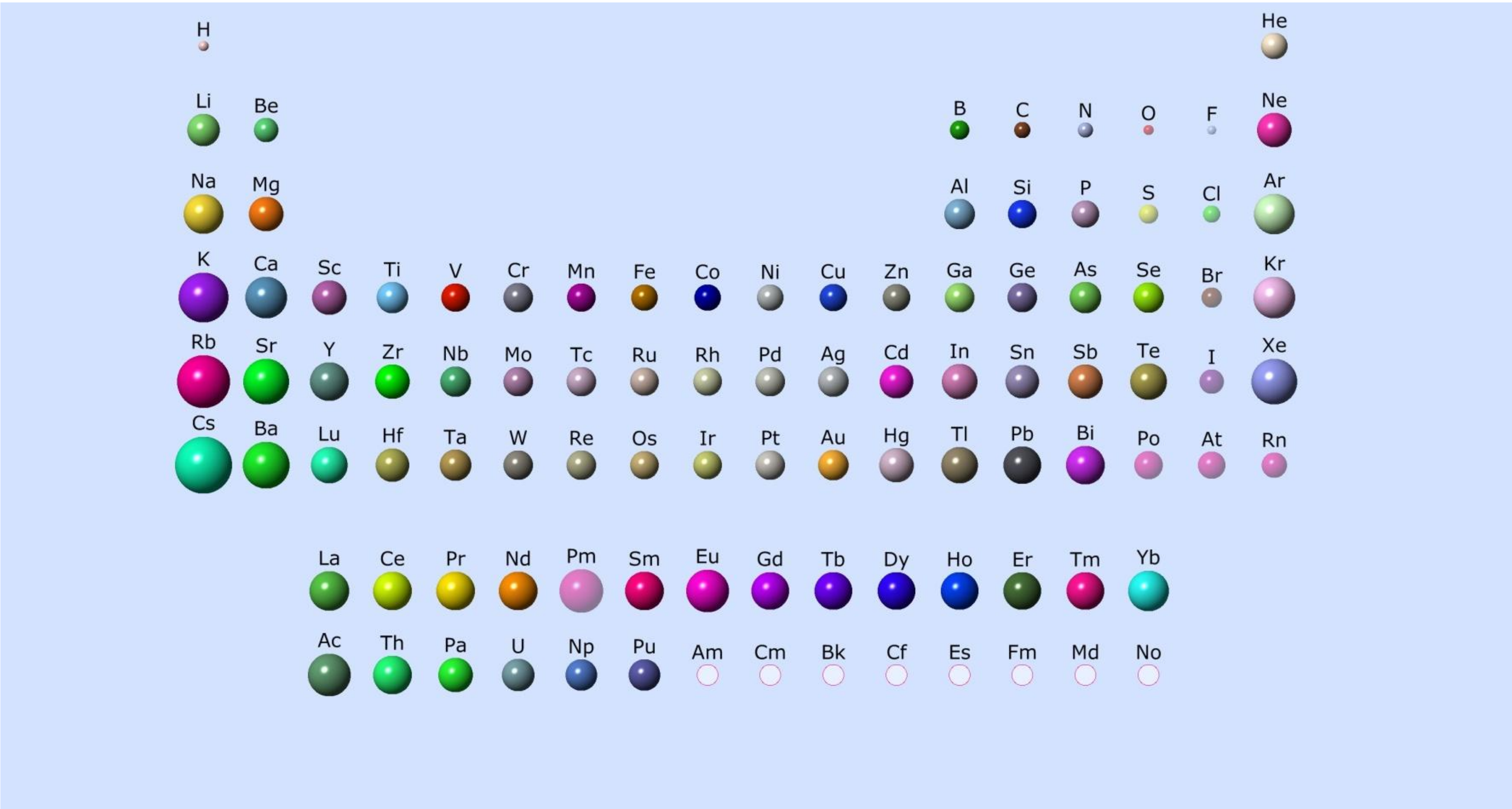
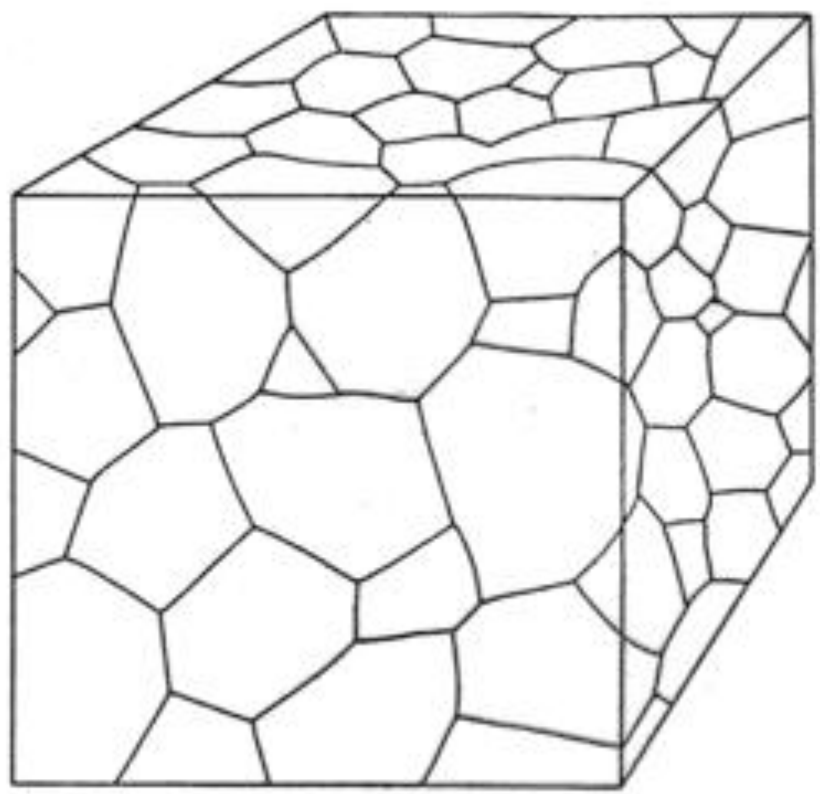
Solubilização e Precipitação – Liga de Aluminio

