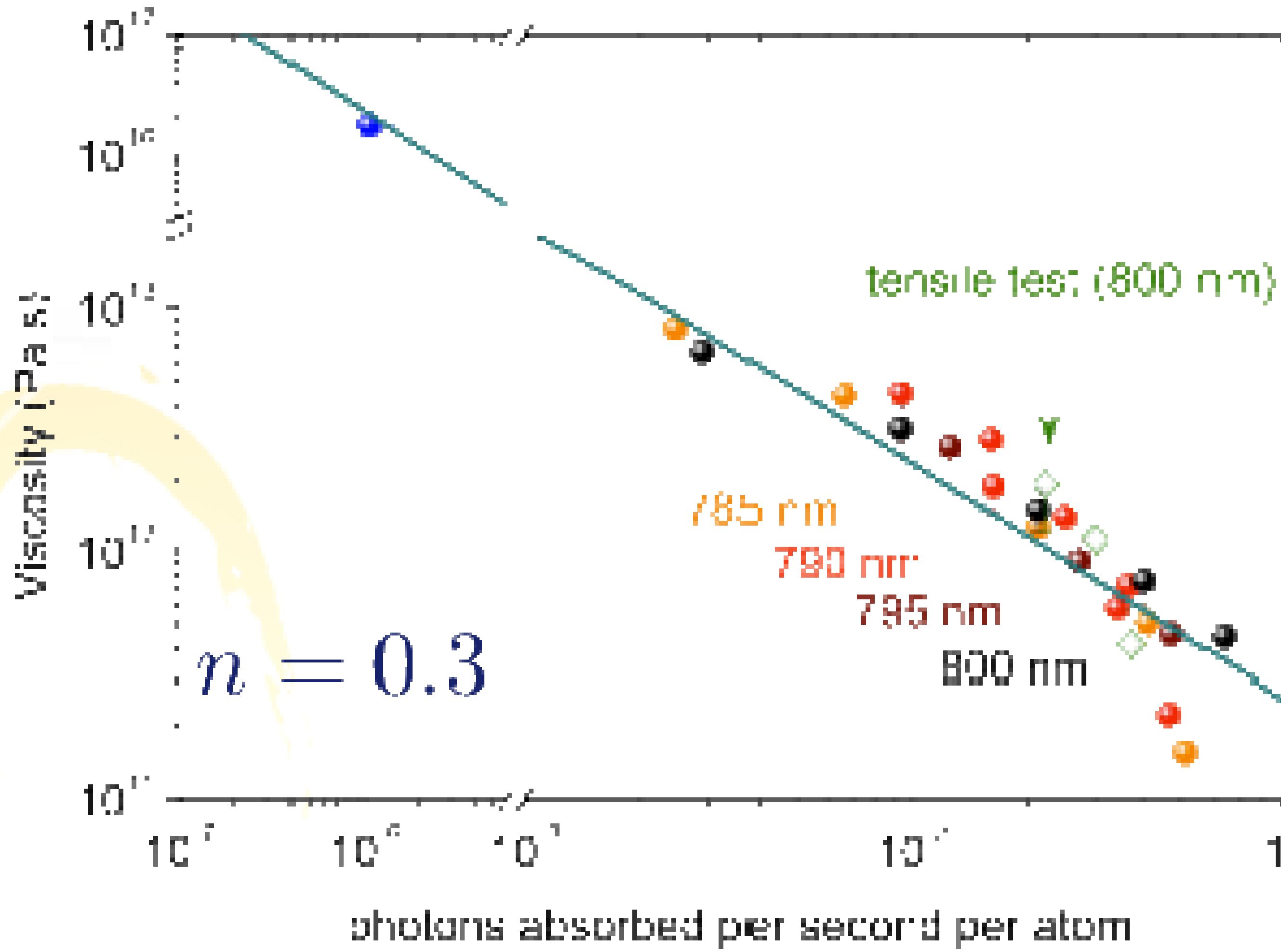
viscosity of the irradiate volume

Collaboration:
E. Lépine (Verres et Céramiques UMR CNRS 6226 SCR)

