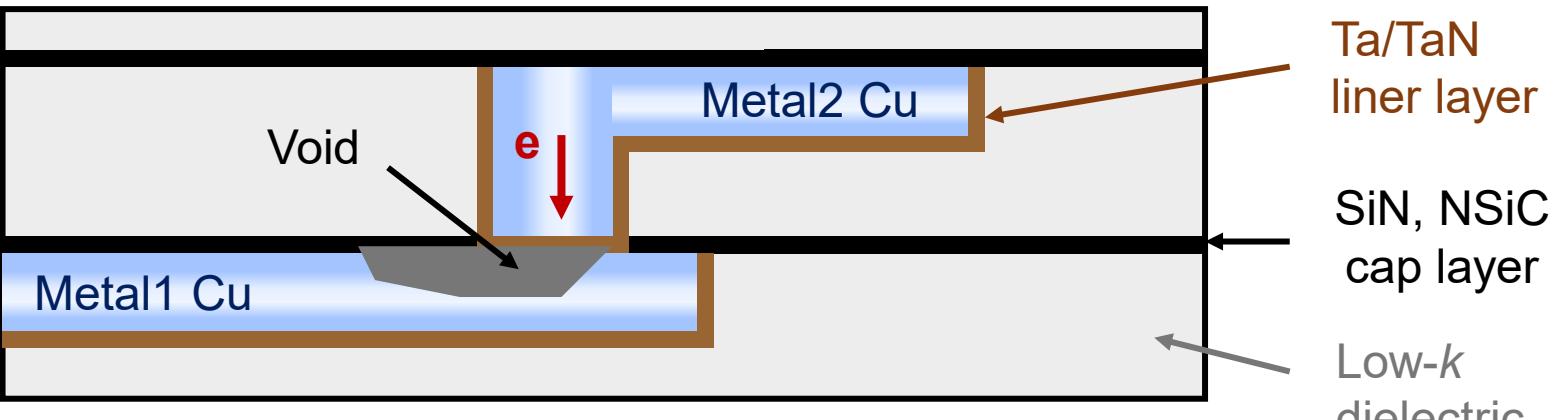
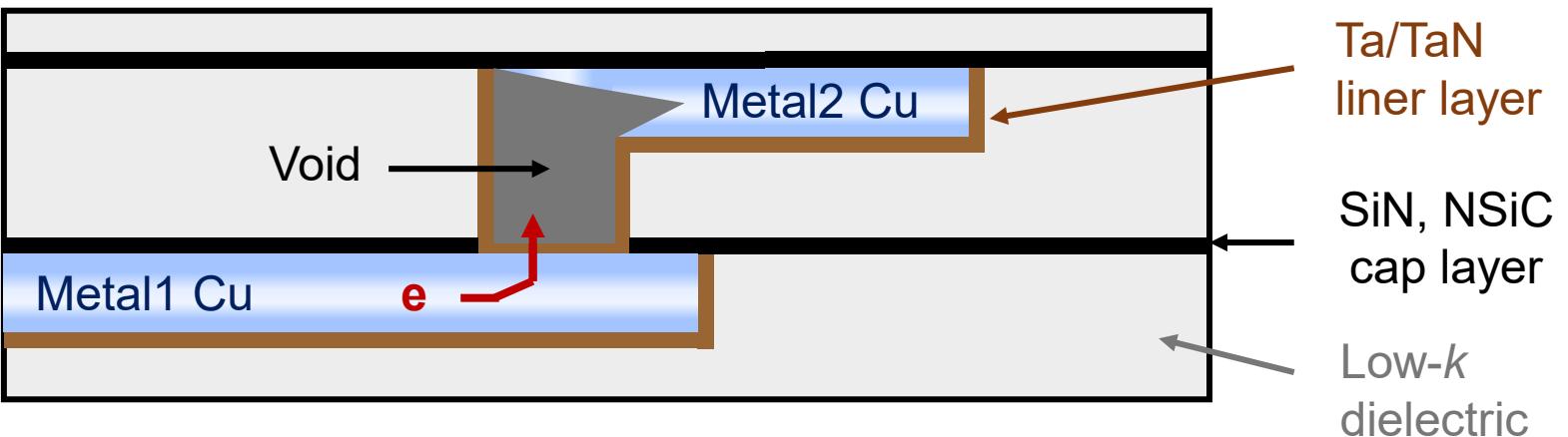
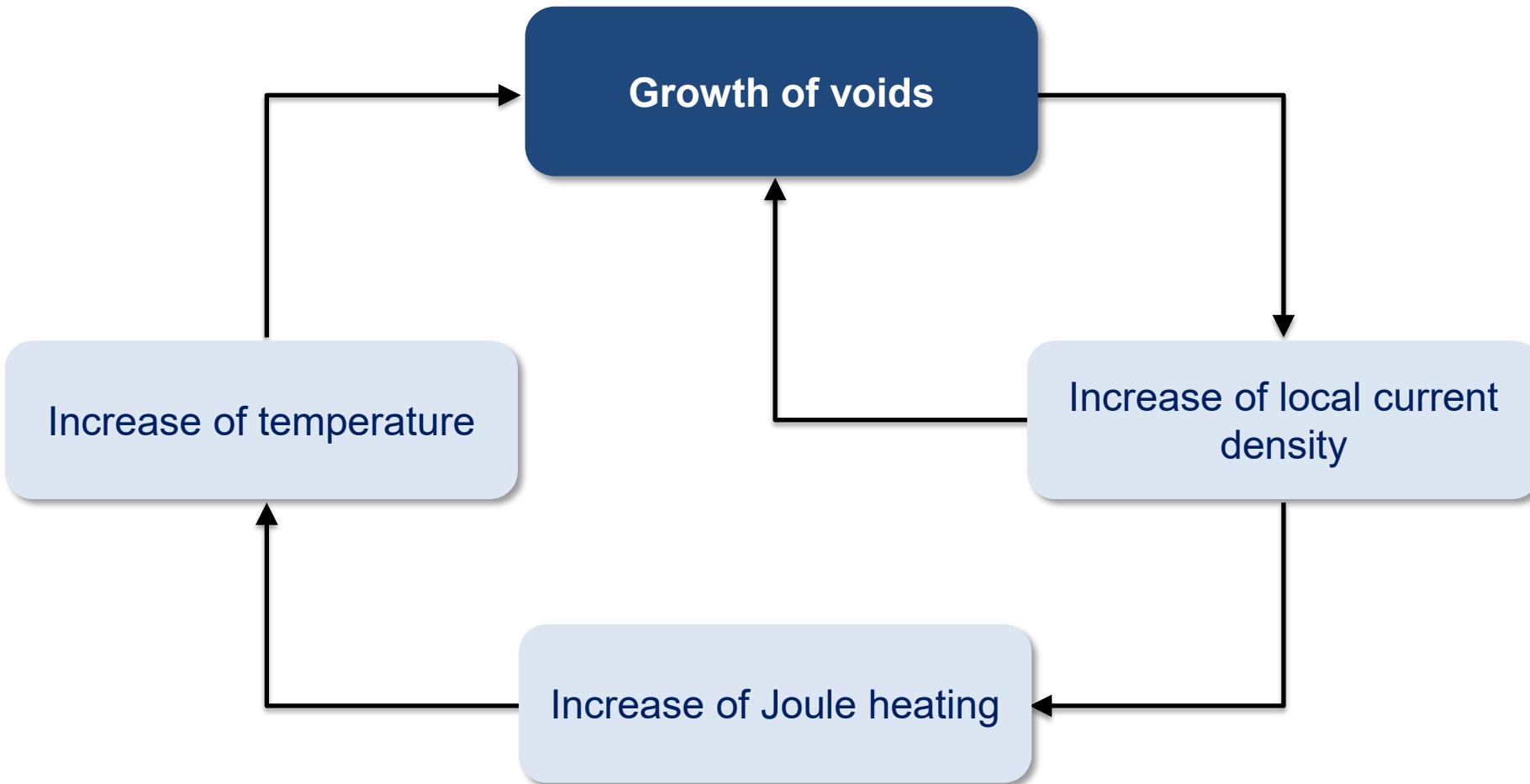


## Line Depletion

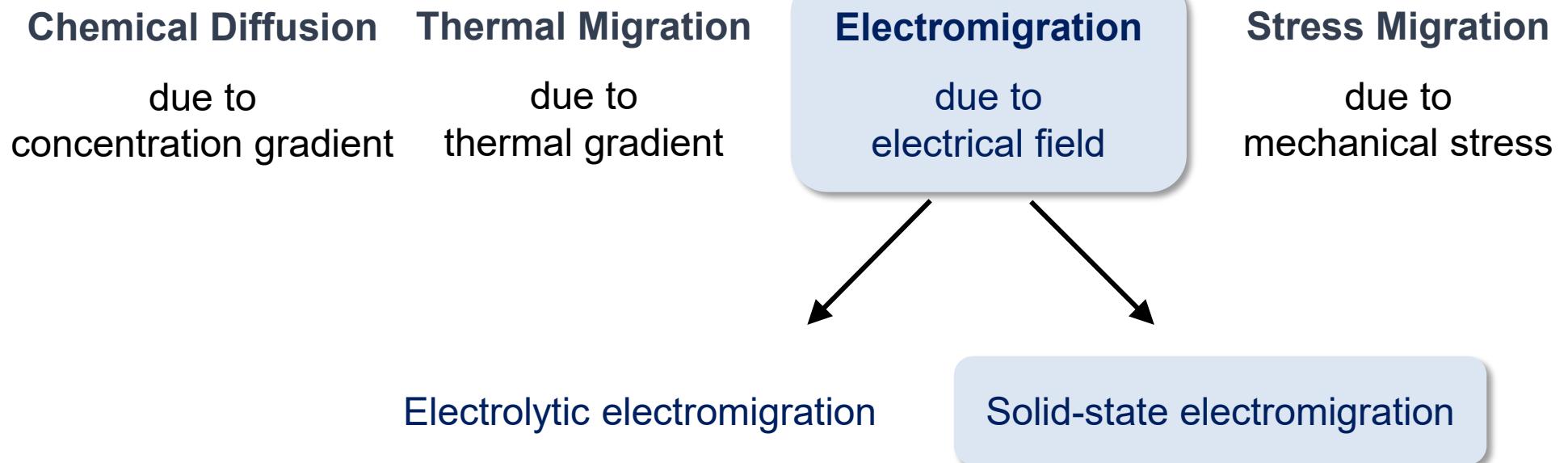


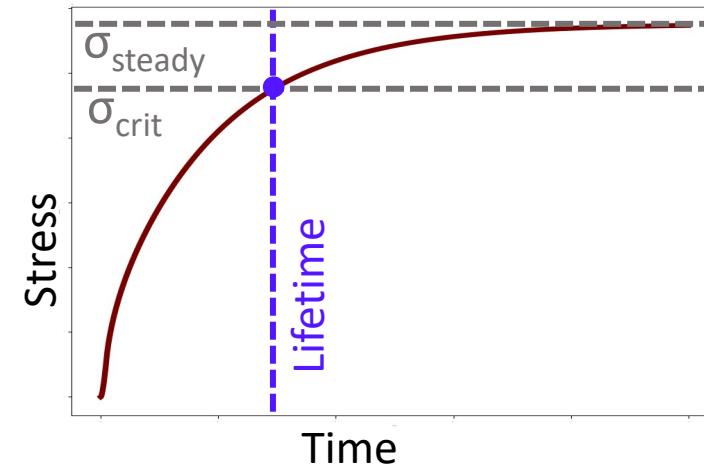
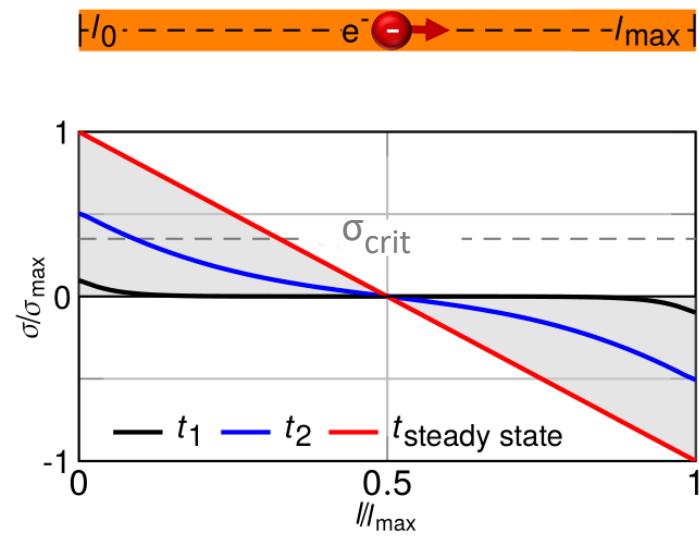
## Via Depletion

