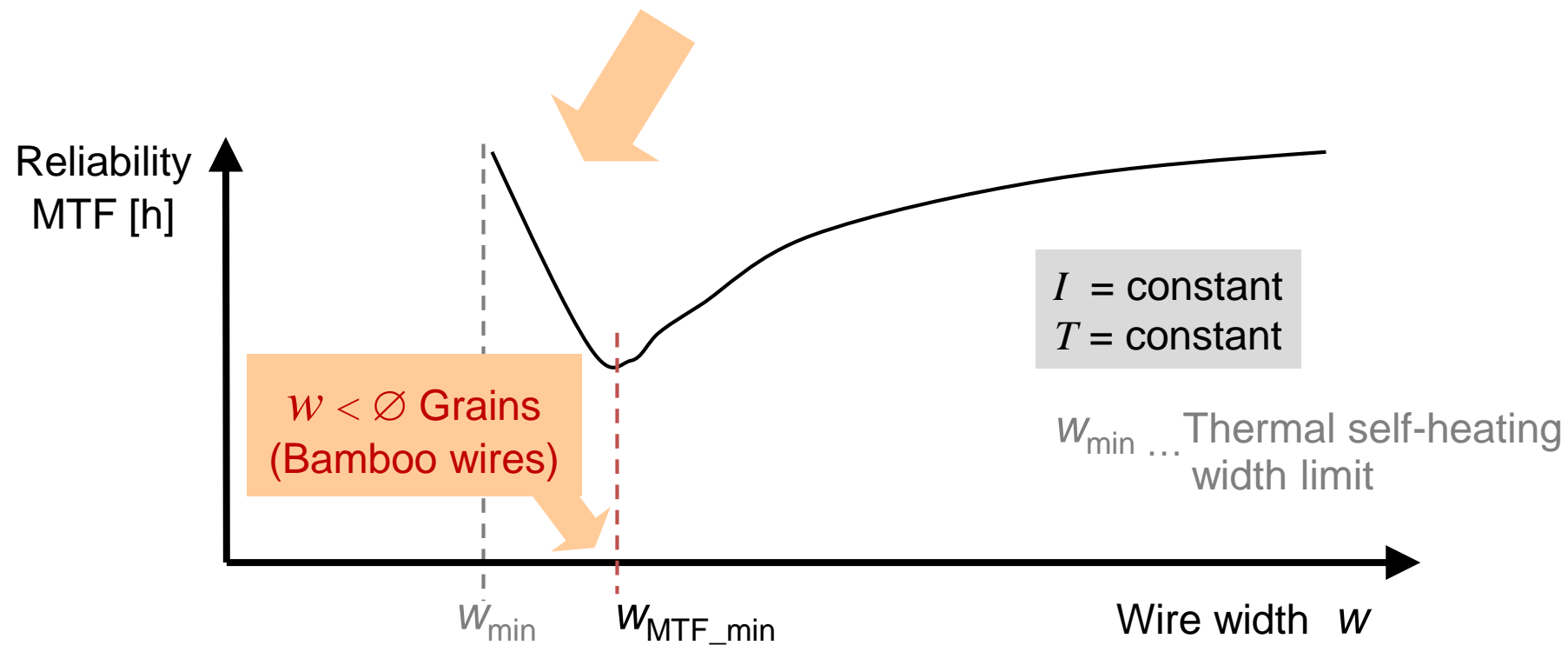
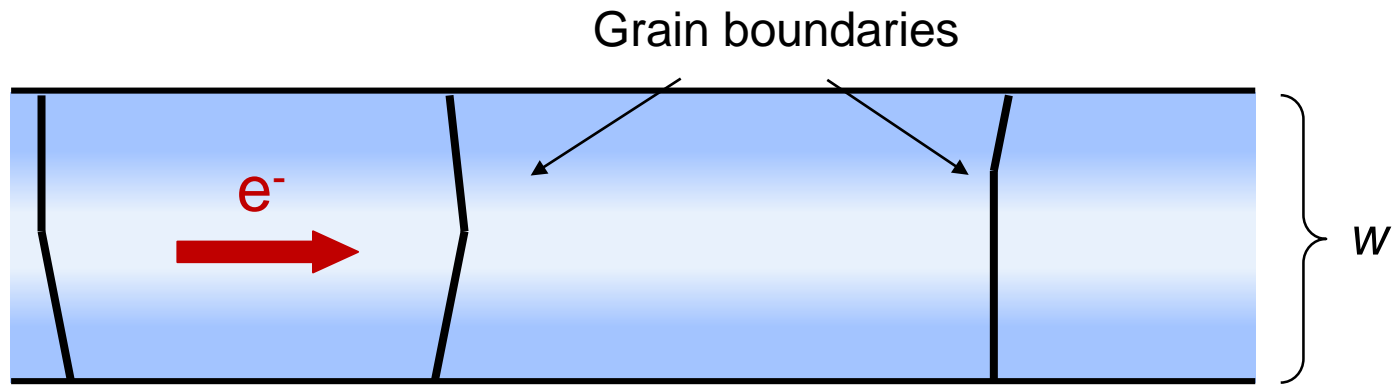
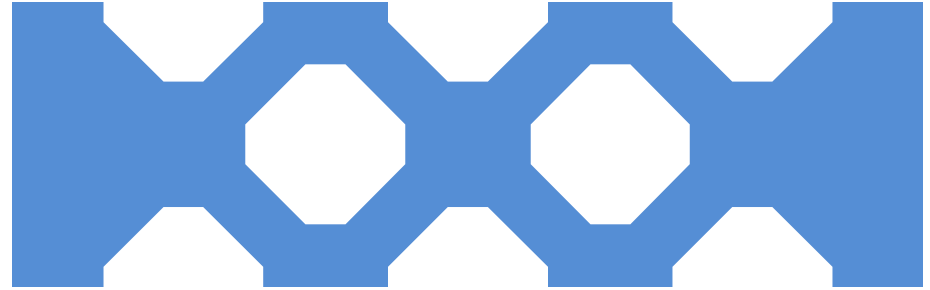
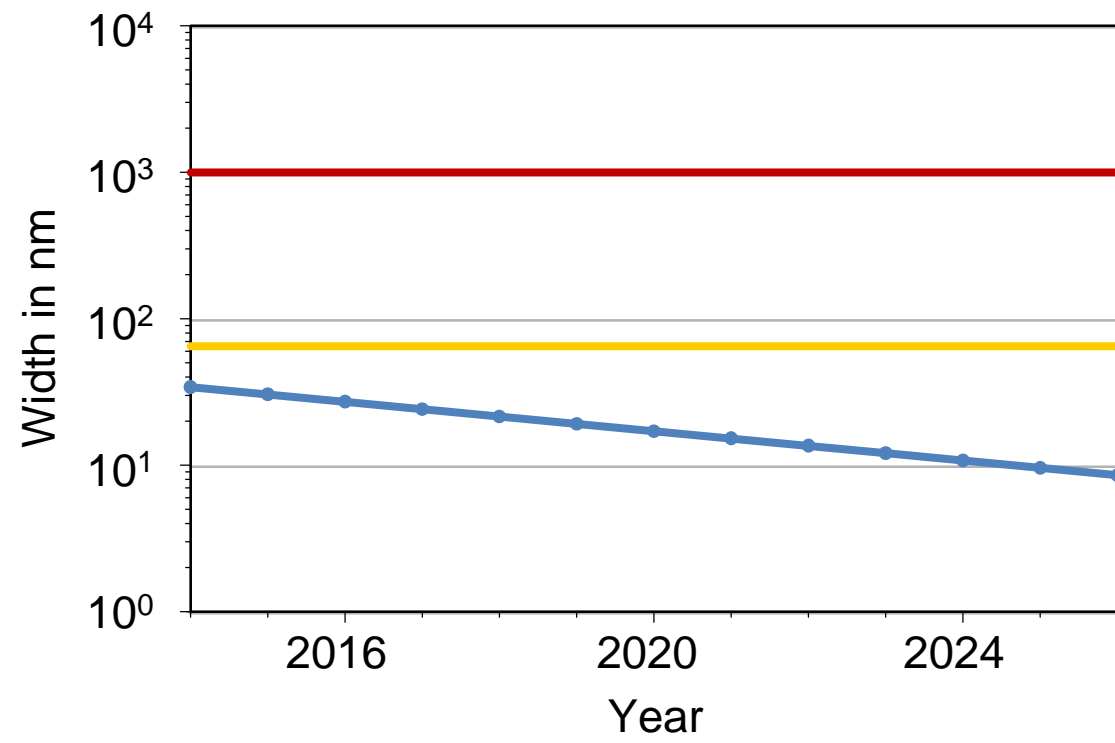


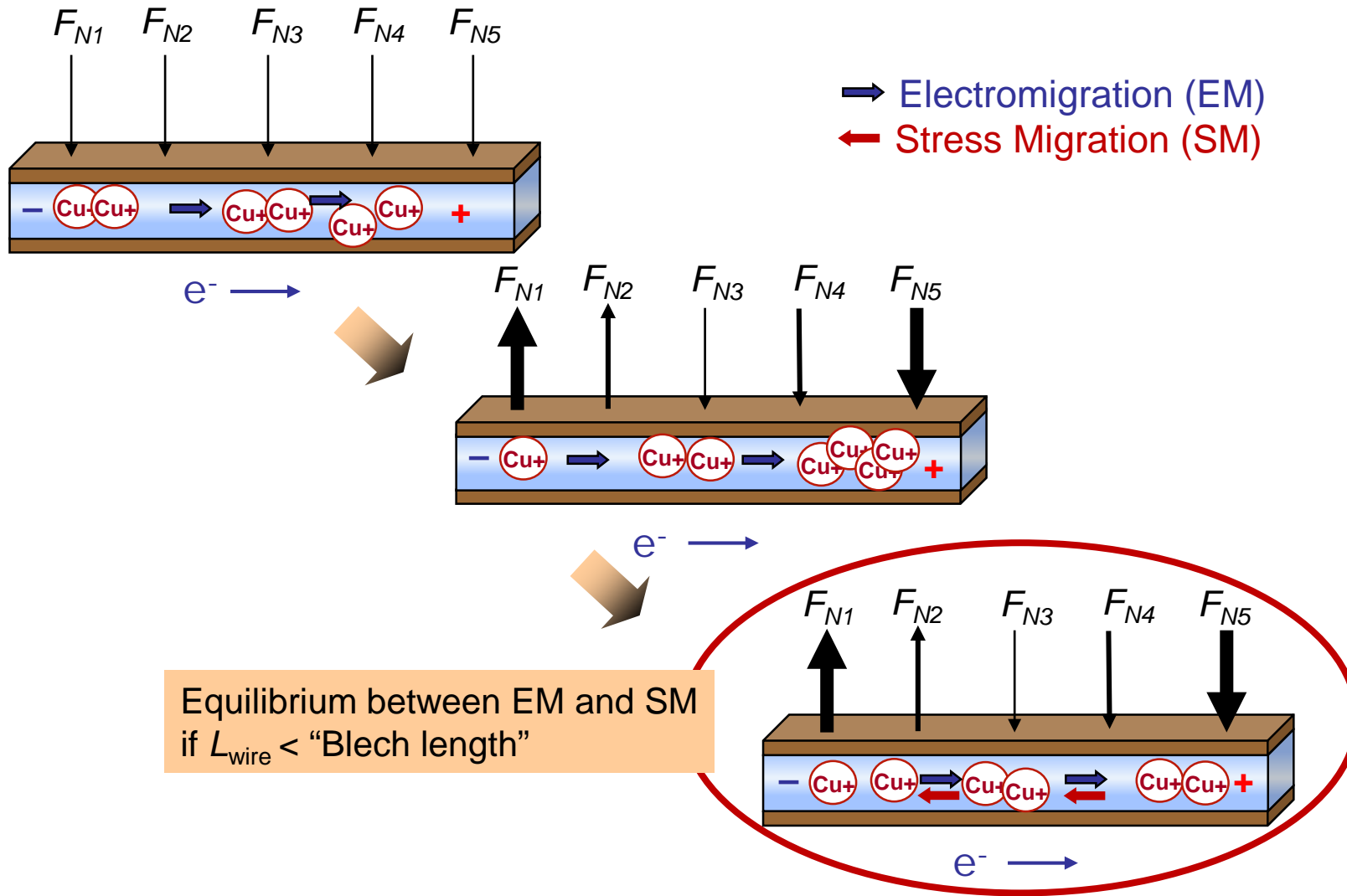
	Length L	Width W	Frequency f	Material	Technology
Bamboo effect, Sect. 4.2		✓		✓	✓
Blech effect, Sect. 4.3	✓			✓	✓
Via effects, Sect. 4.4	✓			✓	✓
Reservoir effect, Sect. 4.5	✓	✓	✓	✓	✓
Via configuration, Sect. 4.6	✓	✓			✓
Self-healing, Sect. 4.7			✓		
Passivation, Sect. 4.8				✓	✓
Immunity, Sect. 4.9				✓	✓