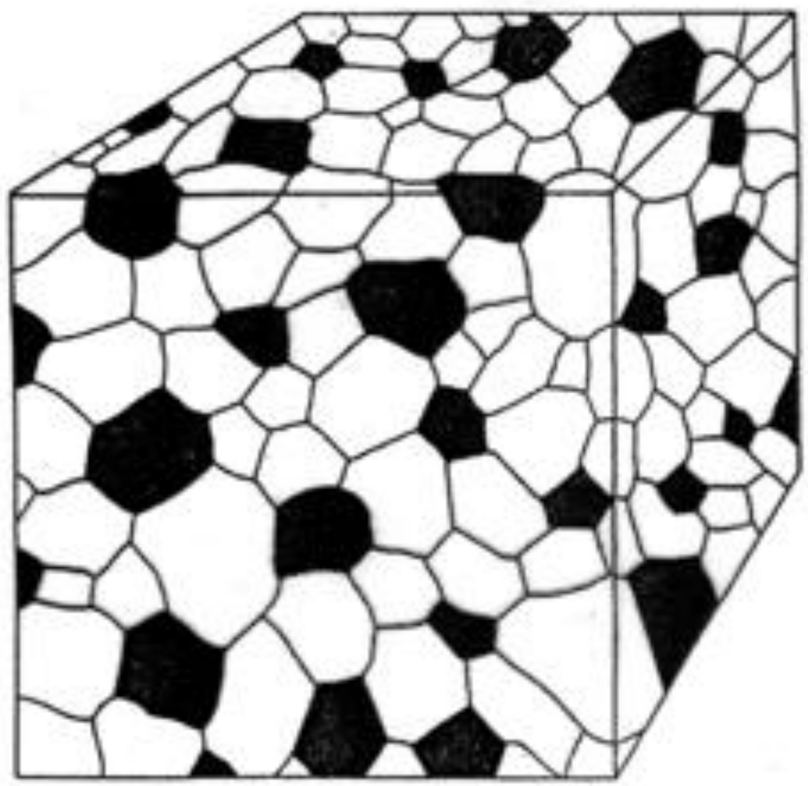
Endurecimento por precipitação (tratamento térmico)