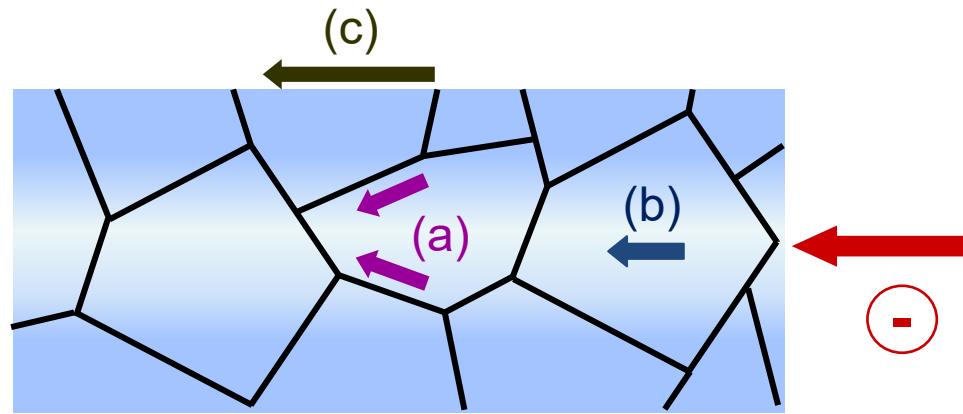


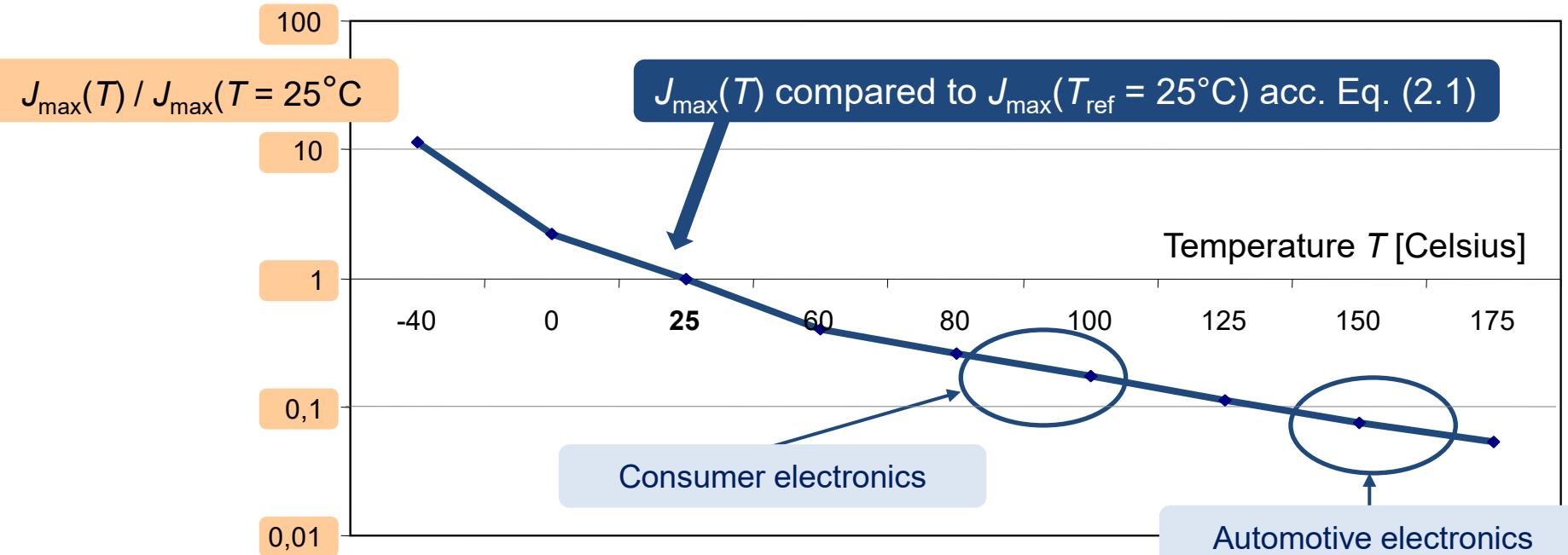


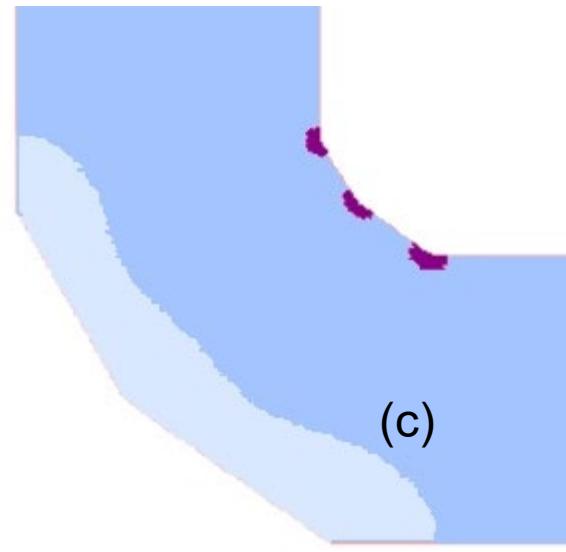
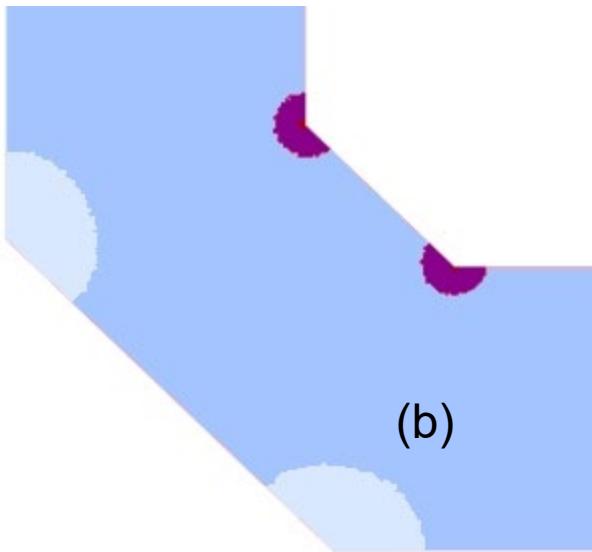
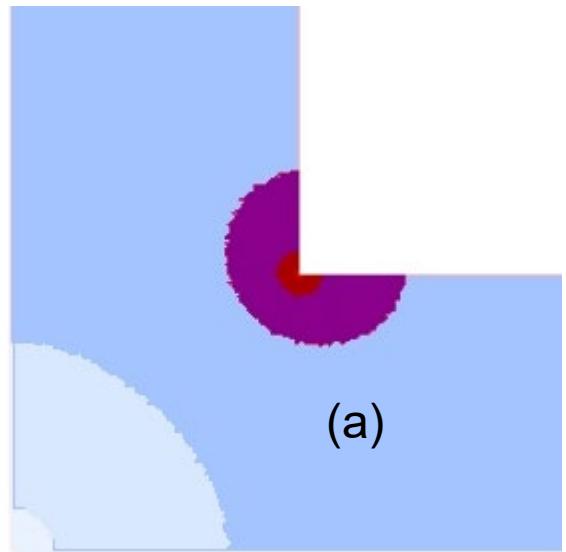
## Migration in Solid-State Materials











Current density



Min.

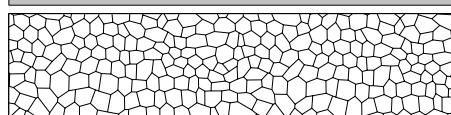
Max.