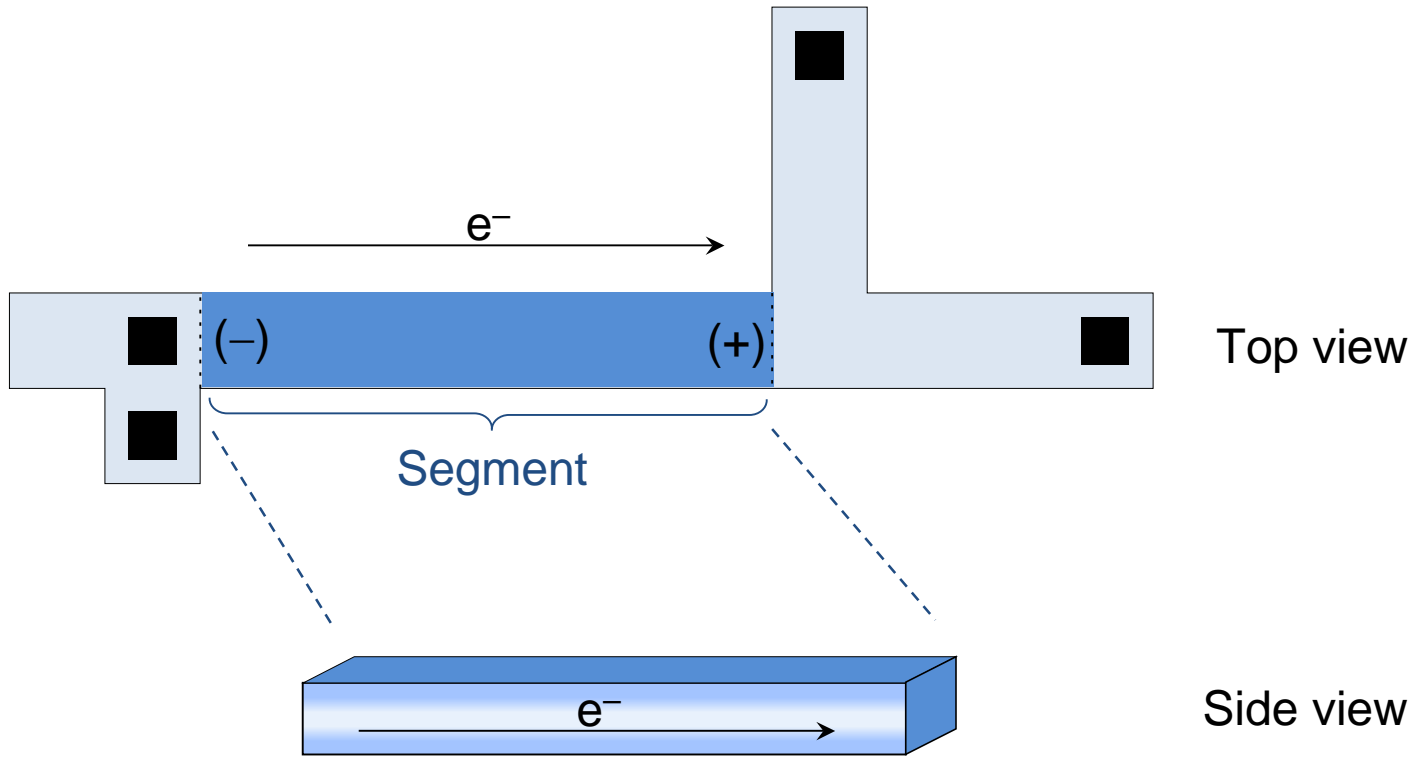


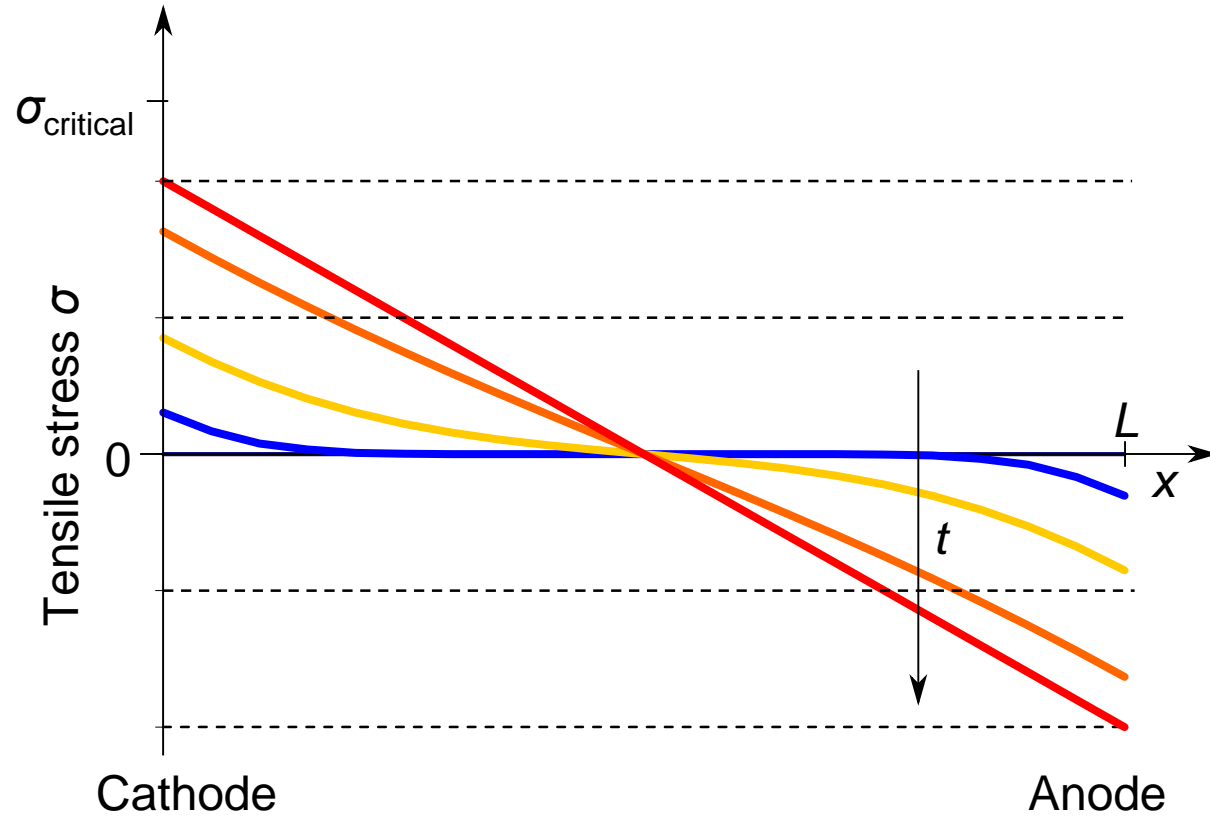
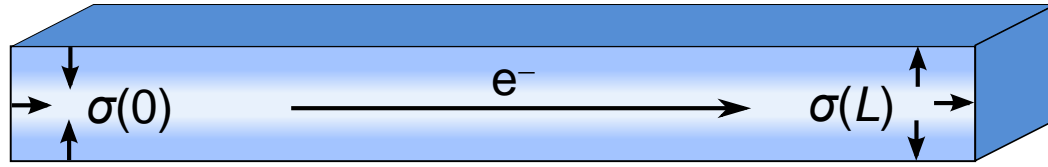


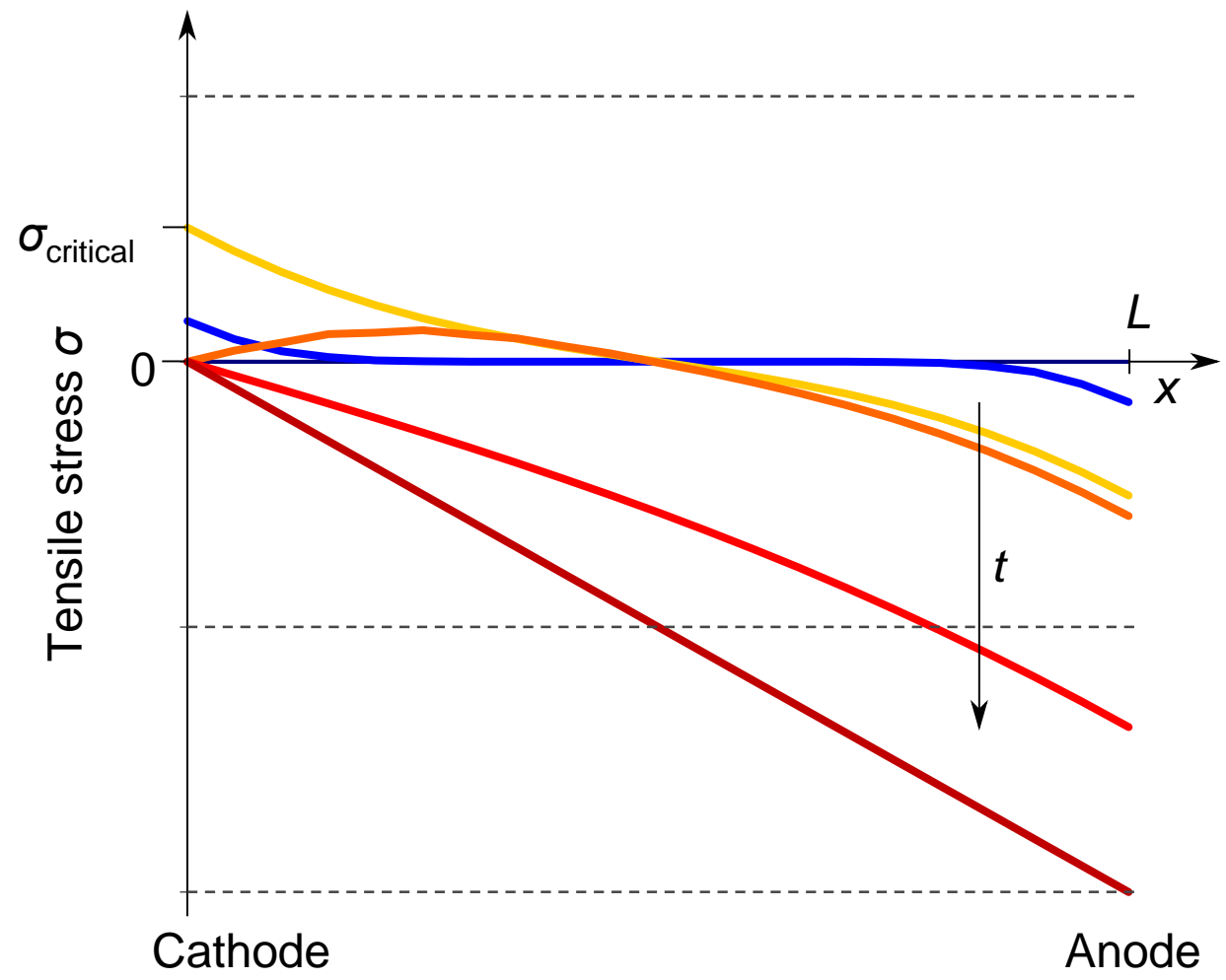
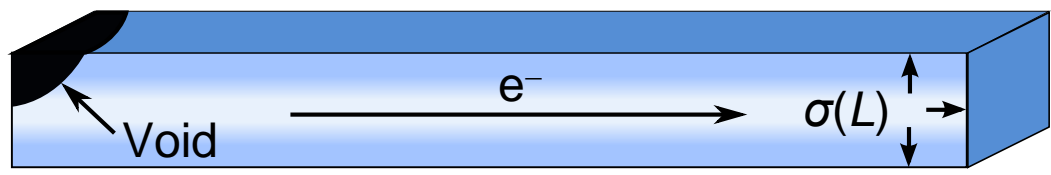
- Minimum width (metal 1)
- Maximum bamboo structure SLA
- Maximum bamboo structure TA