H He
Li Be B C N O F Ne
Na Mg Al Si P S Cl Ar
K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
Cs Ba Lu Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn
La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb
Ac Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No

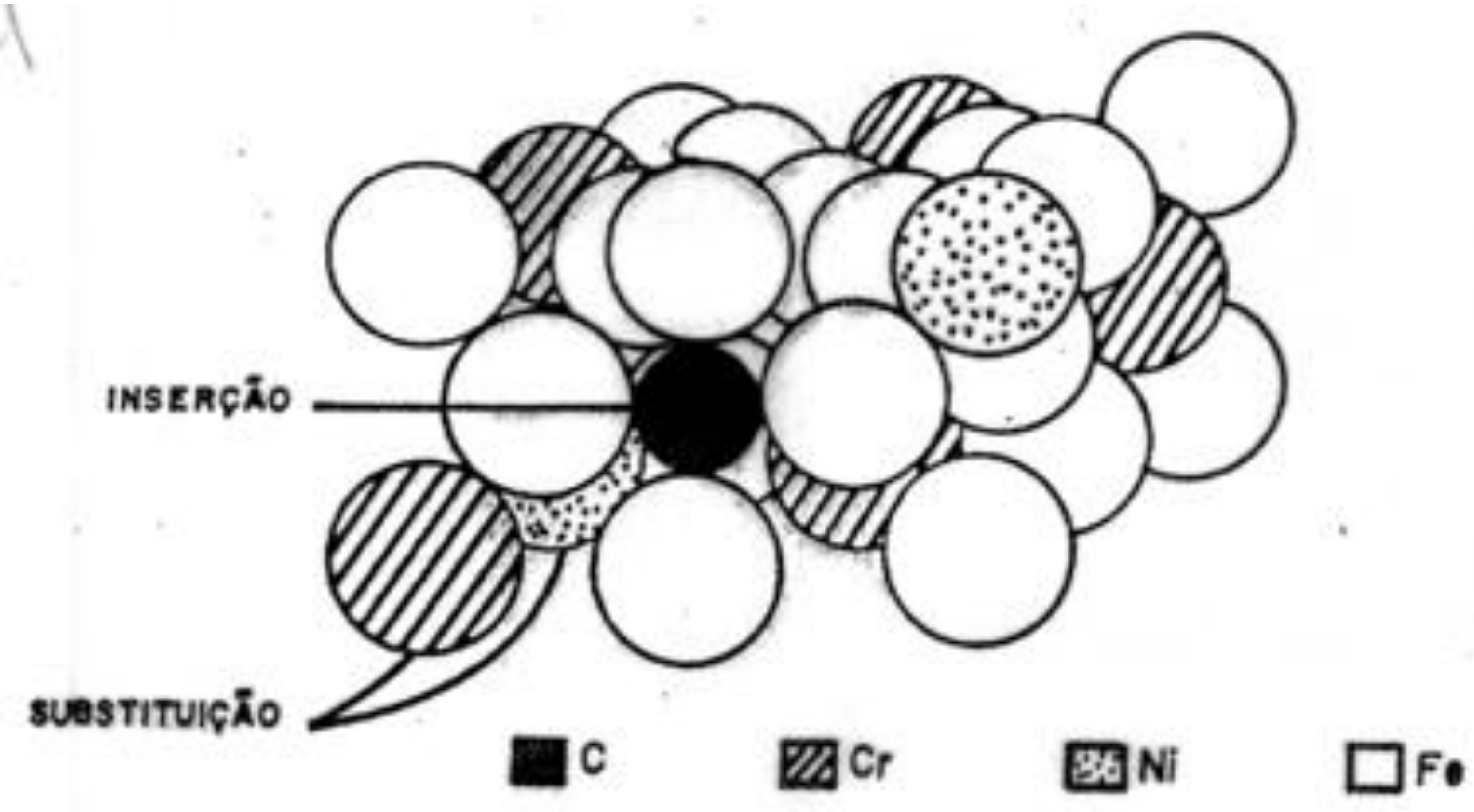
Microestrutura monofásica policristalina vista em três dimensões