Amorphous



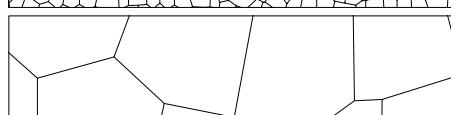
No crystal lattice or grain boundaries

Polycrystalline



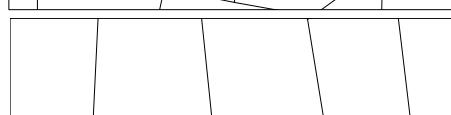
Grain boundaries dominate

Near-bamboo



Featuring both crystal lattice and grain boundaries

Bamboo



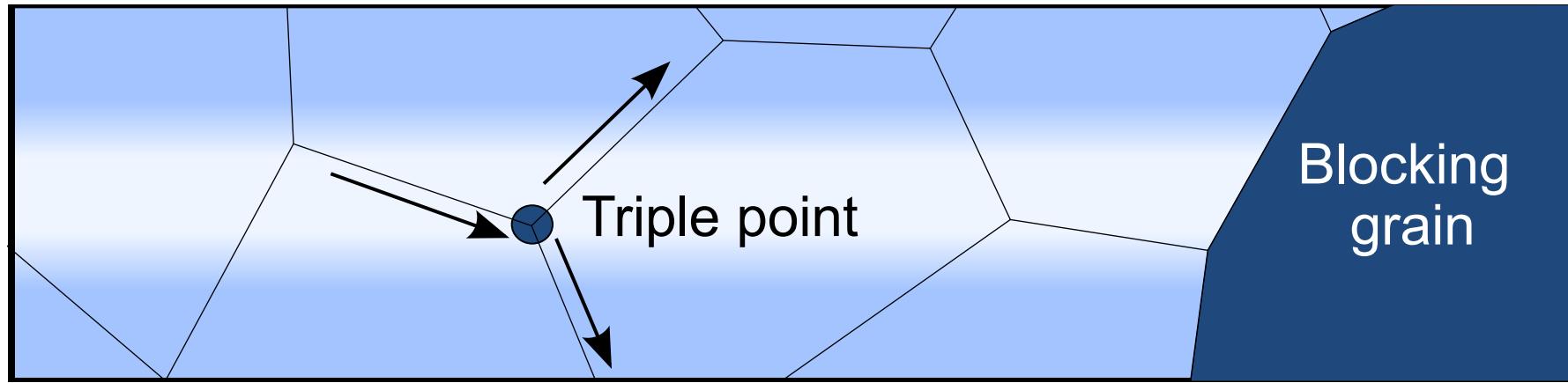
Crystall lattice dominates

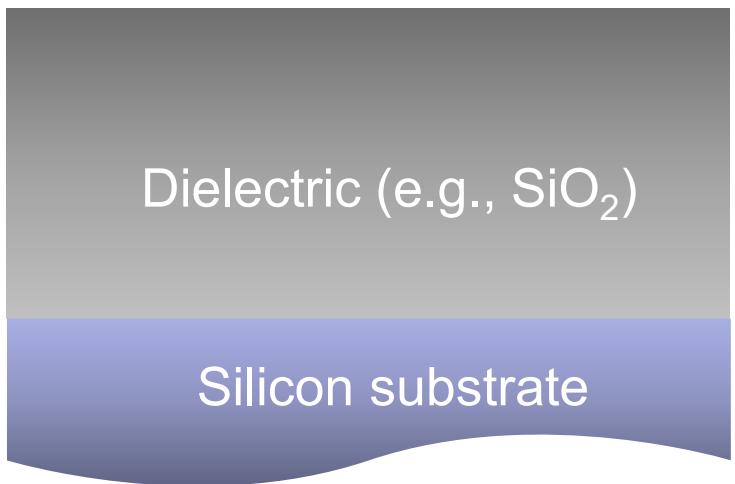
Monocrystalline



Crystall lattice and lattice defects define characteristics

Diffusion process	Activation energy in eV	
	Aluminum	Copper
Bulk diffusion	1.2	2.3
Grain-boundary diffusion	0.7	1.2
Surface diffusion	0.8	0.8

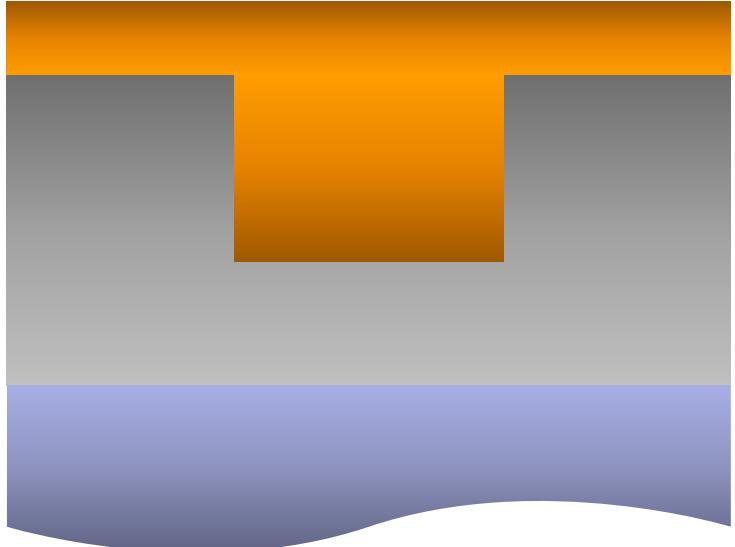




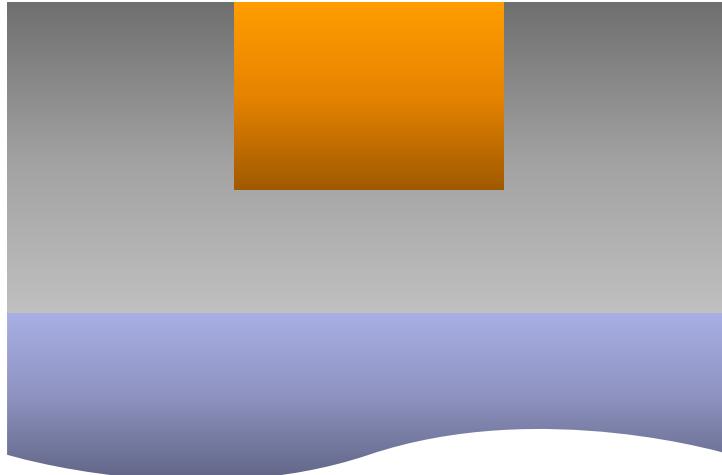
(a) Dielectric deposition



(b) Trench etching



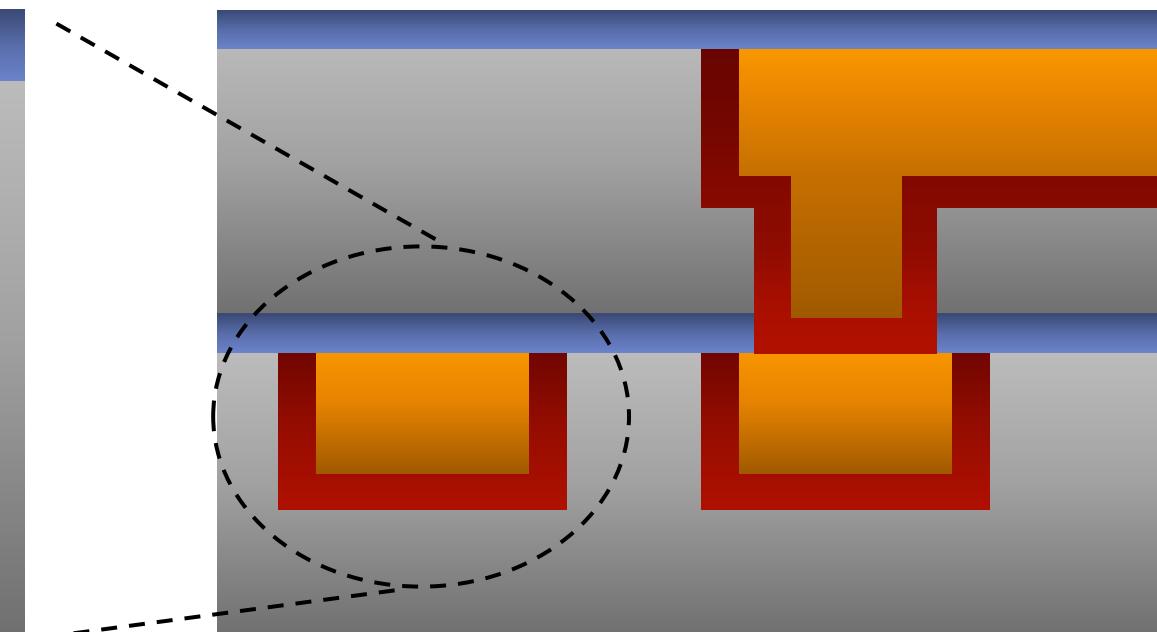
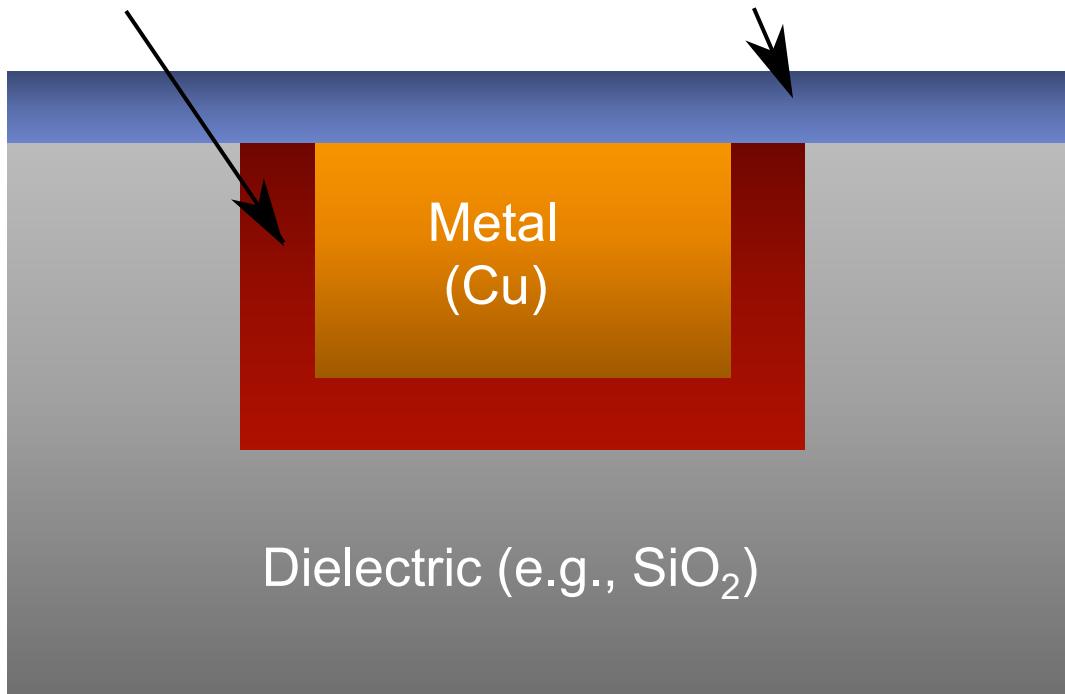
(c) Metal deposition