$0.795\ E_g < E < 0.810 E_g$



Gueguen et al., Physical Review B, **2010**, *82*, 134114

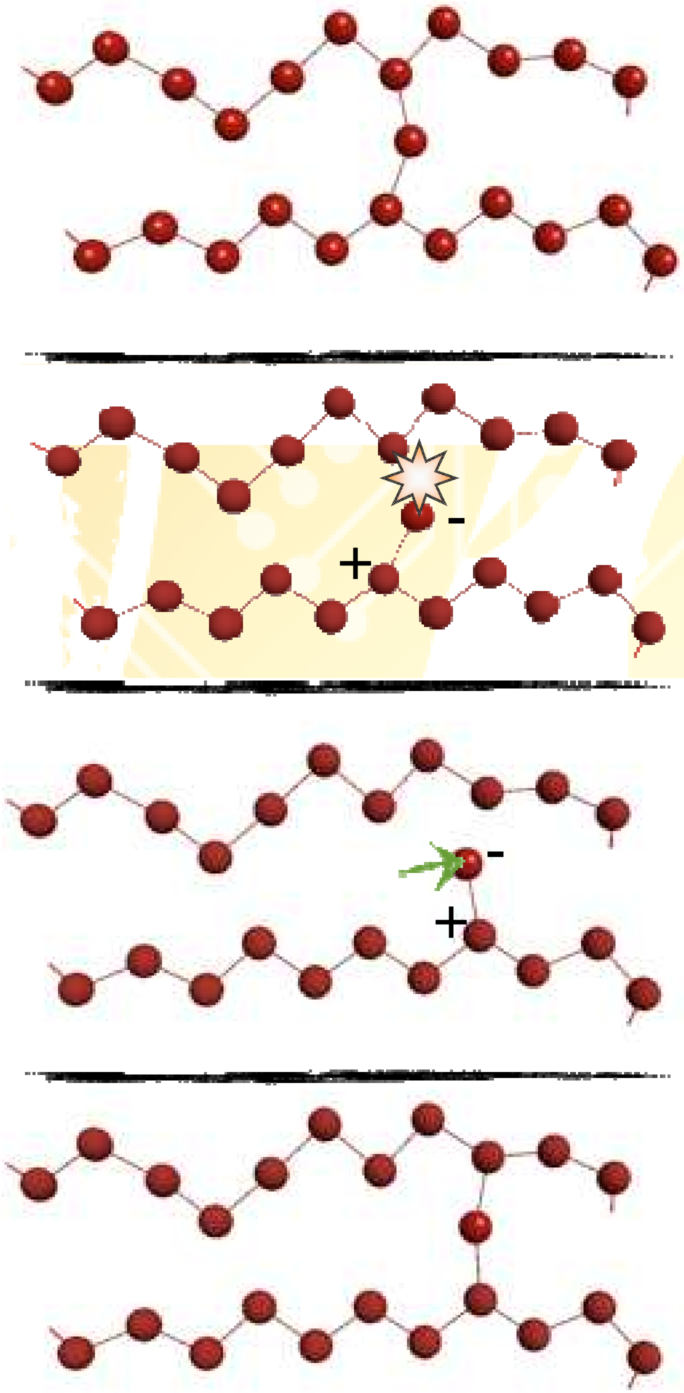


$$\eta = \mu \left(n \frac{Q_s}{N_{atomes}} \right)^{-1}$$

$$\eta = \mu\ \tau$$

PHYSICAL REVIEW B **82**, 134114 (2010)

Photoinduced fluidity in chalcogenide glasses at low and high intensi
A model accounting for photon efficiency