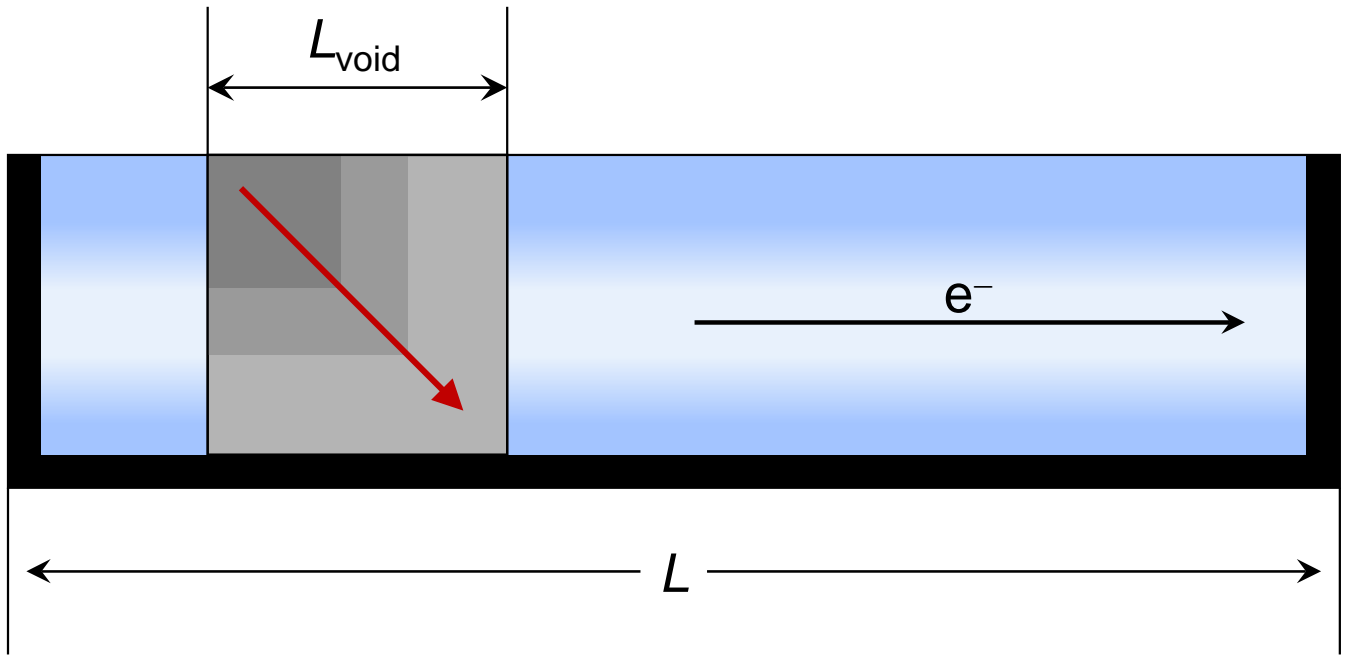


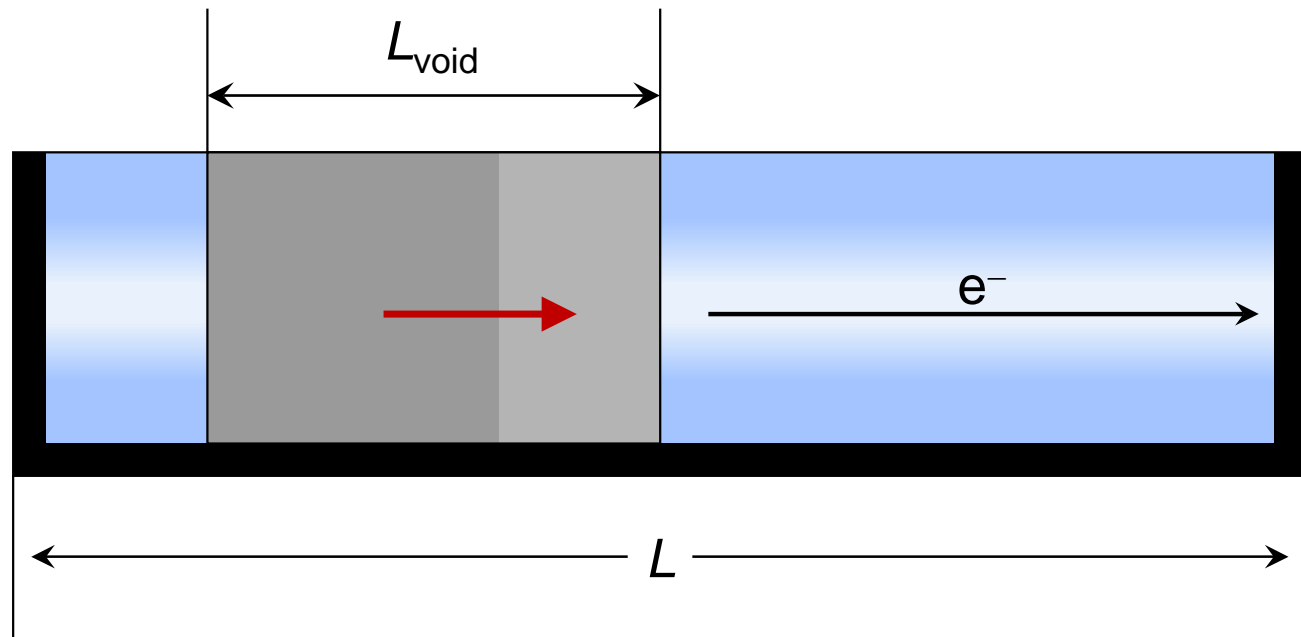


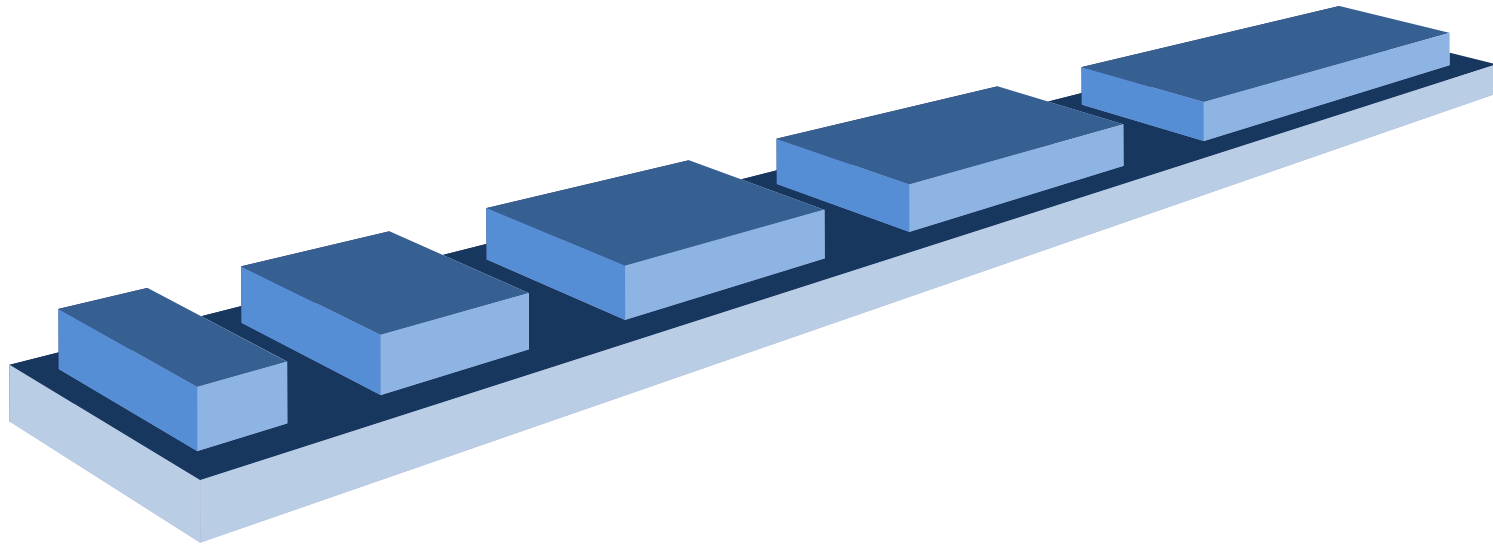


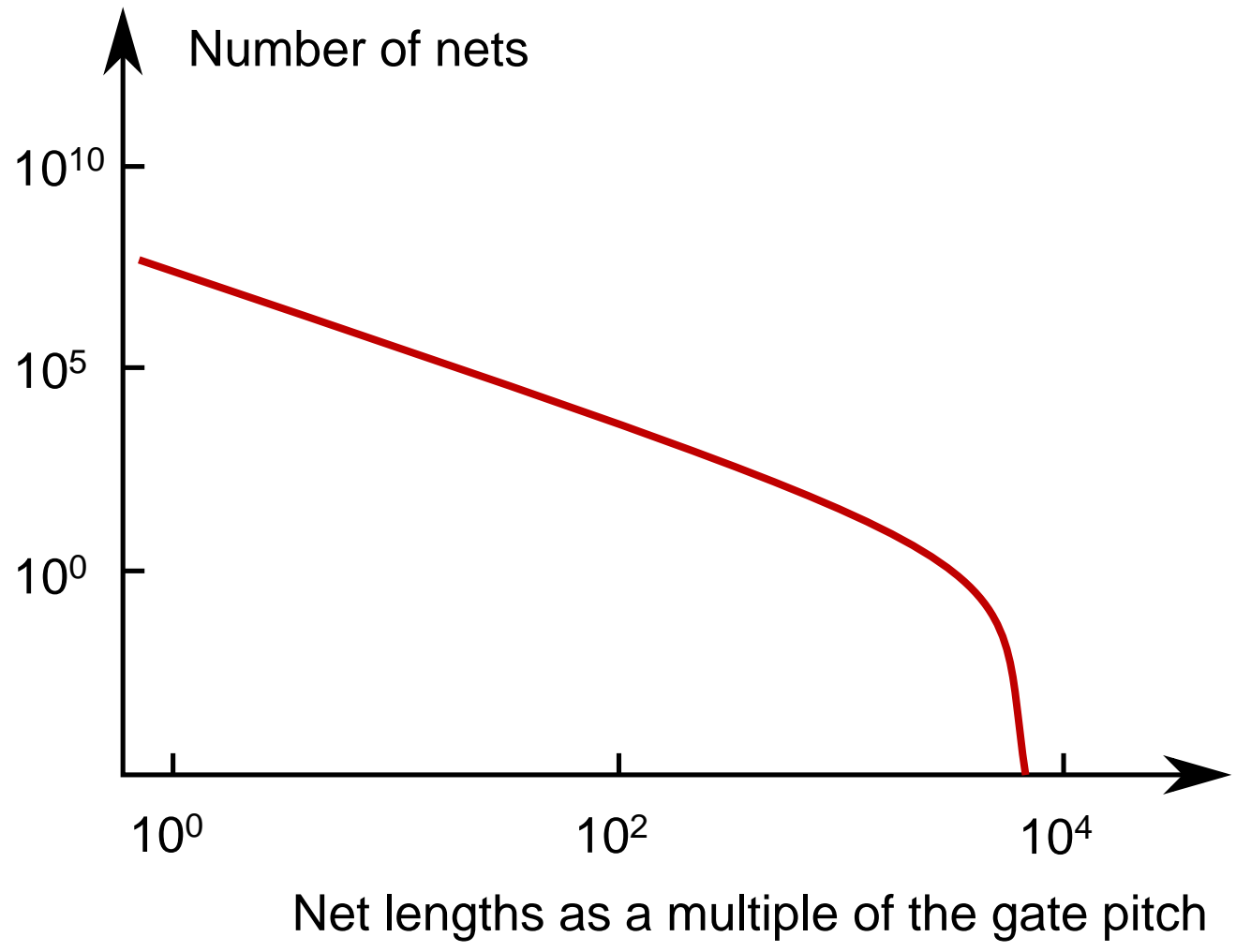




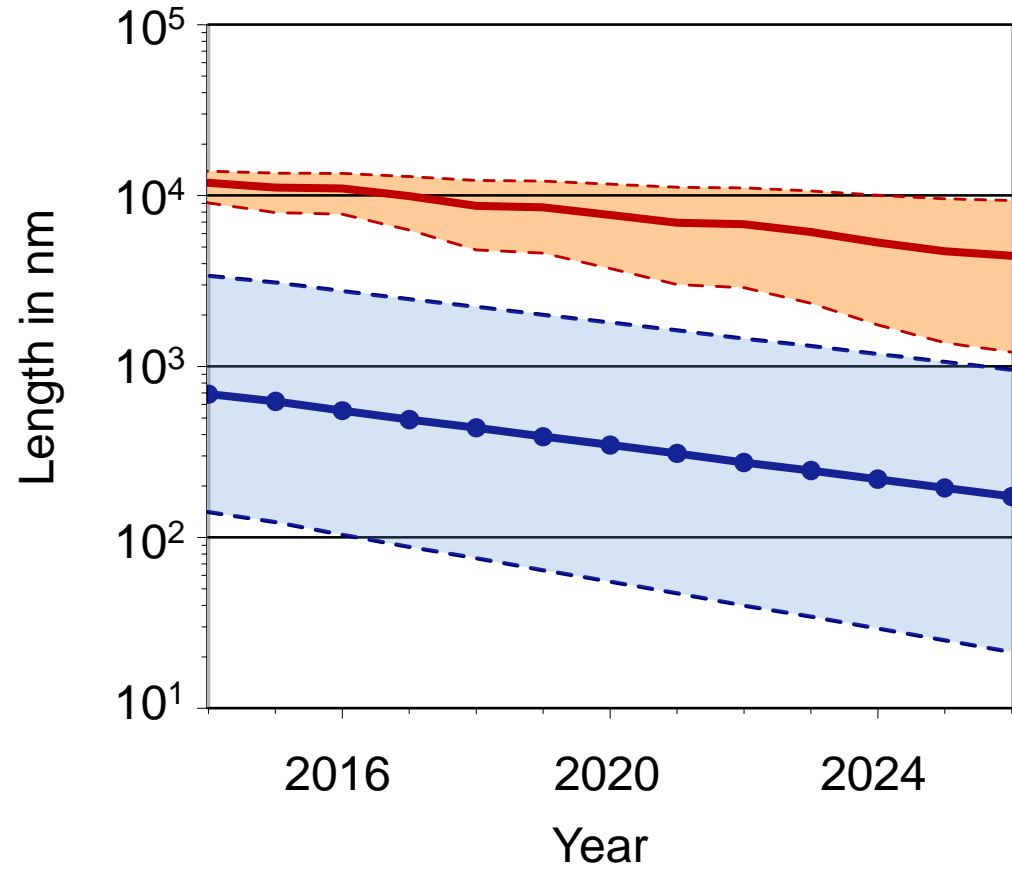








- Blech lengths
- Mean segment lengths (metal 1 through 6)