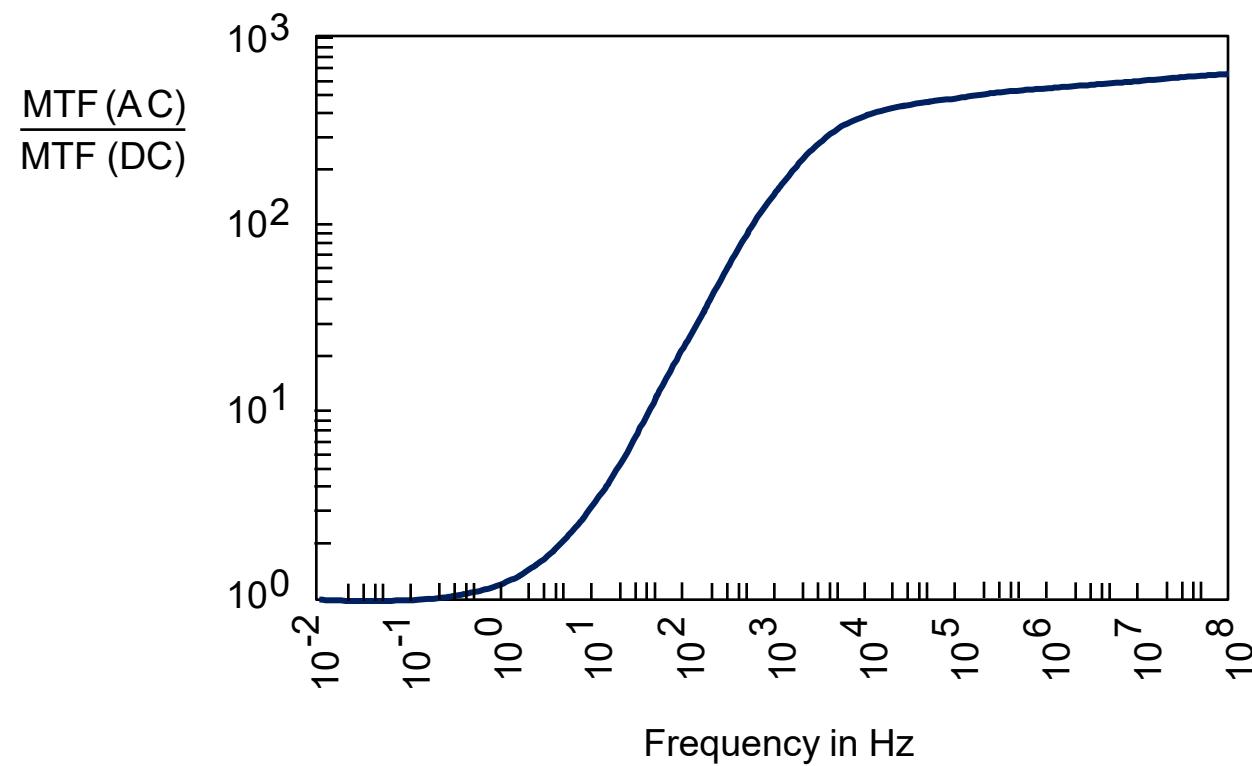
(d) Metal removal

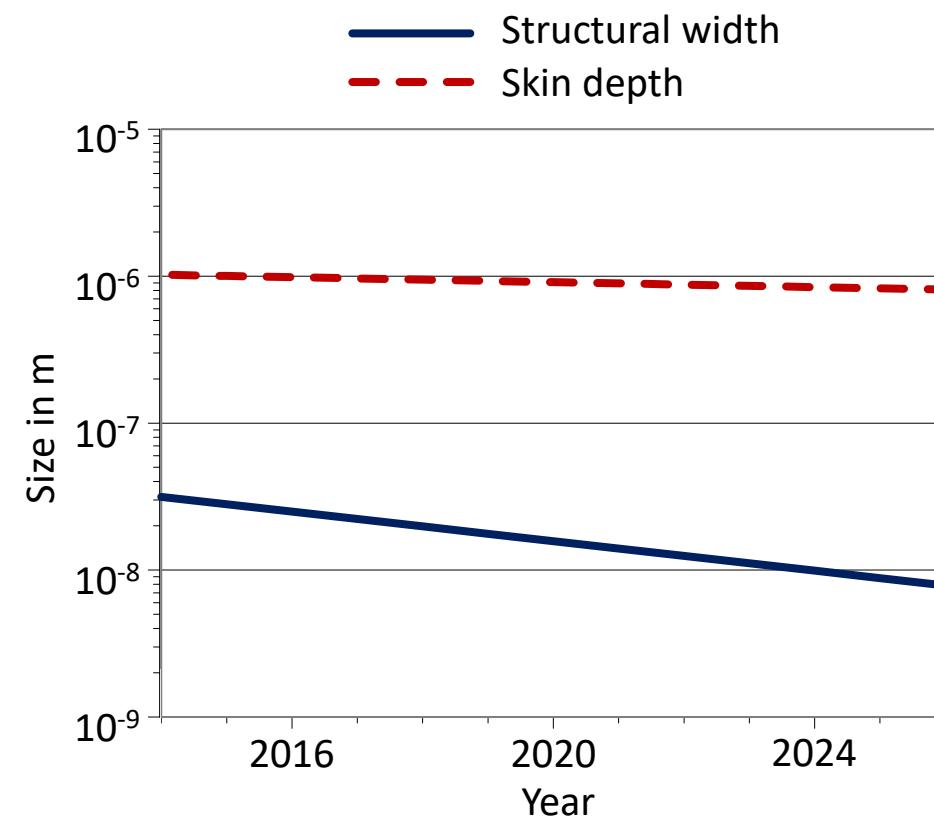
Diffusion barrier  
Metal liner

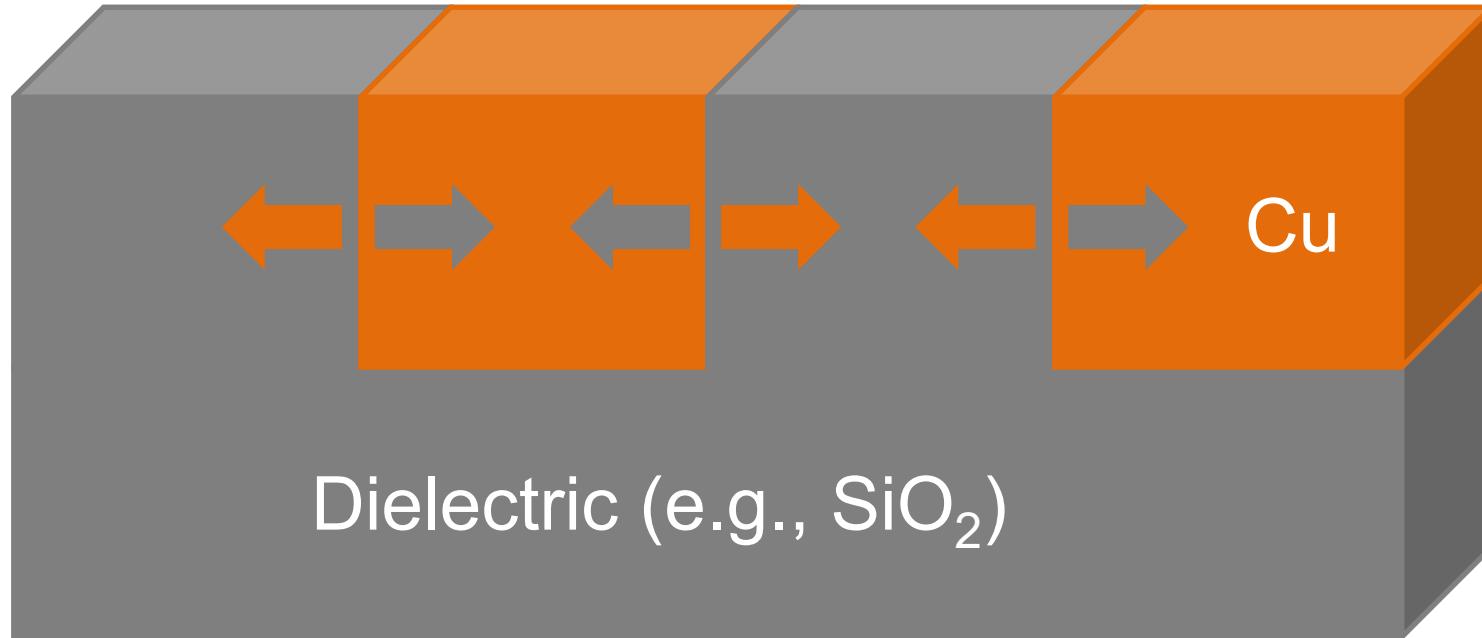
Surface coating  
Dielectric cap

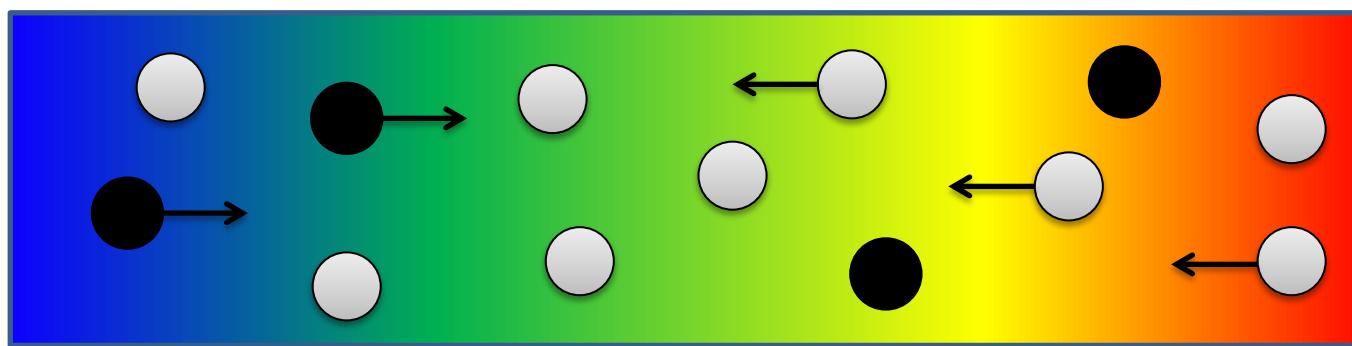
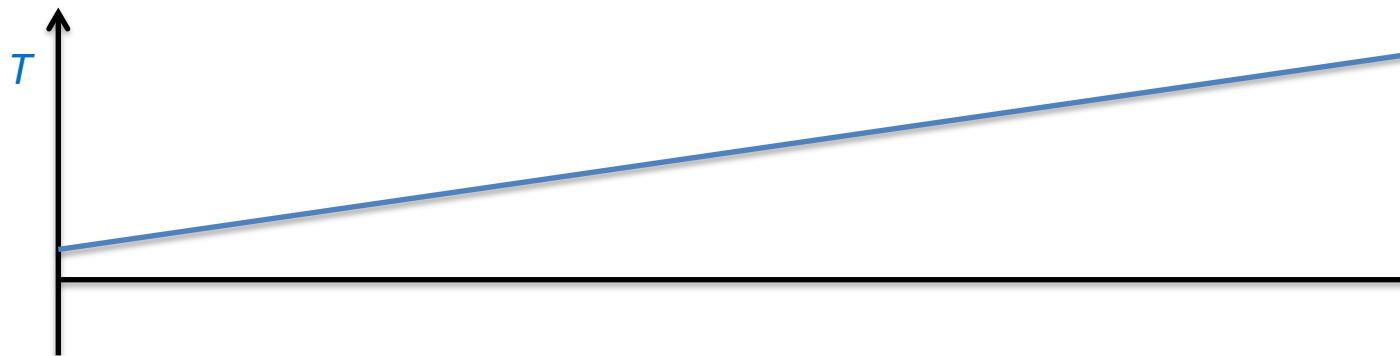


Example	Frequency
Controlling the background lighting for a computer screen	10 mHz
Frame rate on a PC monitor	60 Hz
Sampling frequency for audio signals	44 kHz
Carrier frequency for radio frequency identification (RFID)	13.56 MHz
Processor clock frequency	3 GHz