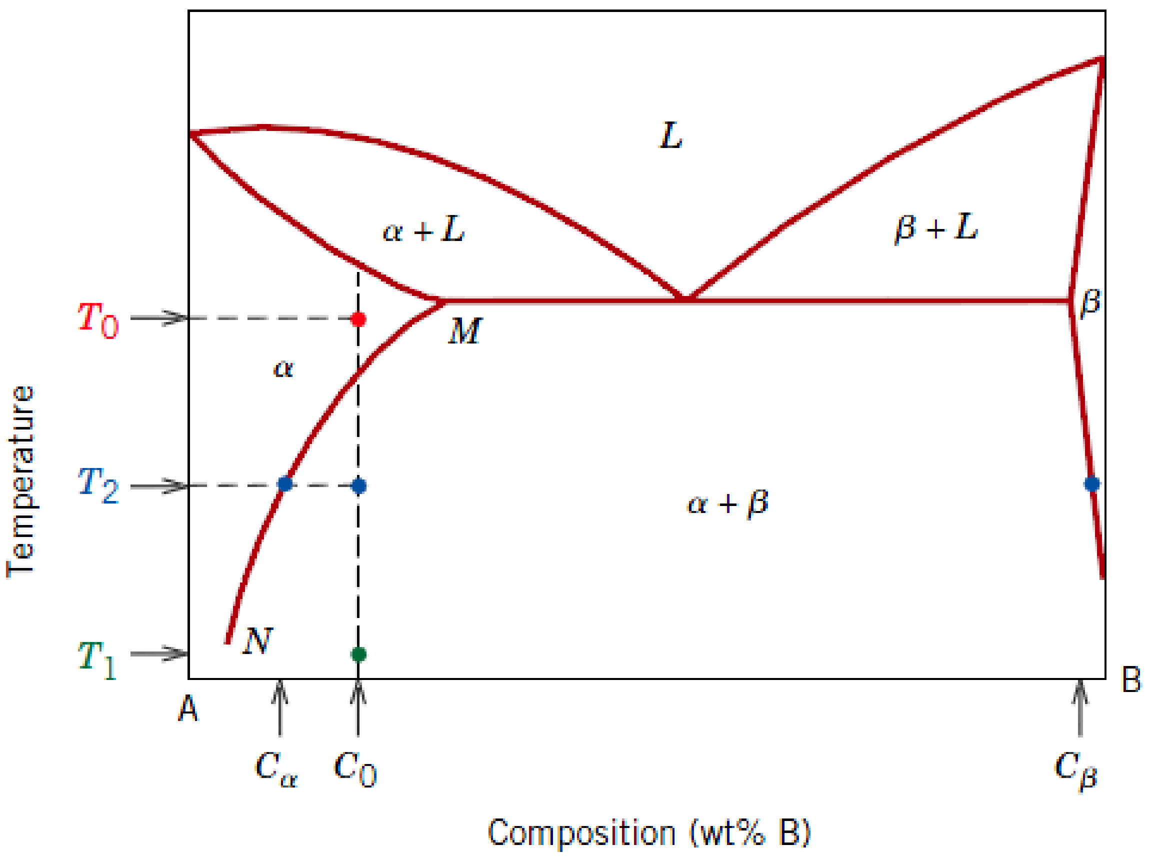
Microestrutura bifásica policristalina vista em três dimensões