Metal $n+1$

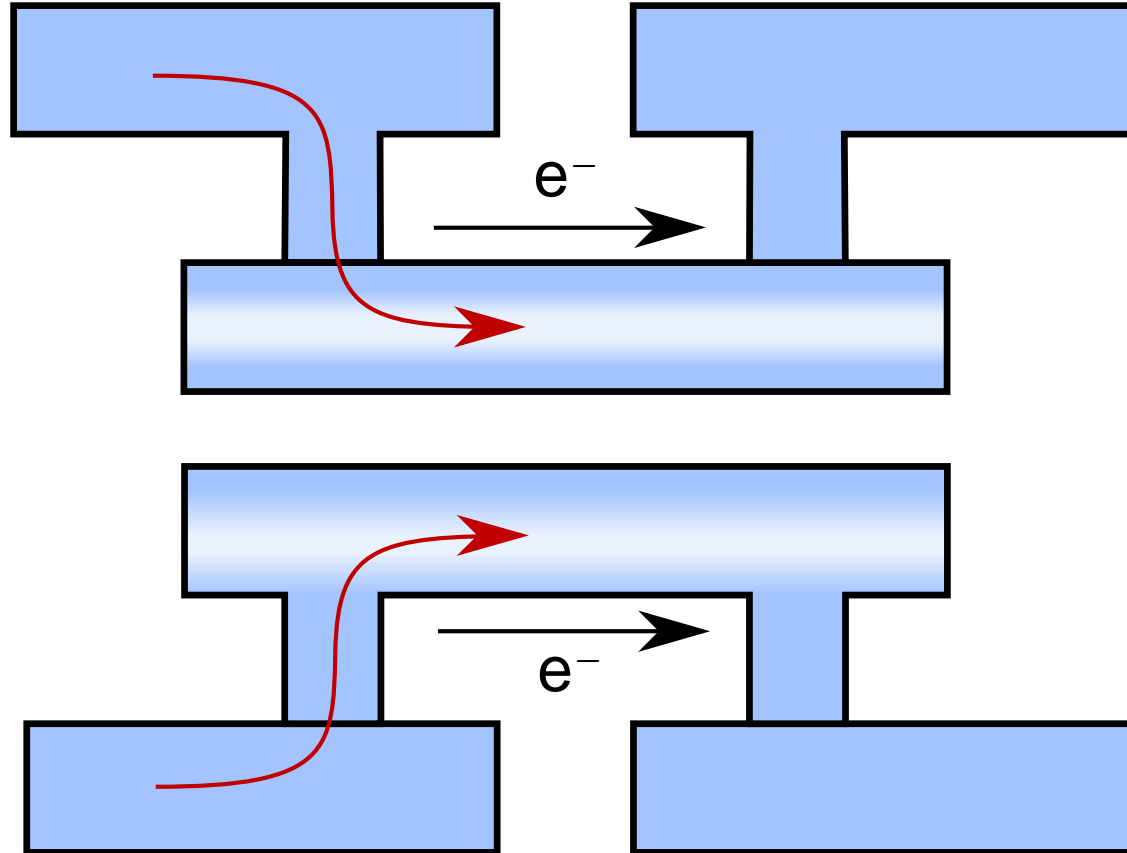
Via layer

Metal n

Metal n

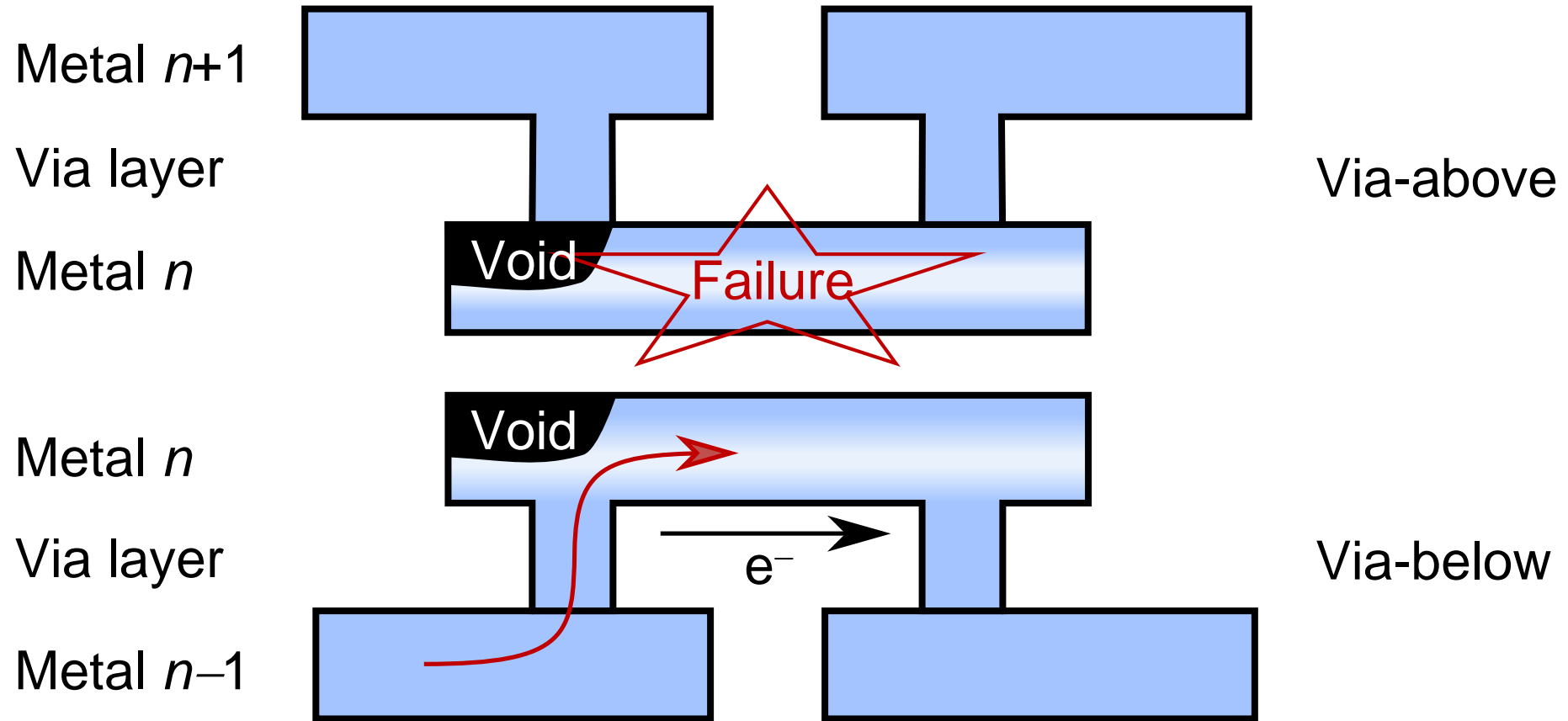
Via layer

Metal $n-1$

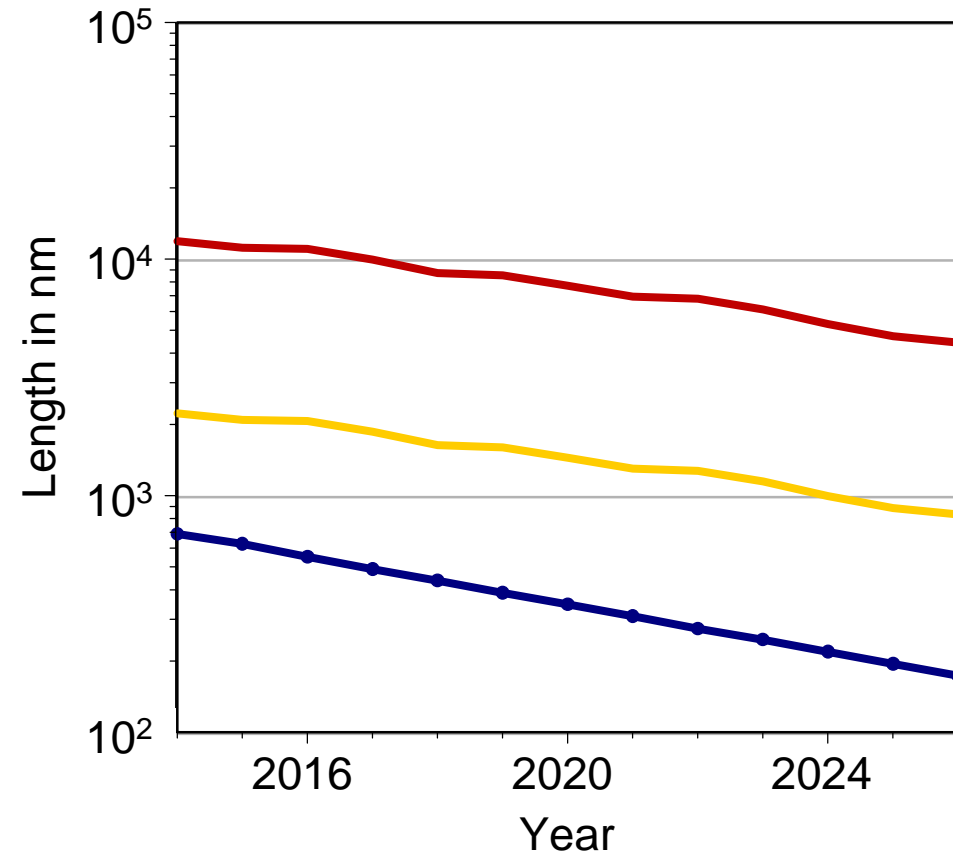


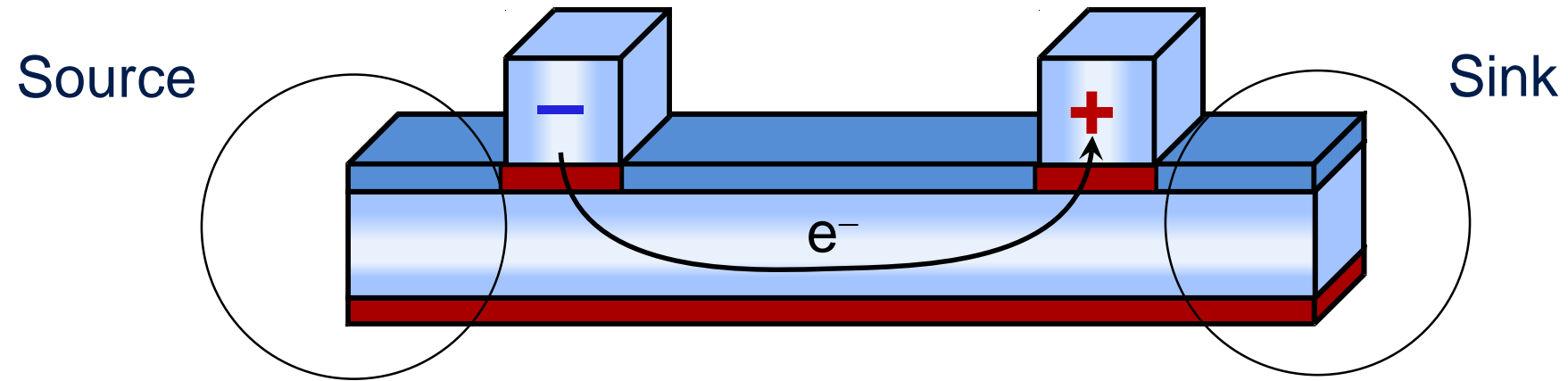
Via-above

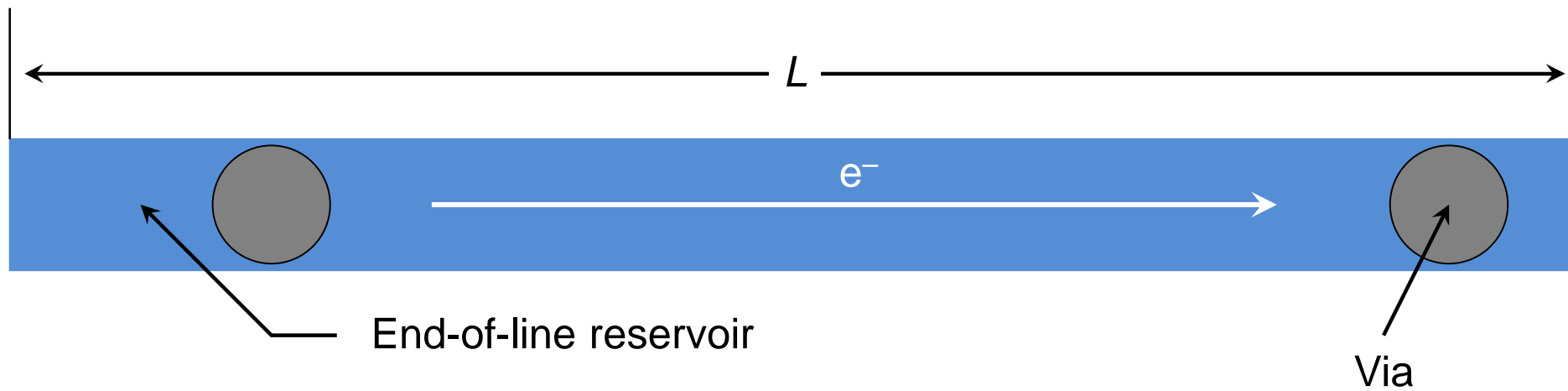
Via-below

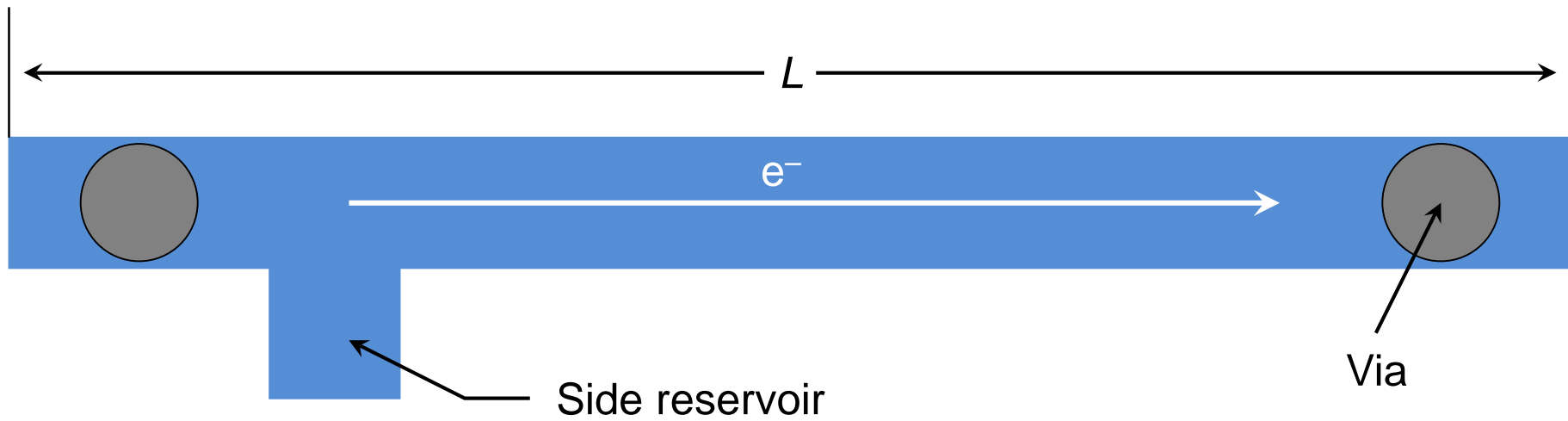


- Blech lengths for via below
- Blech lengths for via above