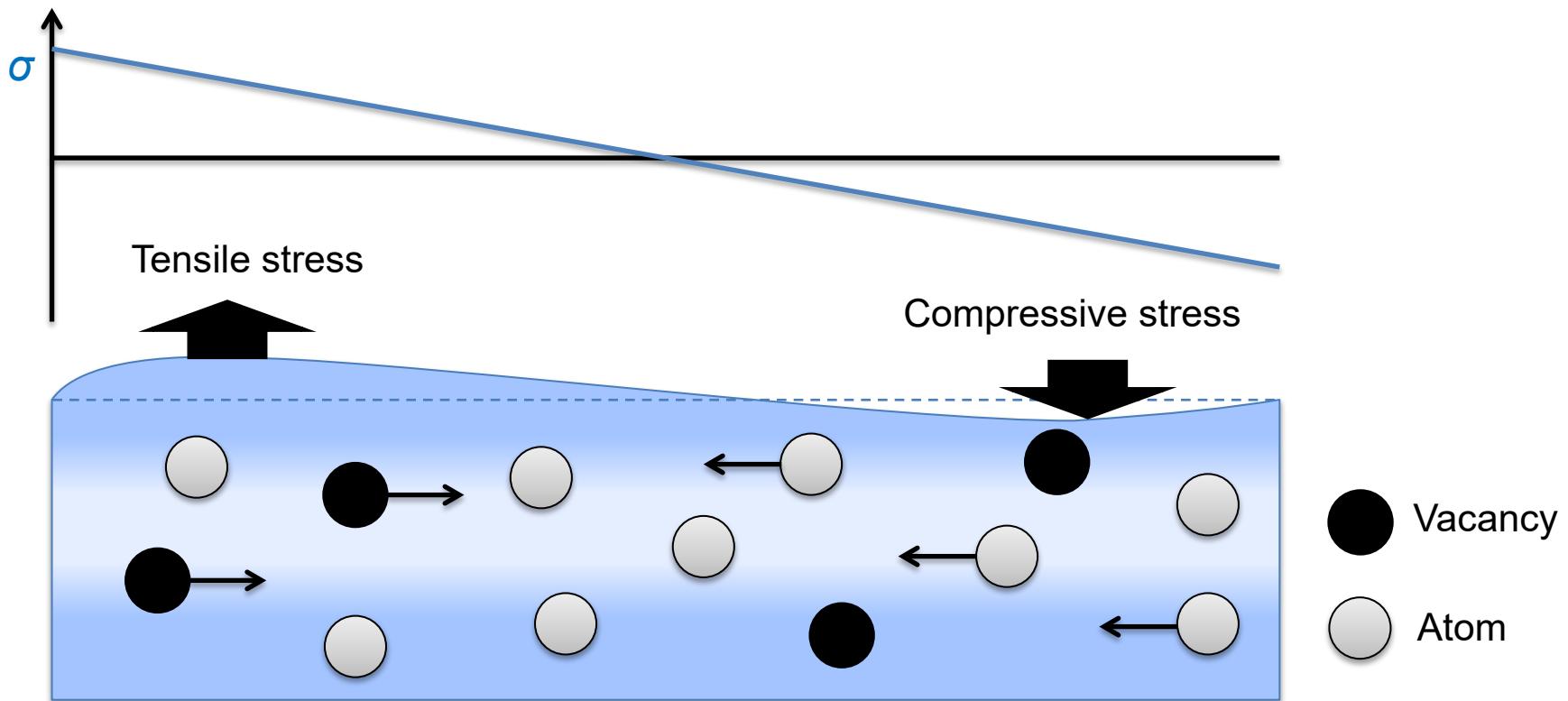


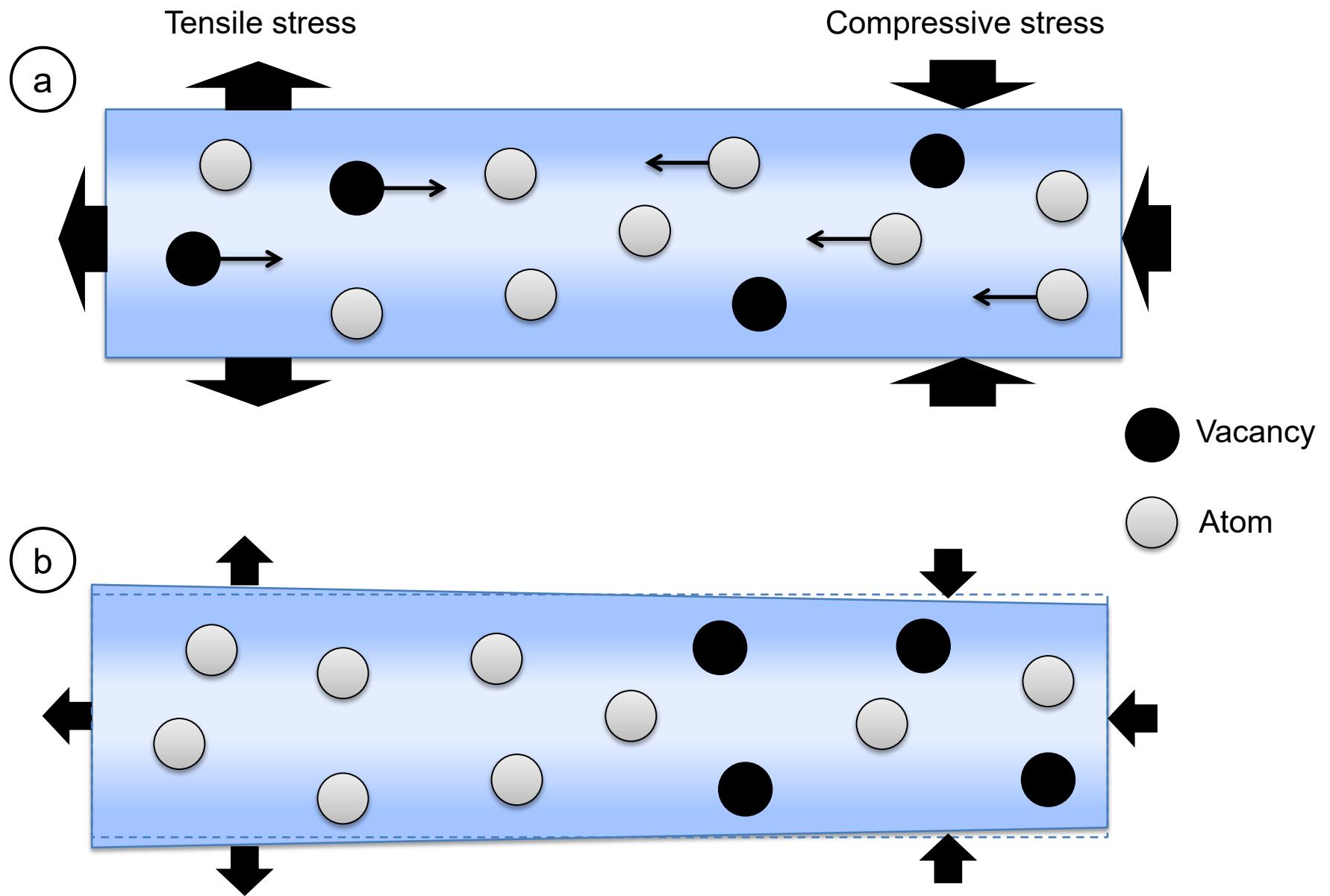


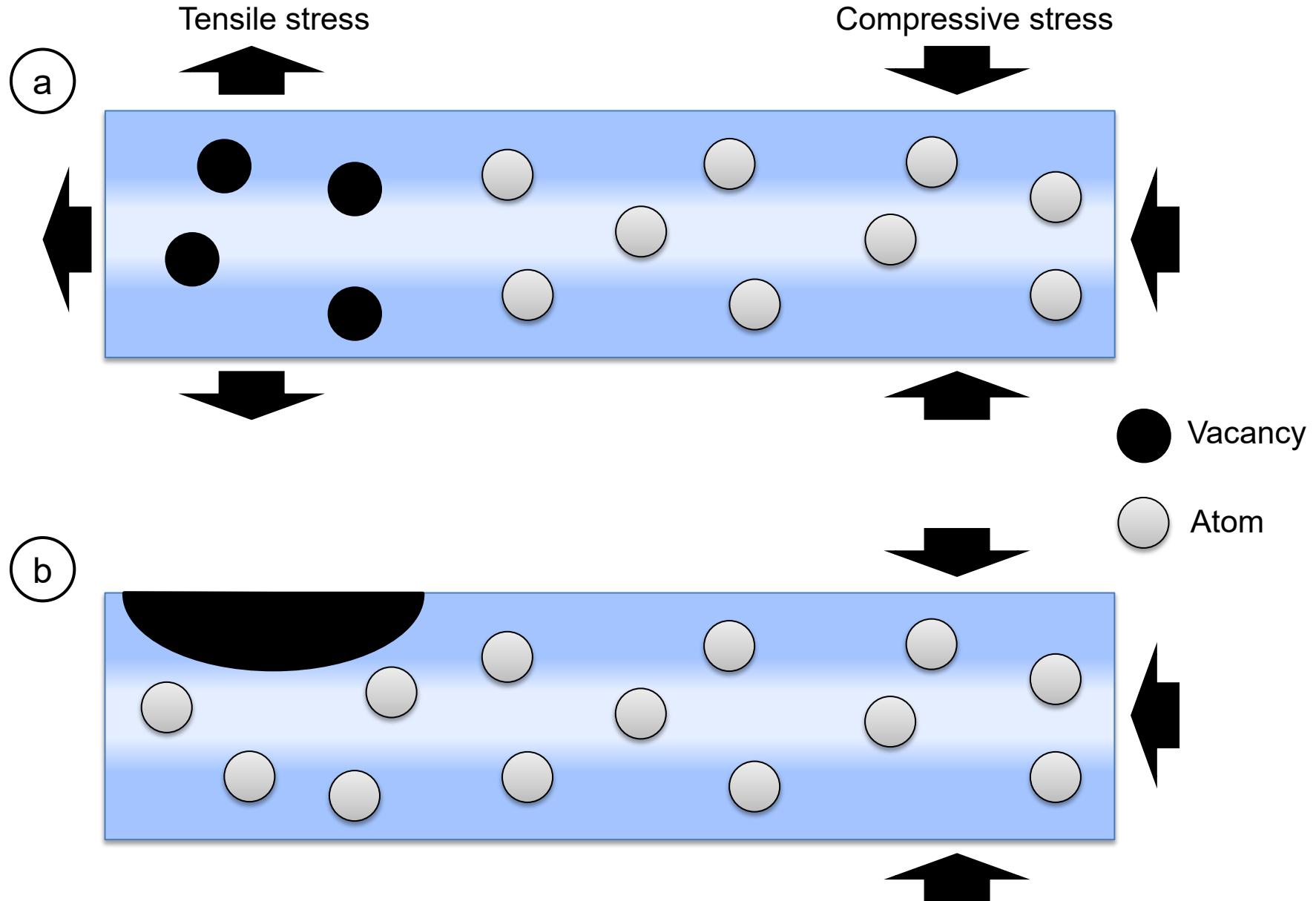


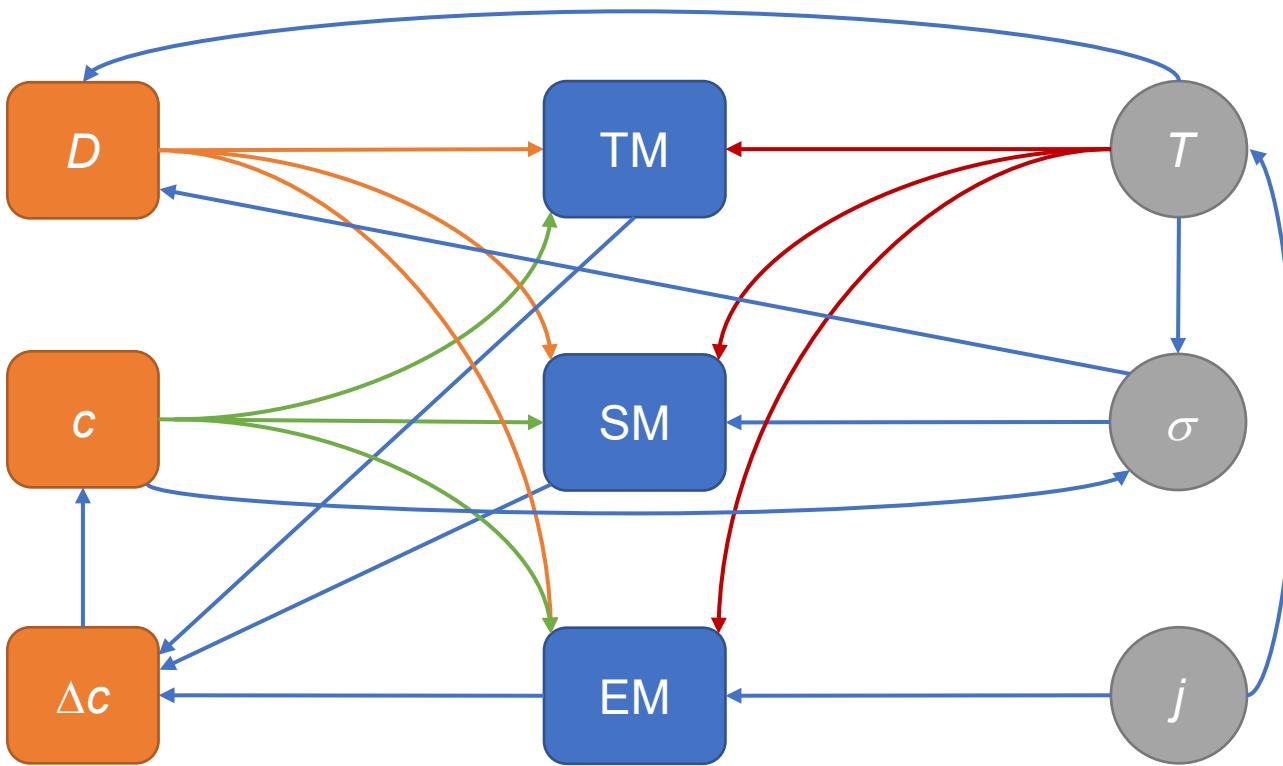
● Vacancy

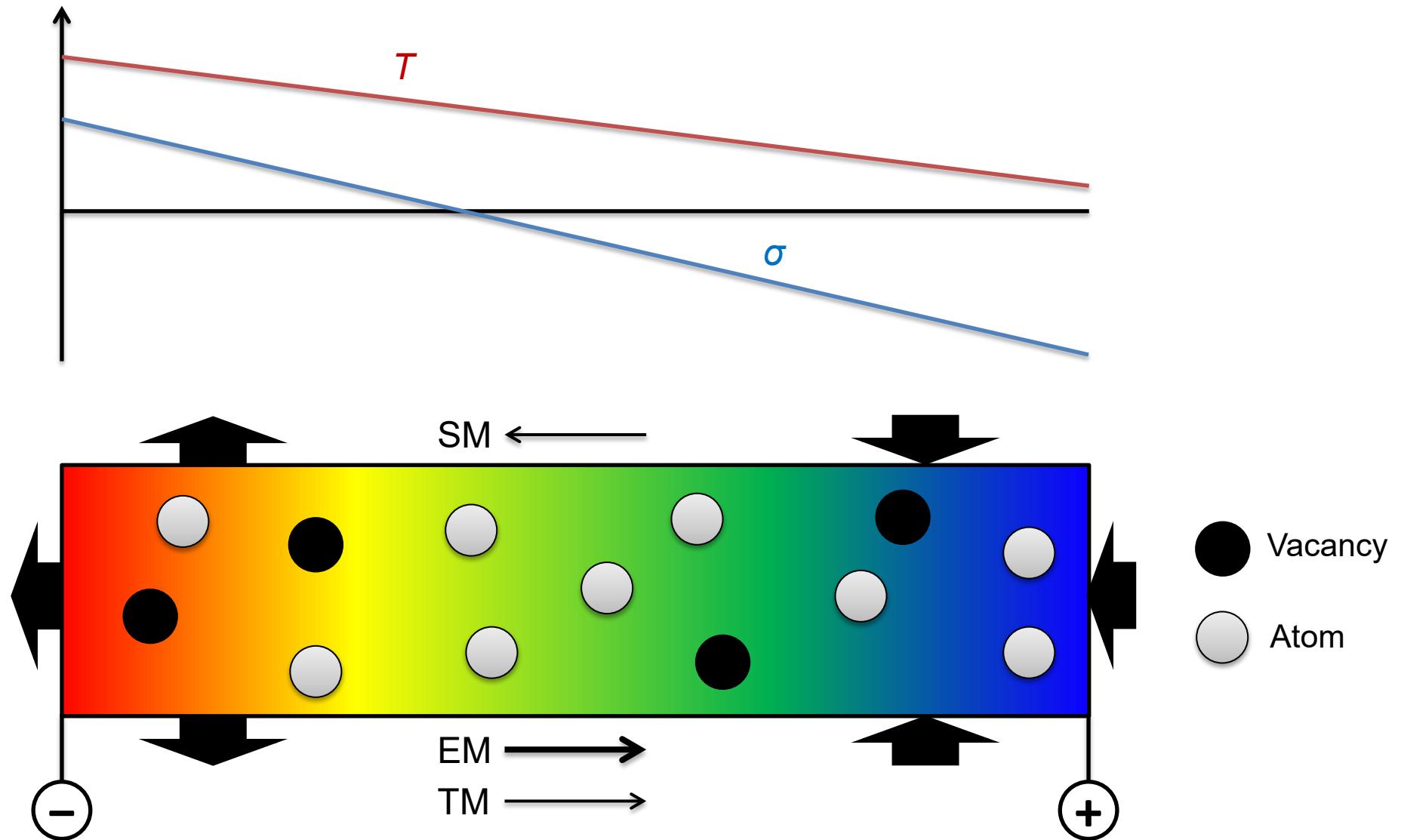
○ Atom