Localized state

Exciton creation: VAP

Fritzsche's model

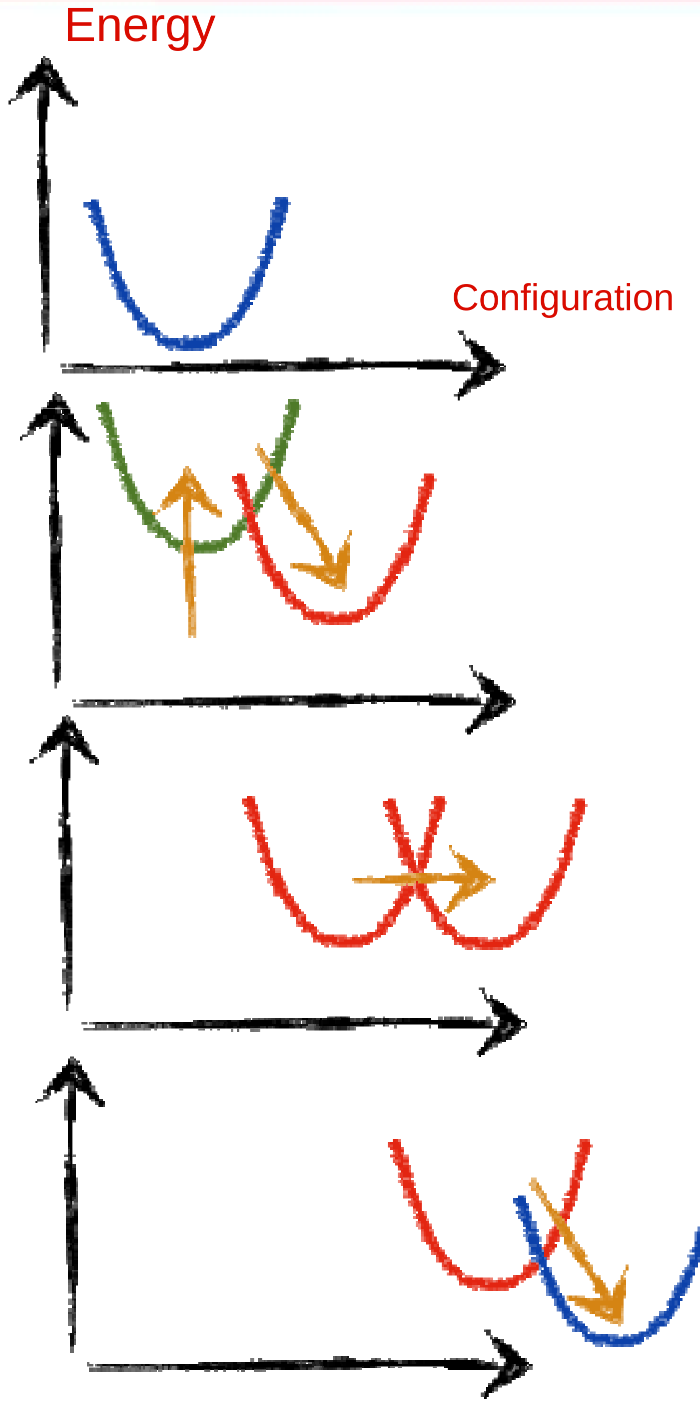
Philos. Mag. B, **1993**, *68*, 561-572

Diffusion

Conell's model

Physical Review B, **1981**, *24*, 4560-4565

Recombination



Irradiation induces creations of photoinduced metastabl

- Photoinduced viscosity changes

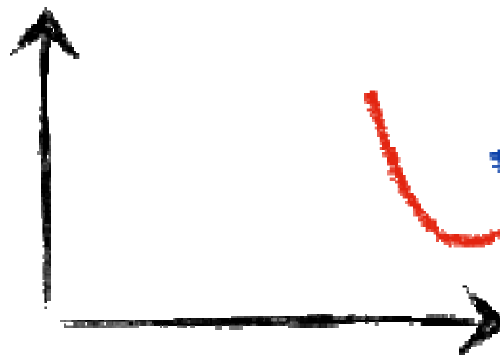
Photoageing produced by photorelaxation

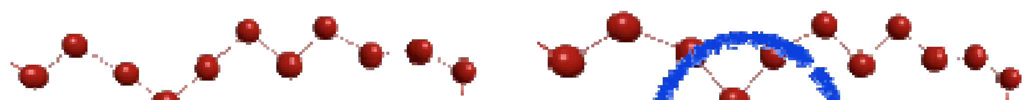
Photoinduced defe
mobility
(photofluidity)