- Mean segment lengths (metal 1 through 6)

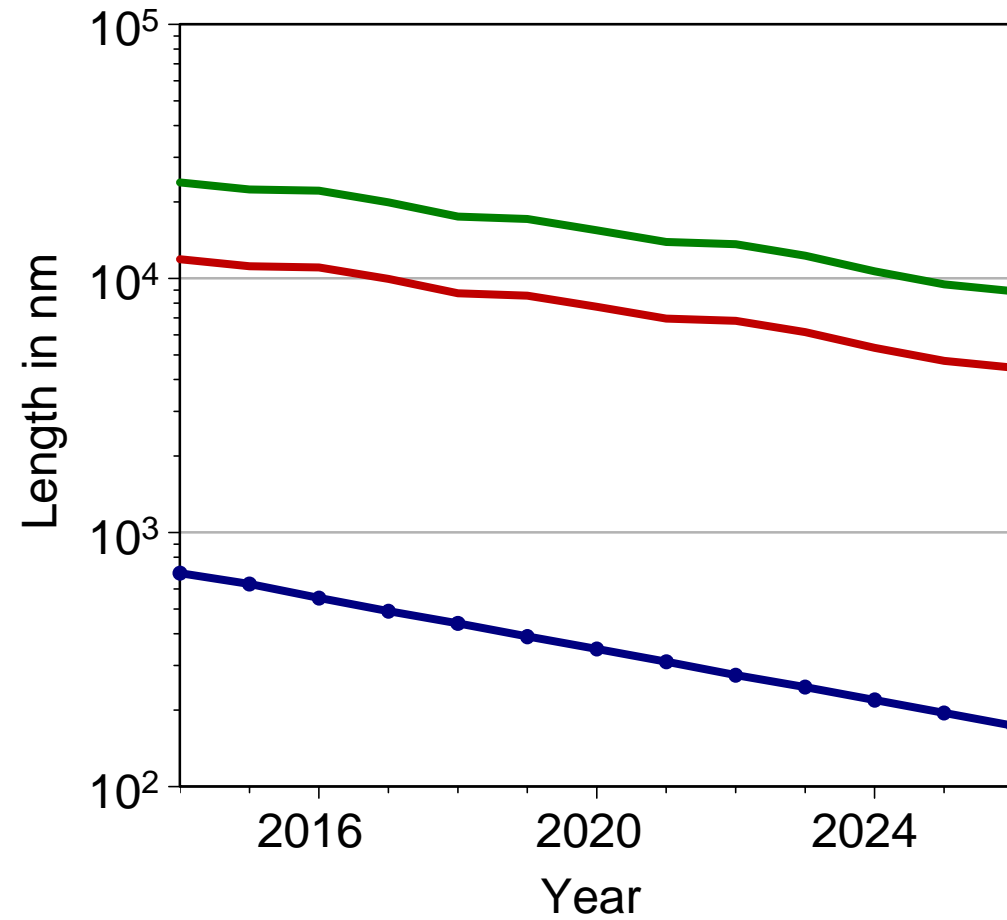


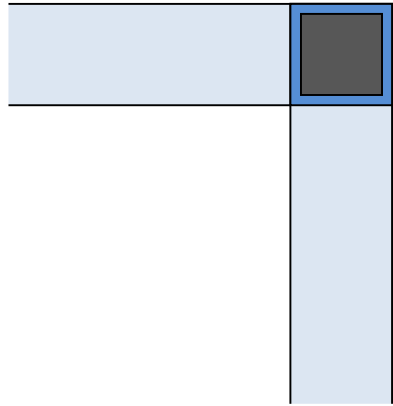




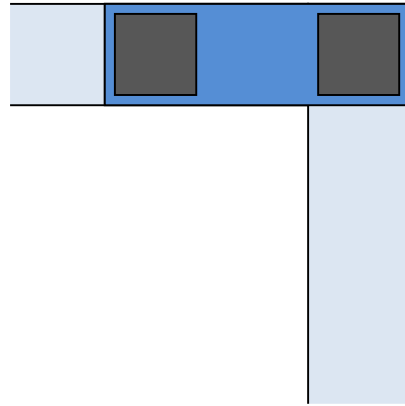


- Blech lengths
- Blech lengths with reservoir
- Mean segment lengths (metal 1 through 6)

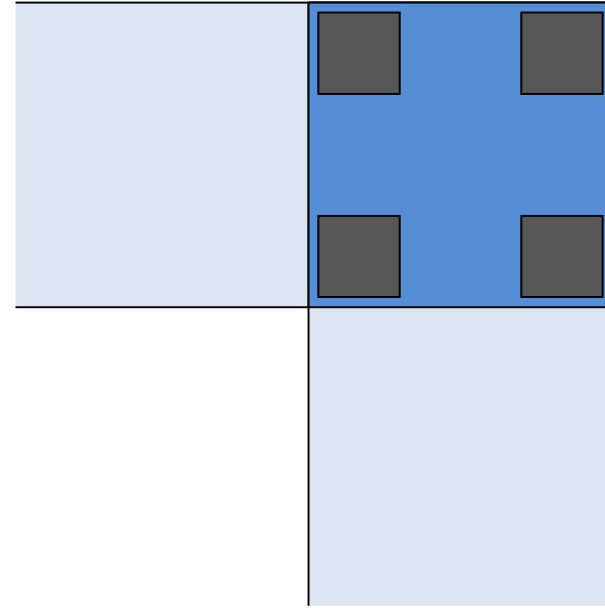




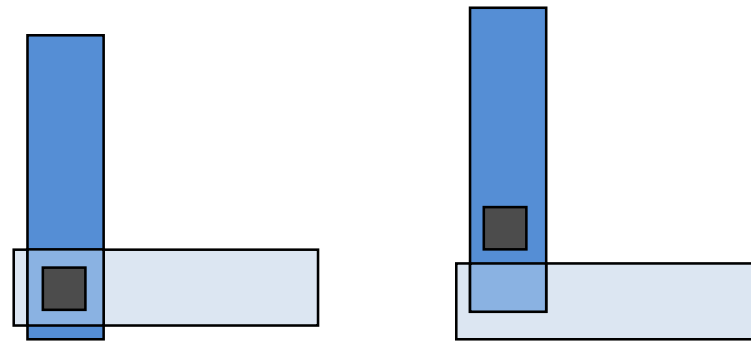
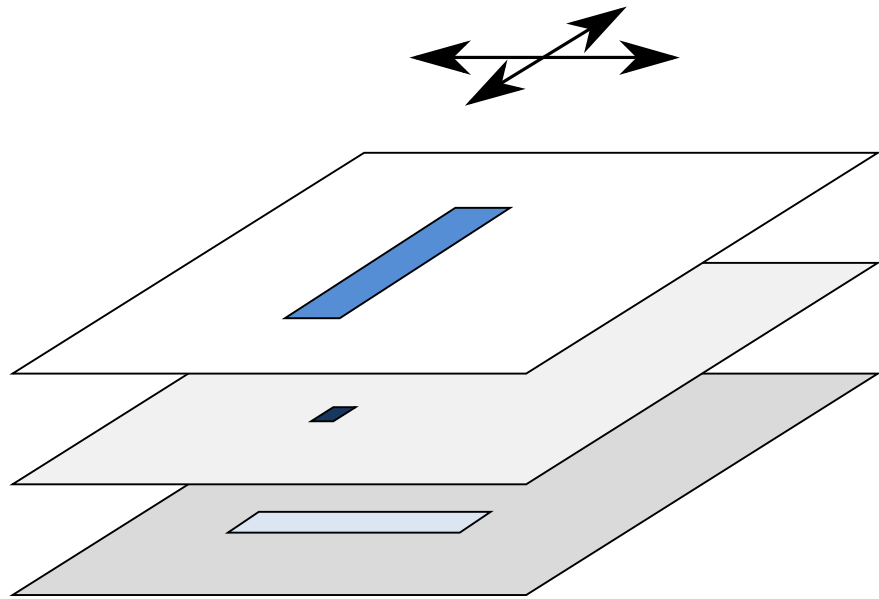
Single via