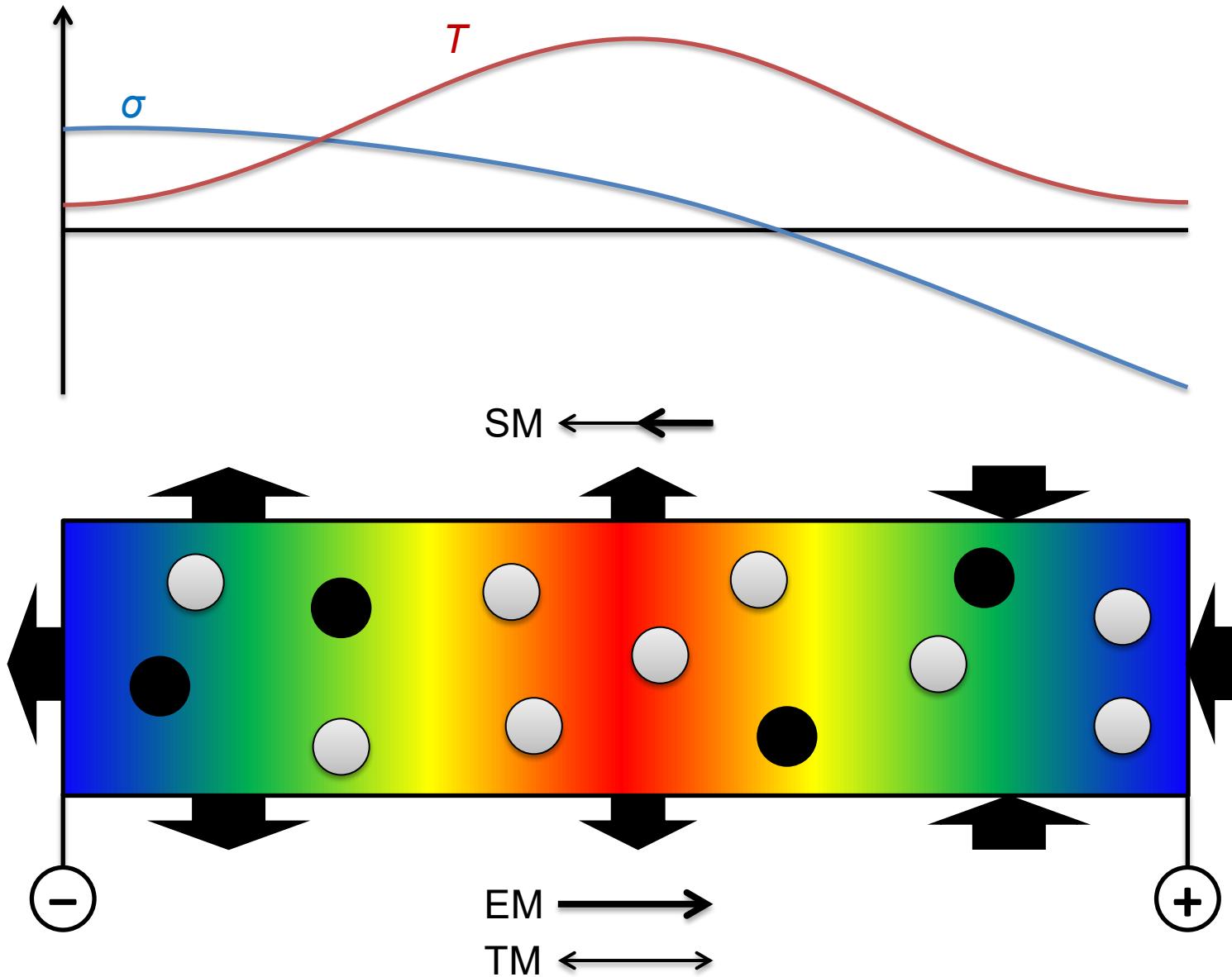


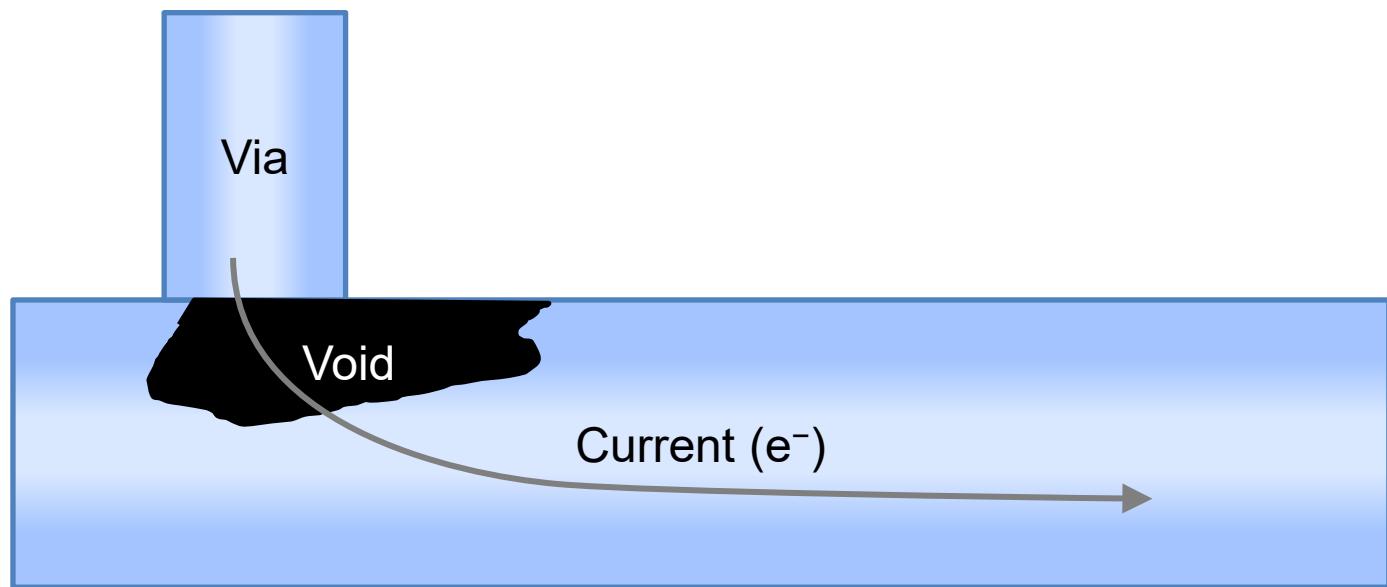


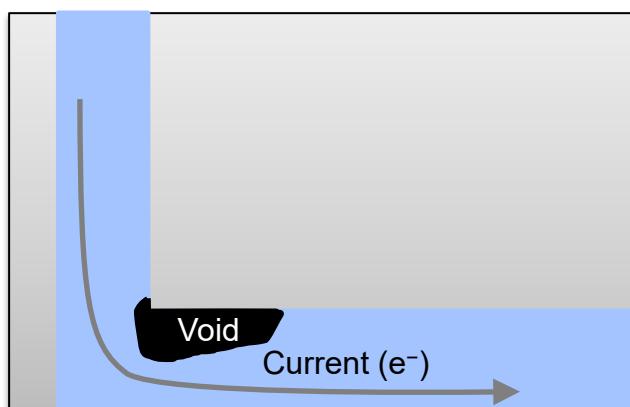




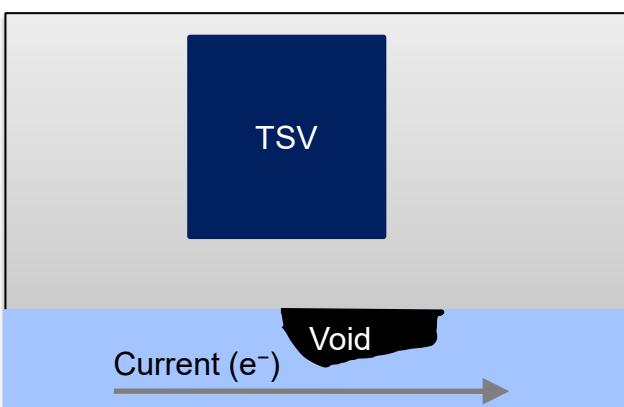




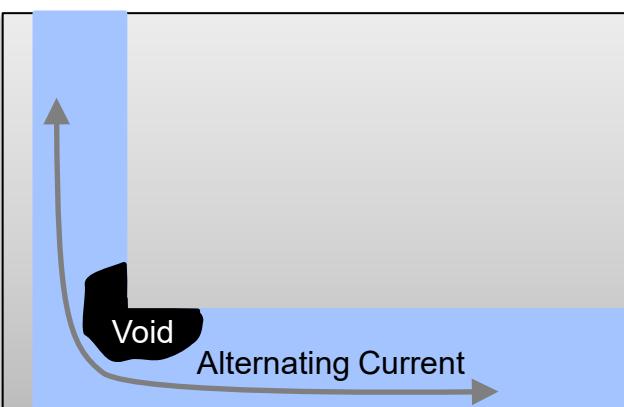