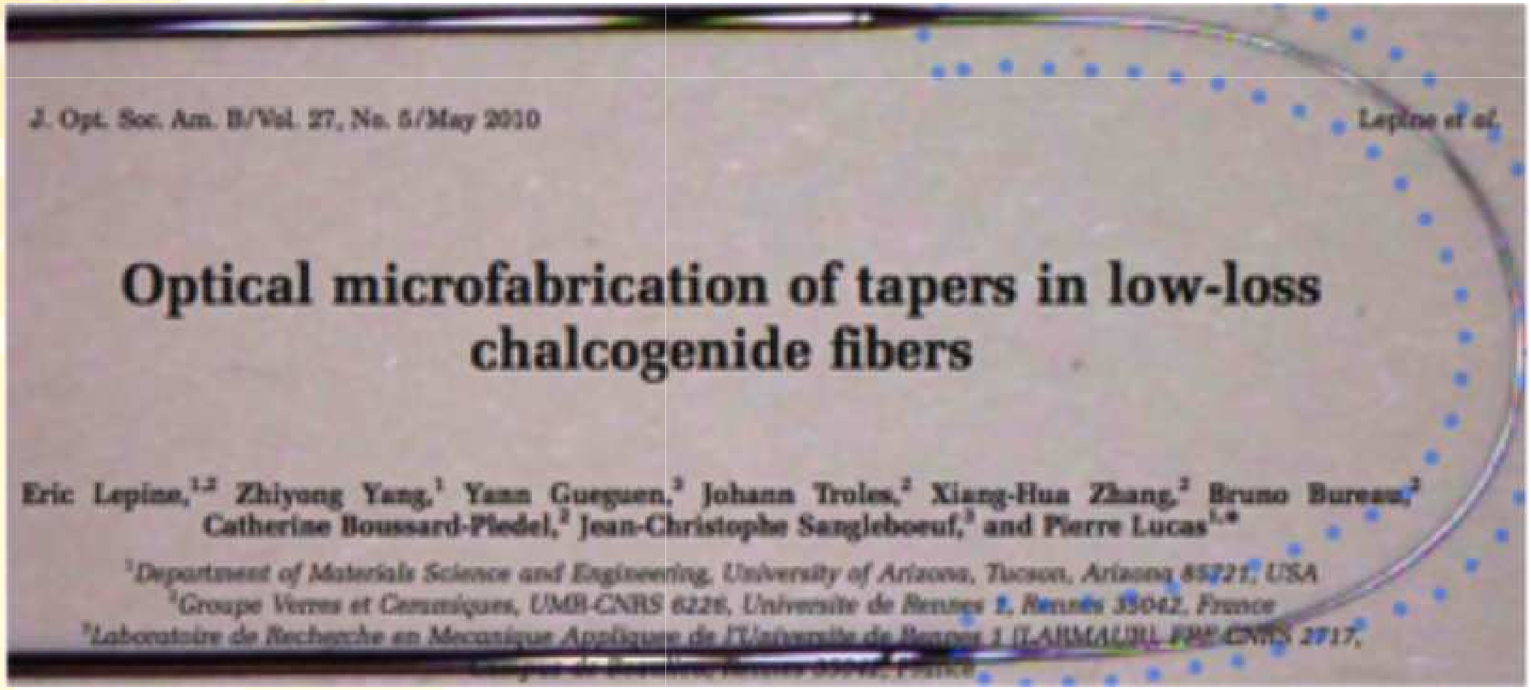
- should dominate at h
fluence

Photoexcitation disorder due to defects creations

Photorelaxation defects mobility







- Photoinduced glass-forming
- Photoageing: are other mechanical properties sensitive to ligh
- Can giant photoinduced effects be explained by photofluidity?

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QuickTime™ et un décompresseur sont requis pour visionner cette image.

QuickTime™ et un décompresseur sont requis pour visionner cette image.

Arizona Material Lab
Tucson, Arizona

Glass and Ceramic Team
University of Rennes
UMR 6226