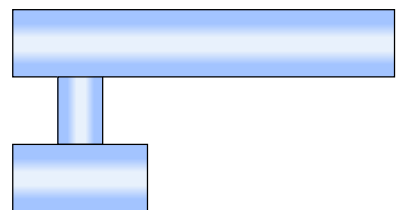


Double via

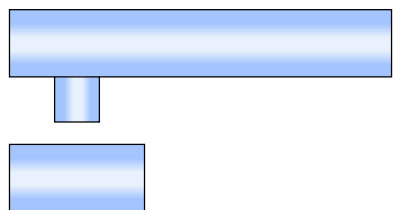


Via array

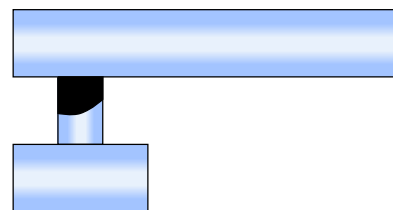




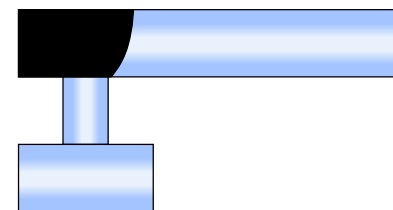
(a)



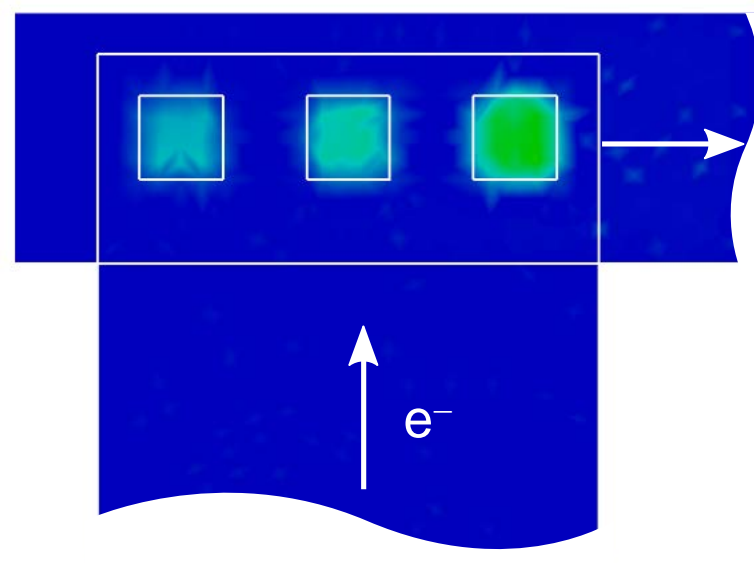
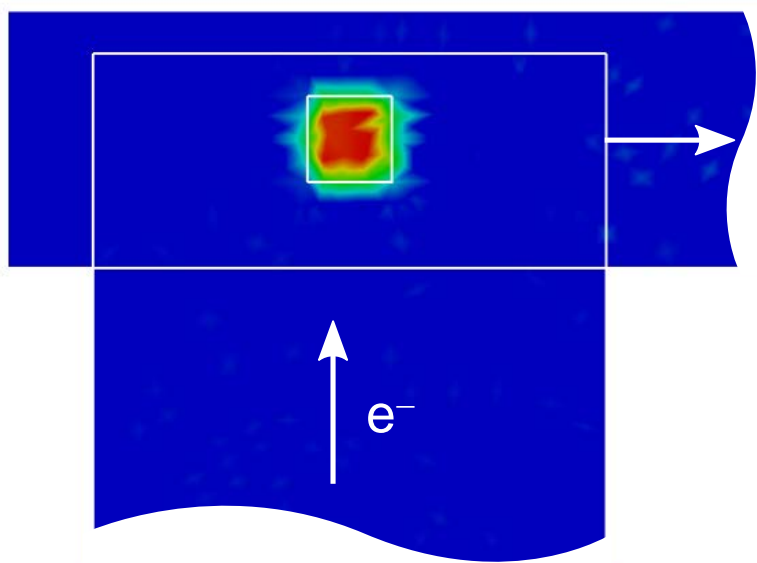
(b)

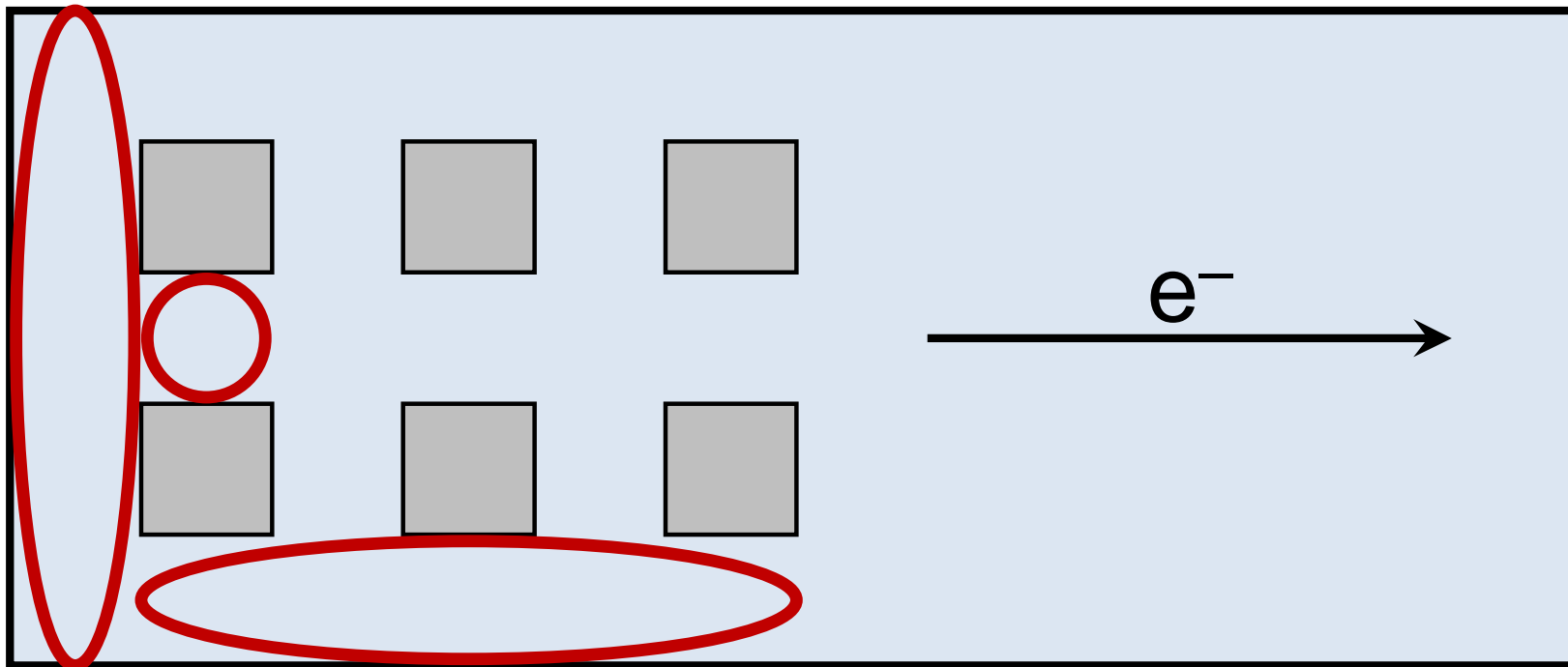


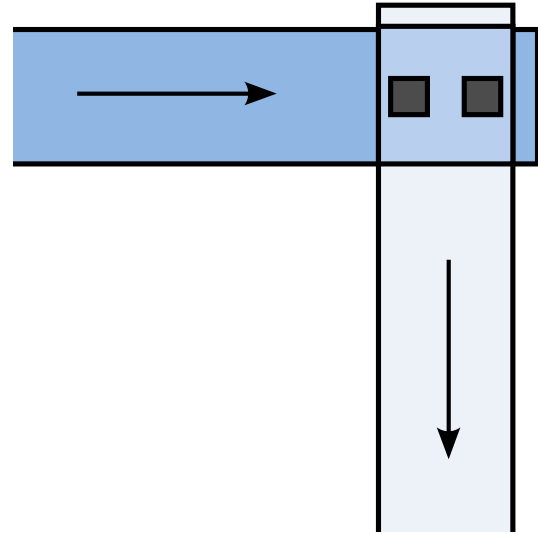
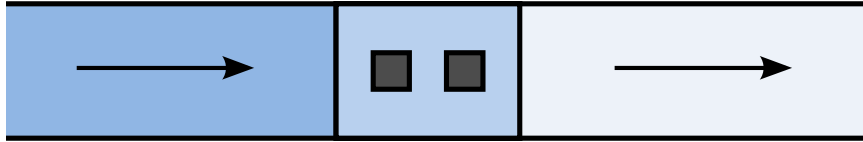
(c)

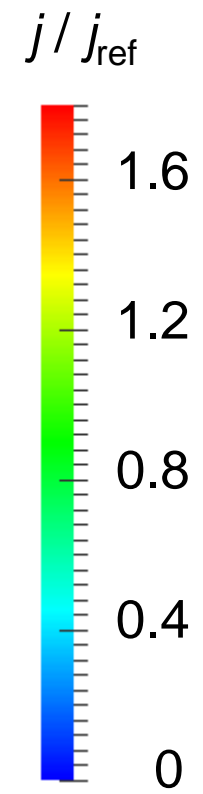
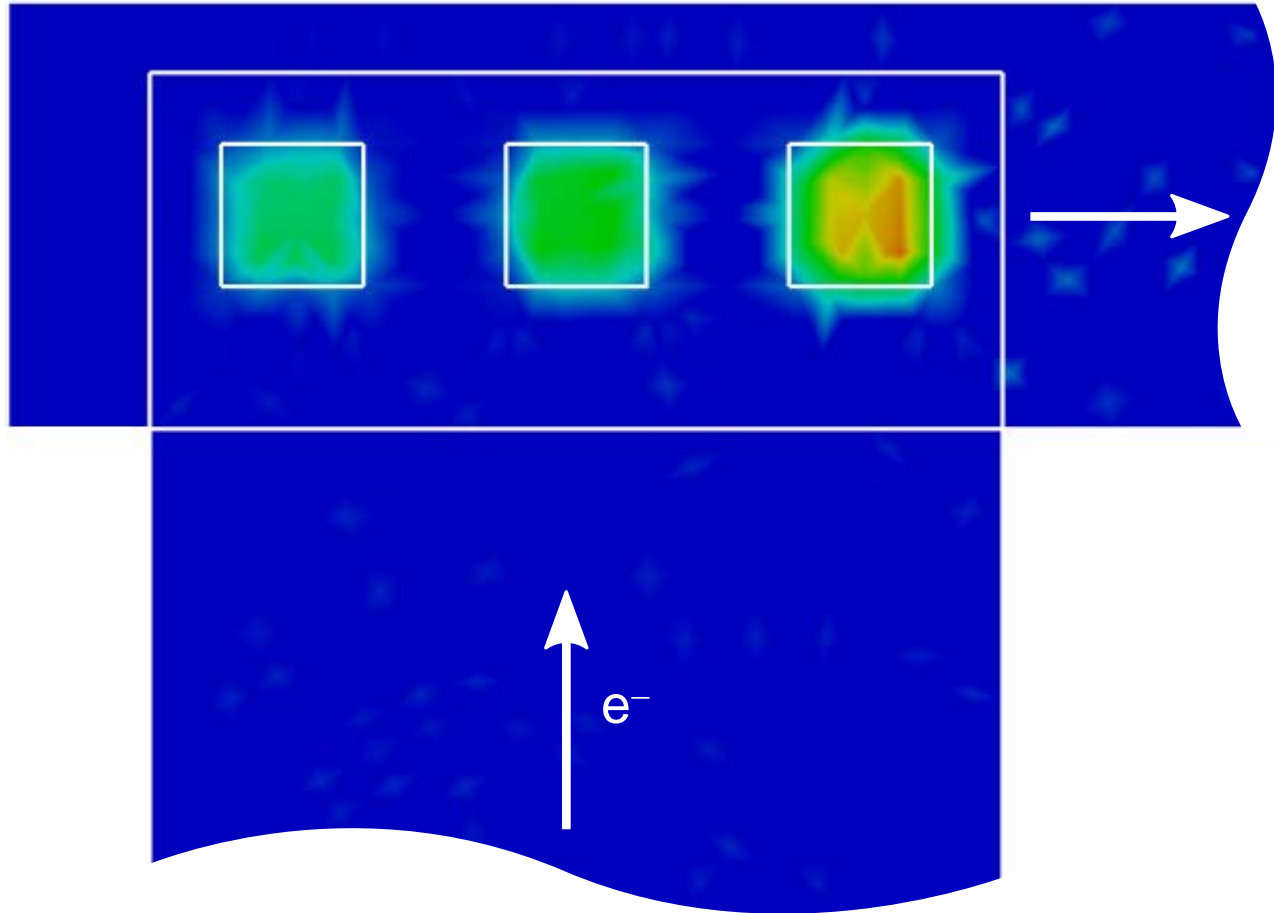