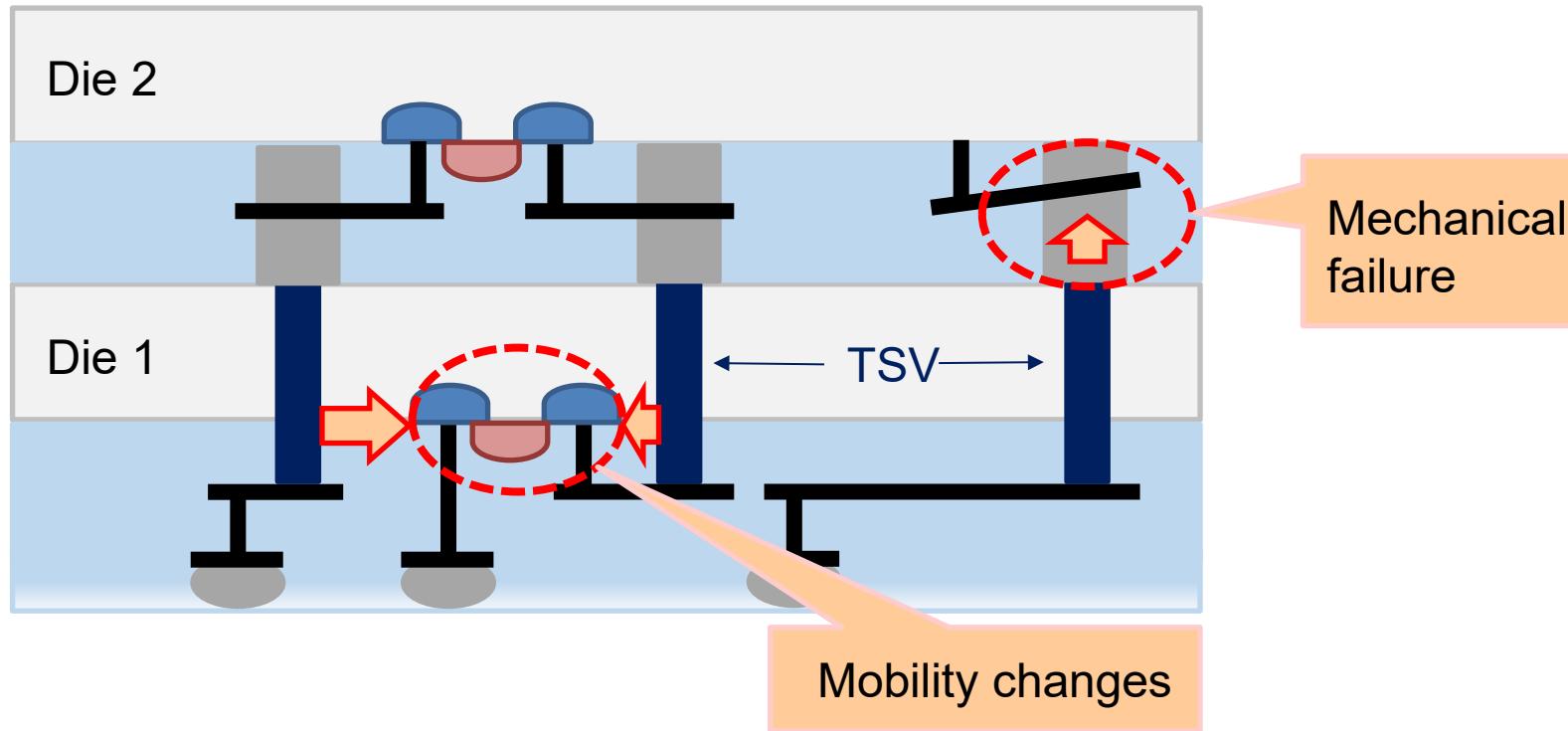
a



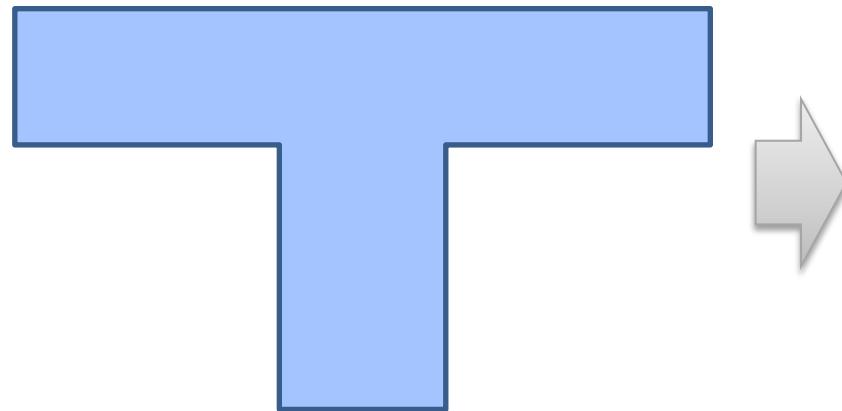
b



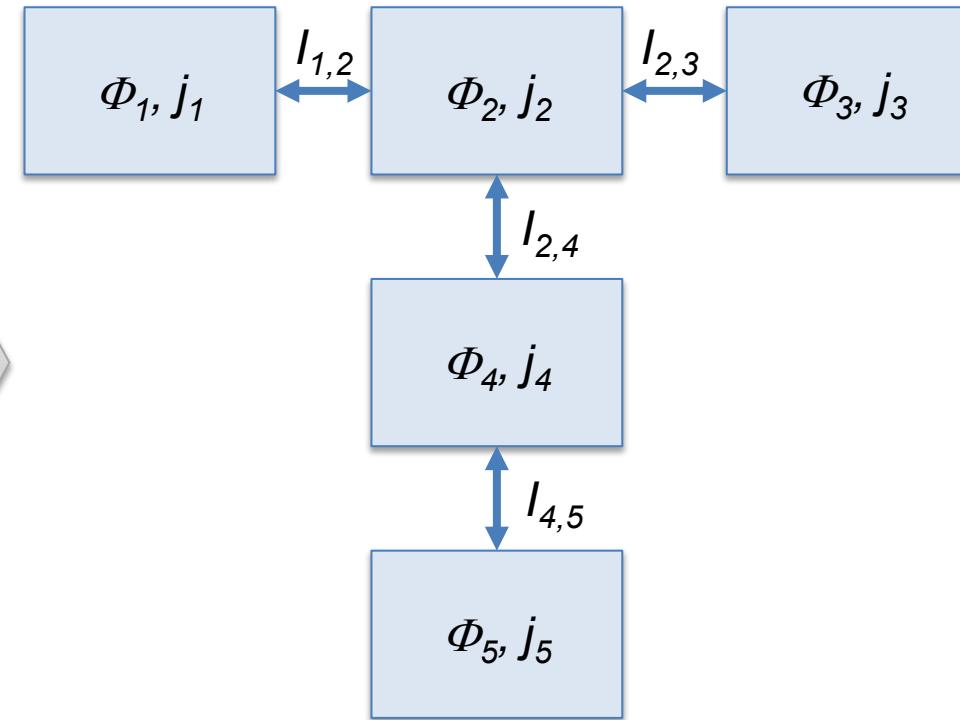
c



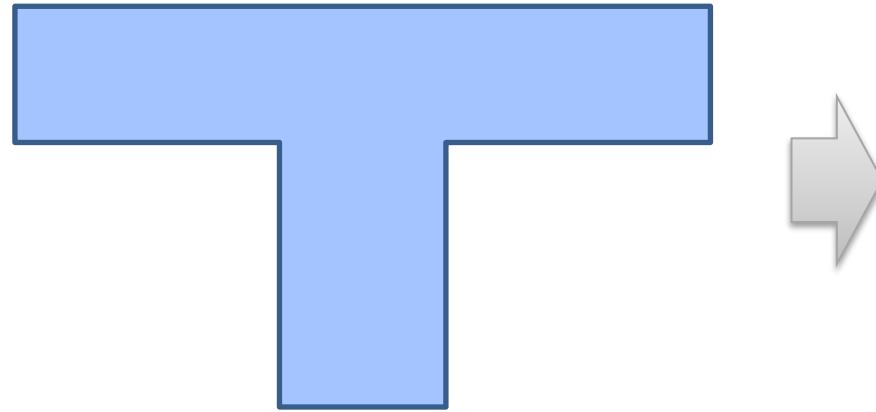
Layout



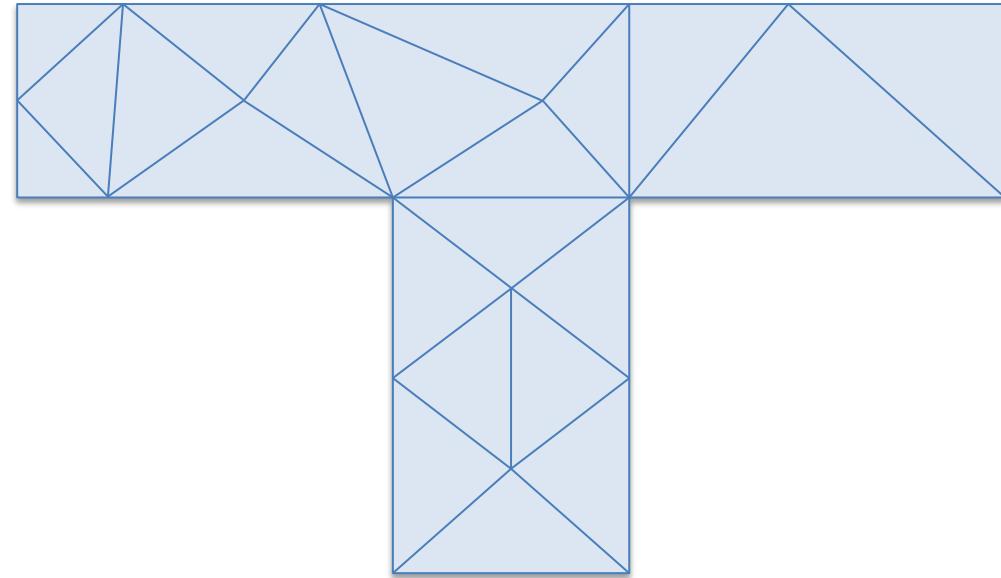