Célula unitária de um aço inoxidável AISI 304

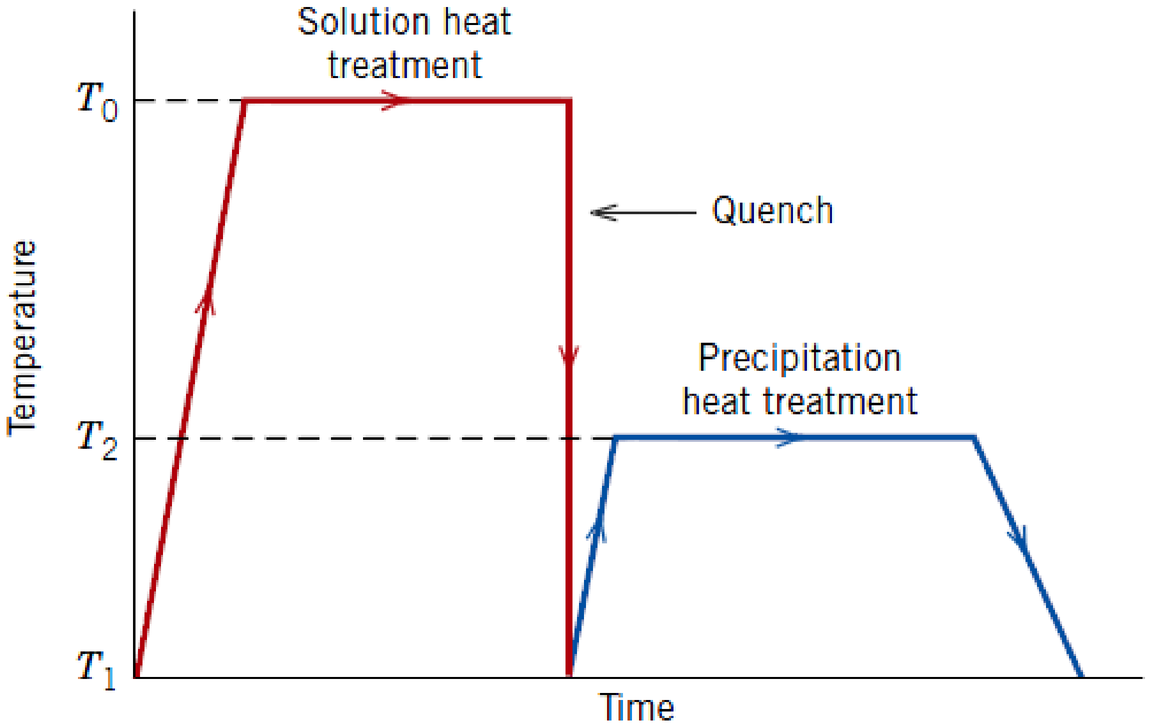


Endurecimento por precipitação



Hypothetical phase diagram for a precipitation-hardenable alloy of composition C_0.