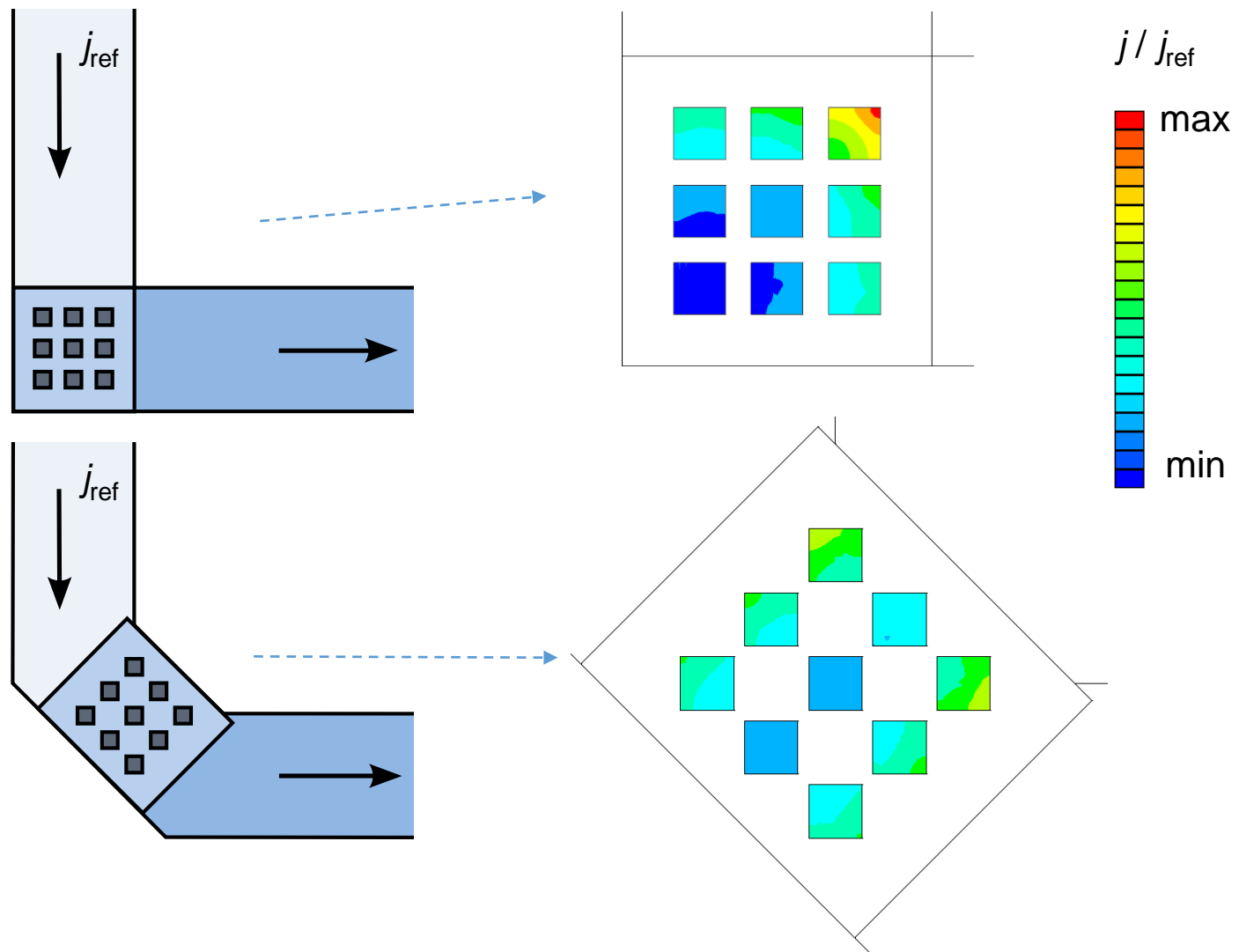
(d)

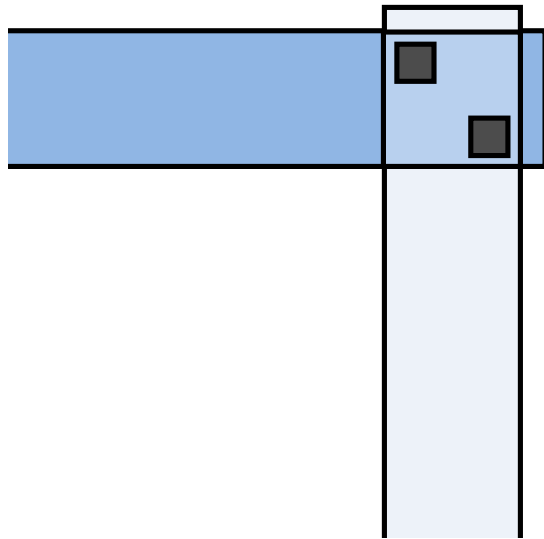
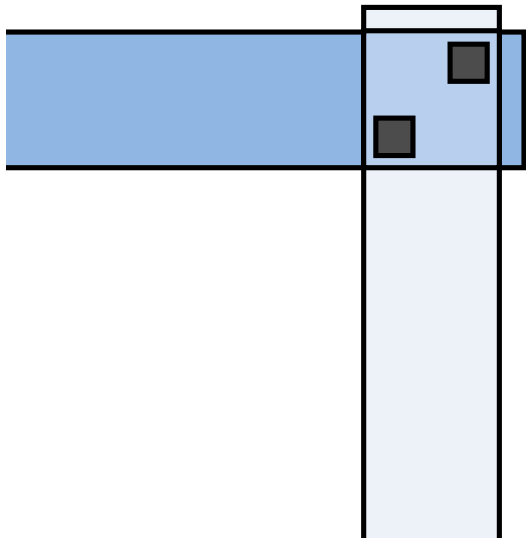


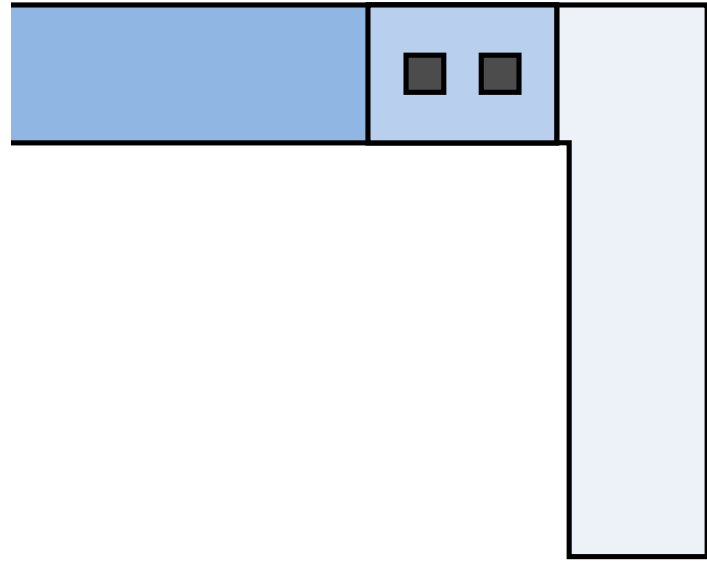
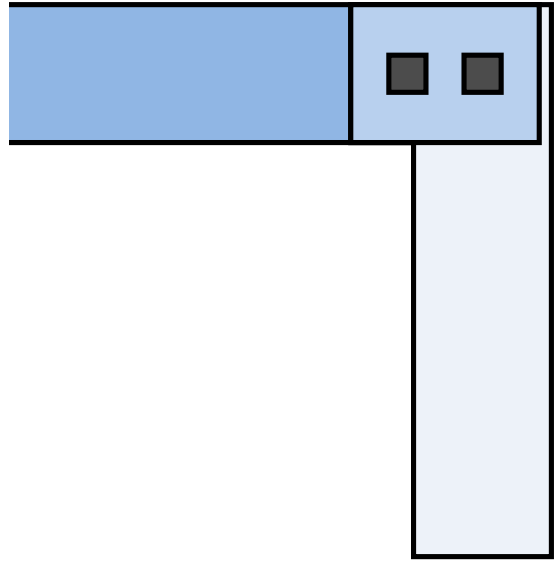