Model

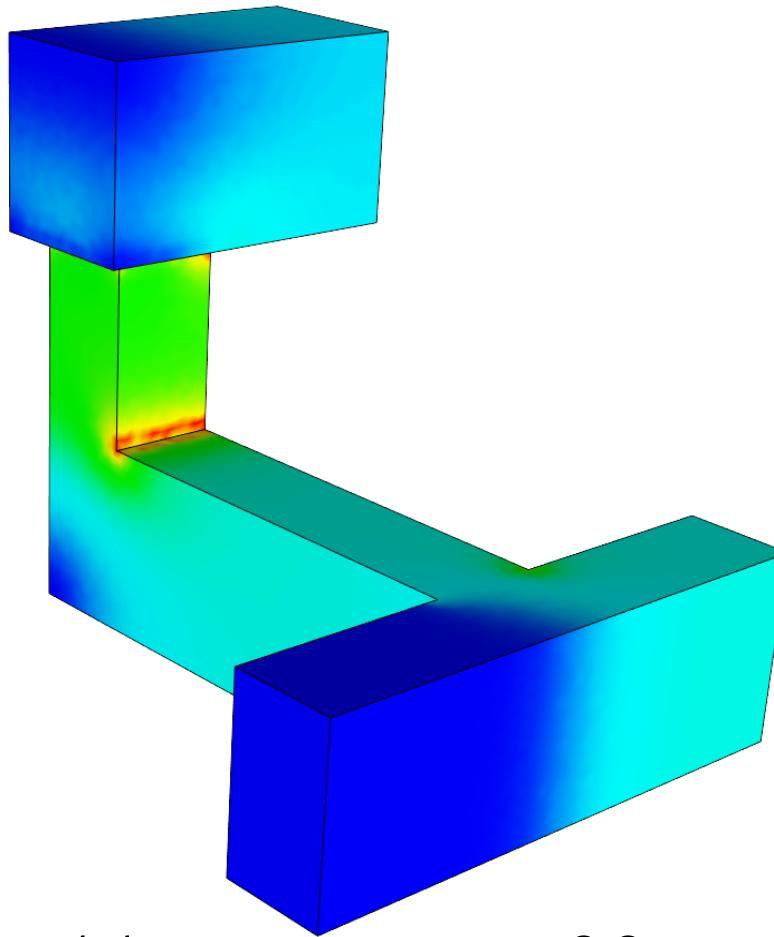


Layout



Model





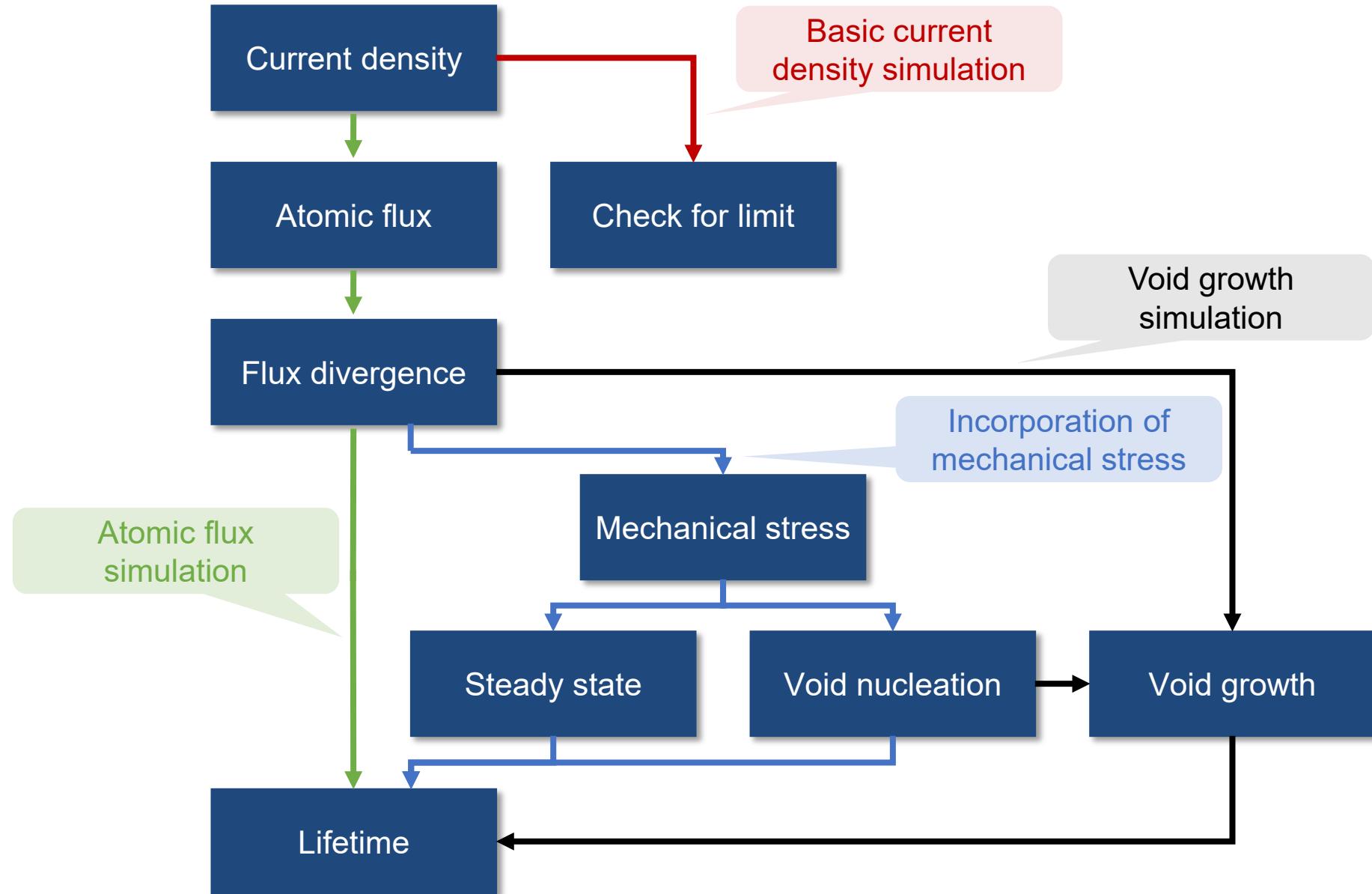
0

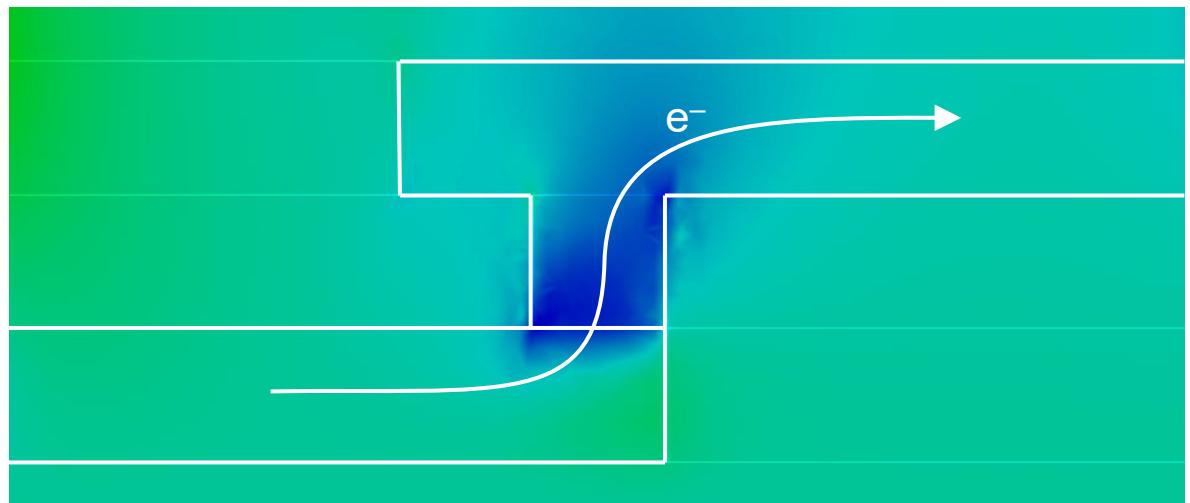
1.1

2.2

3.3

$j / j_0$





-1.0

0

1.0

$\Delta J / \Delta J_{\max}$