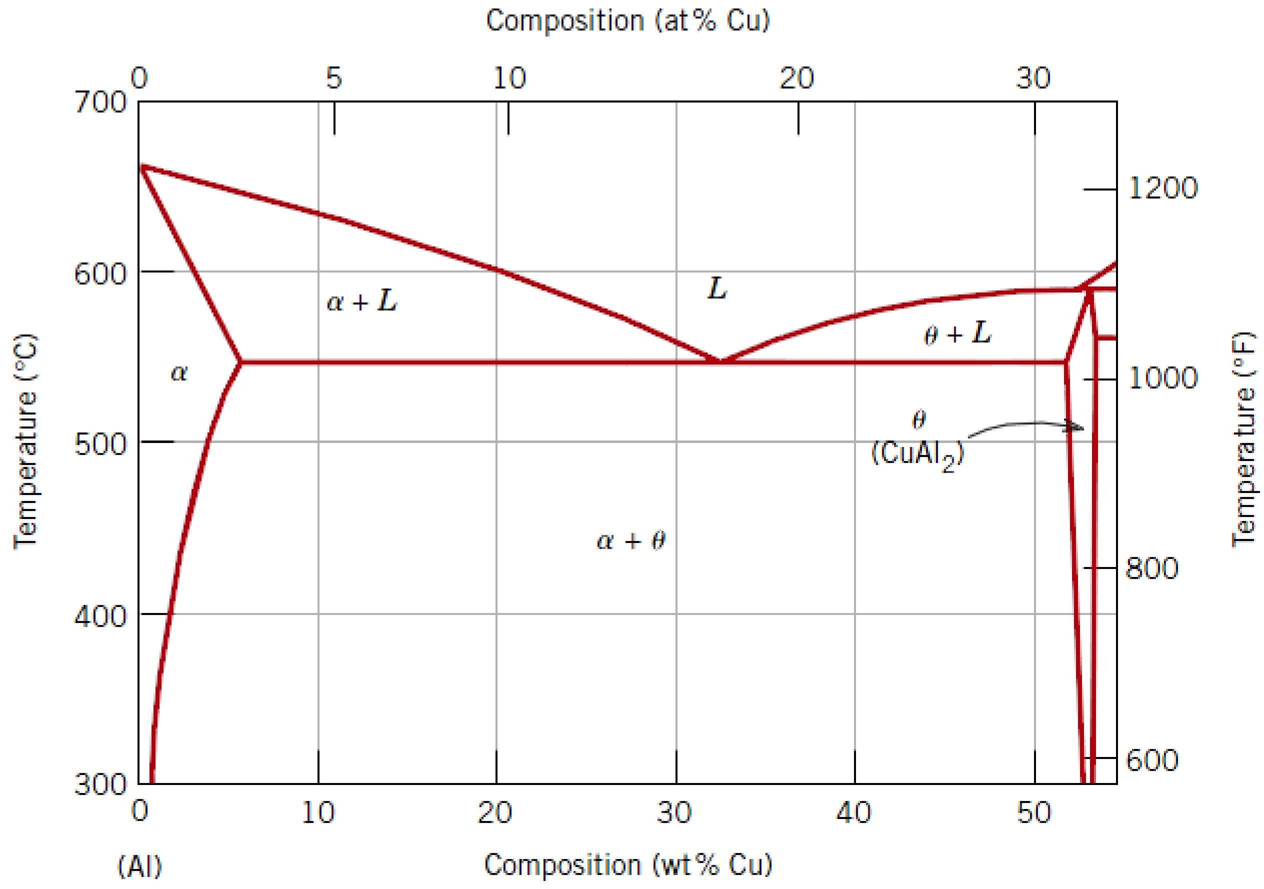
Tratamento térmico



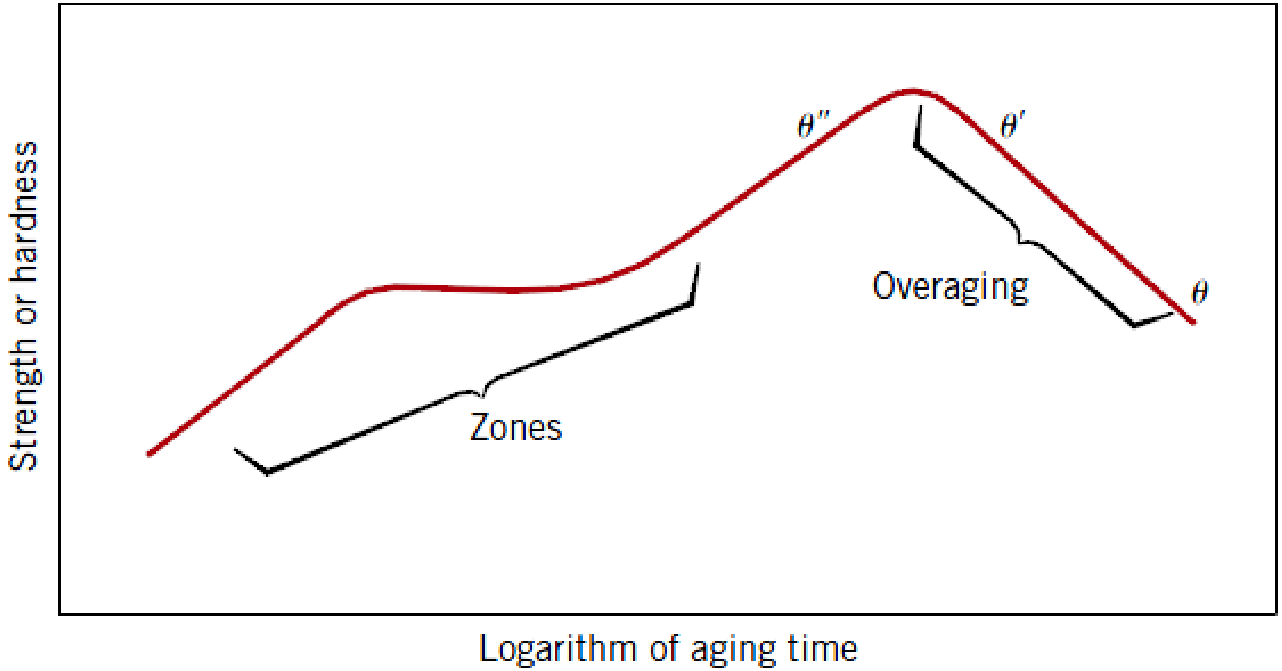
Schematic temperature-versus-time plot showing both solution and precipitation heat treatments for precipitation hardening.