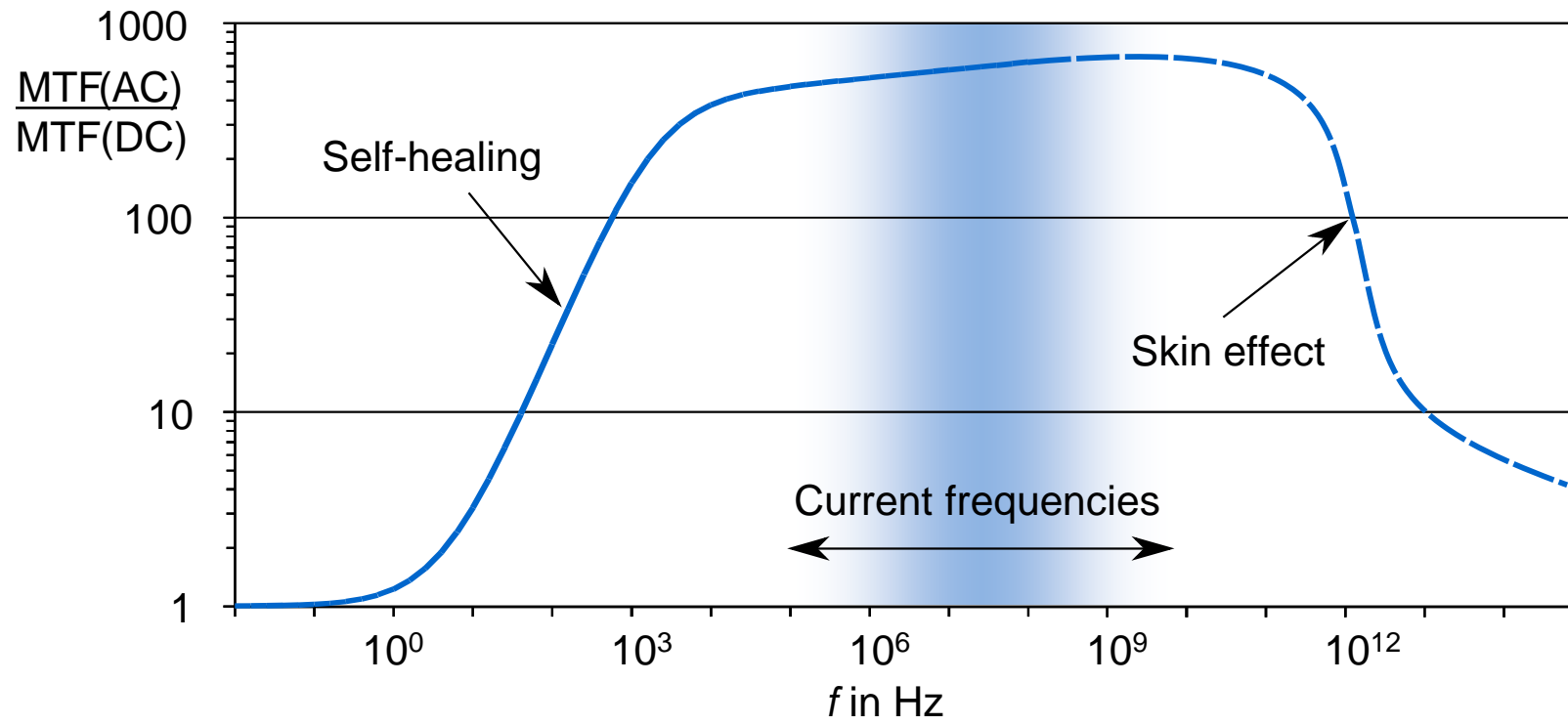




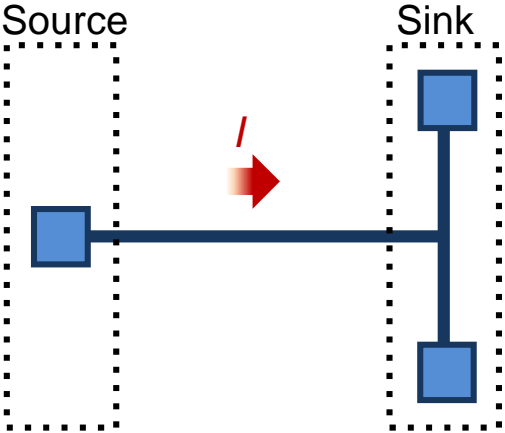




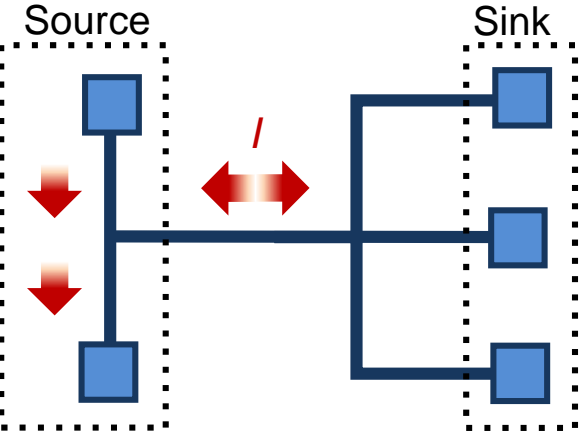




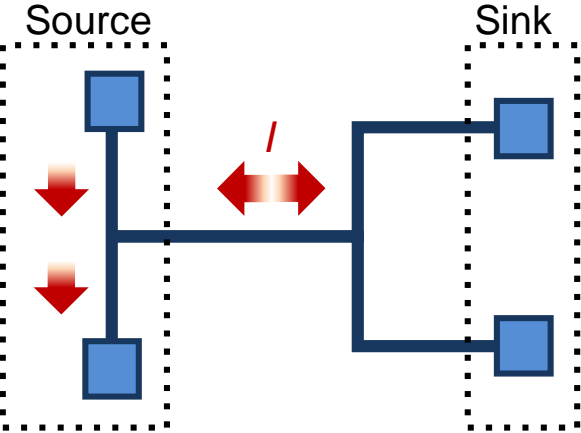
Power supply net



Clock net

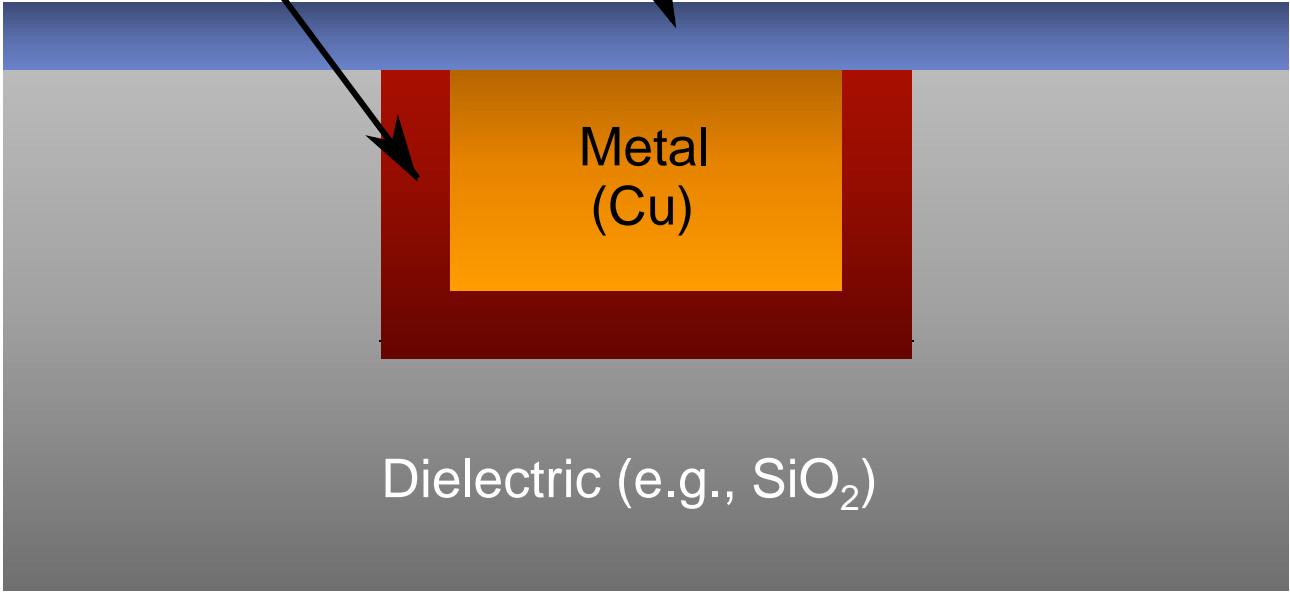


Signal net



Metal liner

Dielectric cap



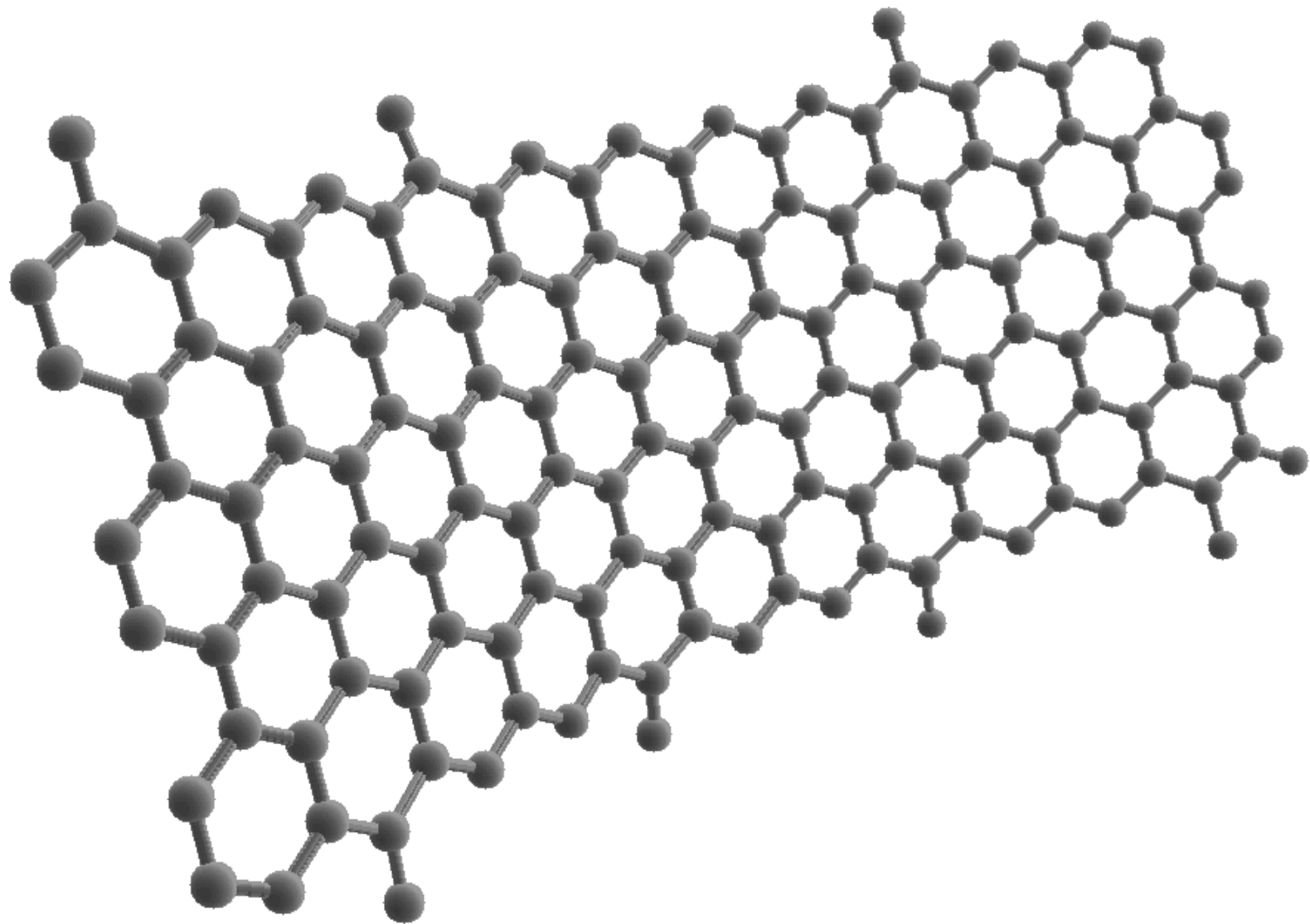
Metal
(Cu)

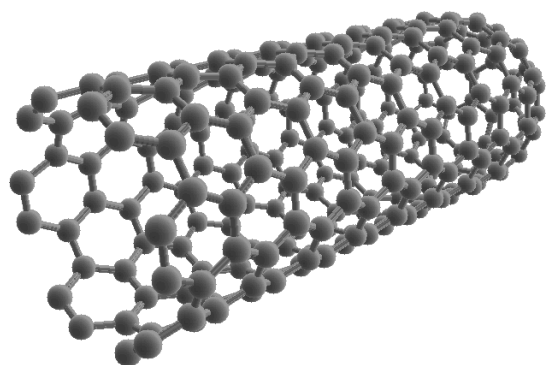
Dielectric (e.g., SiO₂)

Metal	Specific resistance ρ in $\mu\Omega\cdot\text{cm}$	Activation energy E_a in eV	Source
Aluminum	2.44	0.61	[EJS91]
Silver	1.47	0.66	[EJS91]
Copper	1.54	0.70	[EJS91]
Gold	2.03	0.75	[EJS91]
Tungsten	4.84	1.89	[MIH+90][EJS91]

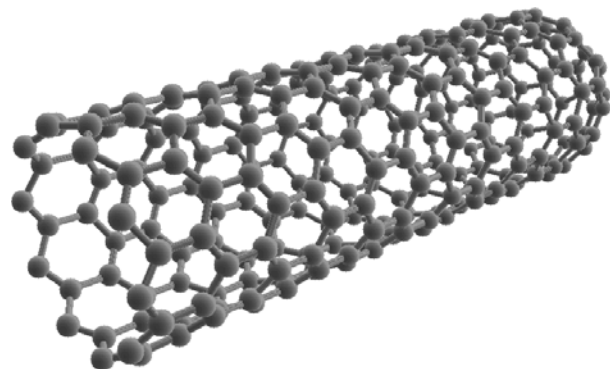
Material	ϵ_r	E in GPa
Vacuum or air	1	—
Aerogels	1.1–2.2	≈ 0.001
Polyimide (organic)	2.7	3.7
Silicon oxide (SiO_2)	3.9	300
Glass-fiber-reinforced epoxy resin	5	20
Silicon nitride (Si_3N_4)	7.5	297
Aluminum oxide (Al_2O_3)	9.5	264
Silicon	11.7	99

Barrier	Activation energy E_a in eV	Sources
Ta	2.1	[Gla05]
Ta/TaN	1.4	[HGR06]
SiN or $\text{SiC}_x\text{N}_y\text{H}_z$	0.7–1.1	[Gla05][HGR06]
SiN on Cu(Ti)	1.3	[HGR06]
CoWP	1.9–2.4	[HGR06]
SiC_xH_y	0.9	[HGR+03]

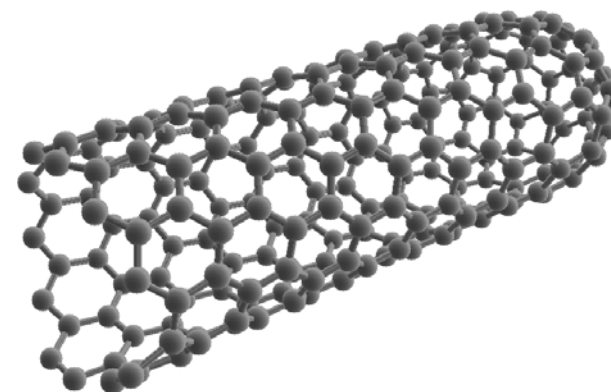




(a) Armchair



(b) Zig-zag



(c) Chiral

	Cu	Single-wall CNTs	Multi-wall CNTs	Cu-CNT Composites
Maximum current density (A/cm ²)	< 1·10 ⁷	> 1·10 ⁹ [YKD00]	> 1·10 ⁹ [WVA01]	> 6·10 ⁸ [SSY16]
Thermal conductivity @300K (W/m·K)	385	3,000-10,000 [MPG13]	3,000 [MPG13]	~ 800 [SYK13]
Electrical conductivity (S/cm)	5.8·10 ⁵	7·10 ⁵ [LYY04]	2.7·10 ⁵ [KKR12]	(2.3 - 4.7)·10 ⁵ [SSY16]
Electron mean free path @300K (nm)	40	> 1,000 [PHR07]	> 25,000 [BYW02]	
Coefficient of thermal expansion (1/K)	17·10 ⁻⁶ [BS06]	(-0.3 - +0.4)·10 ⁻⁶ [JLH04]*		(4 - 5)·10 ⁻⁶ [ARW11]
Young's modulus (GPa)	129 [Bei03]	~ 1,000 [Bel05][MR06]	~ 900 [MR06]	
Tensile strength (GPa)	0.2 [BS06]	~ 100 [MR06]		

*) @ 400 K, axial direction; the specific value depends on temperature, diameter, CNT structure, and direction