Endurecimento por precipitação

The aluminum-rich side of the aluminum–copper phase diagram. (Adapted from J. L. Murray, *International Metals Review*, **30**, 5, 1985. Reprinted by permission of ASM International.)

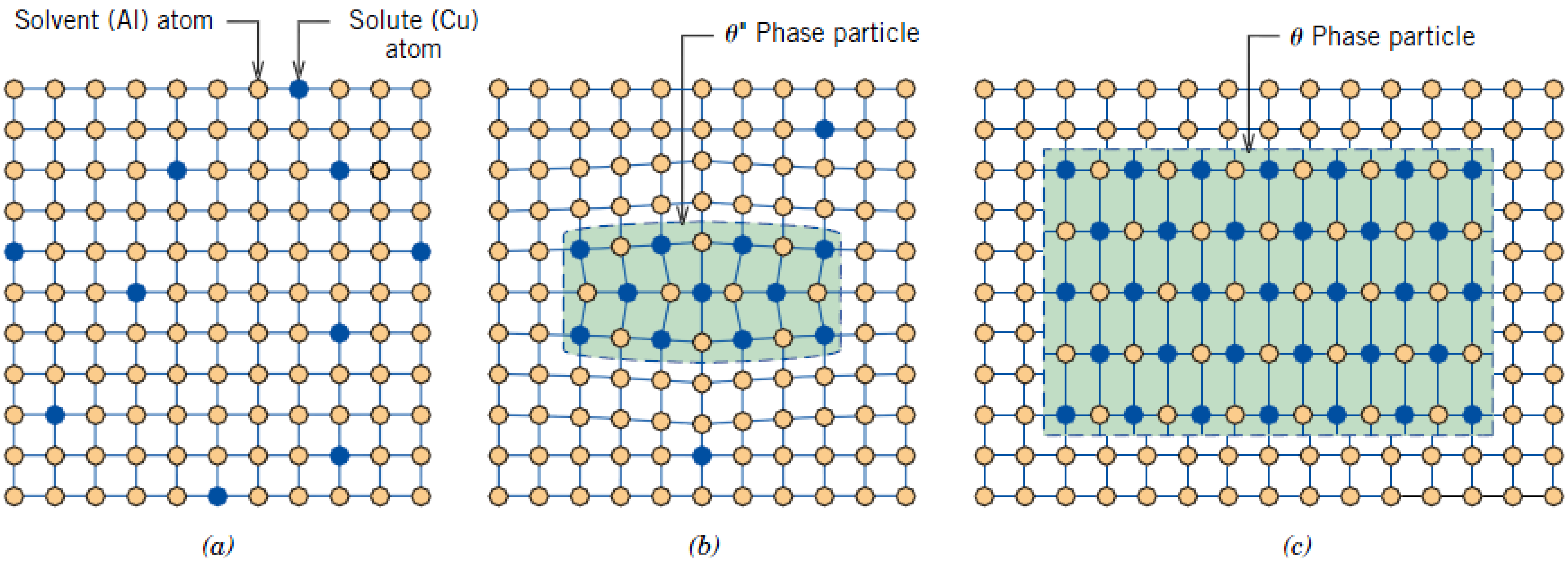


Tratamento térmico



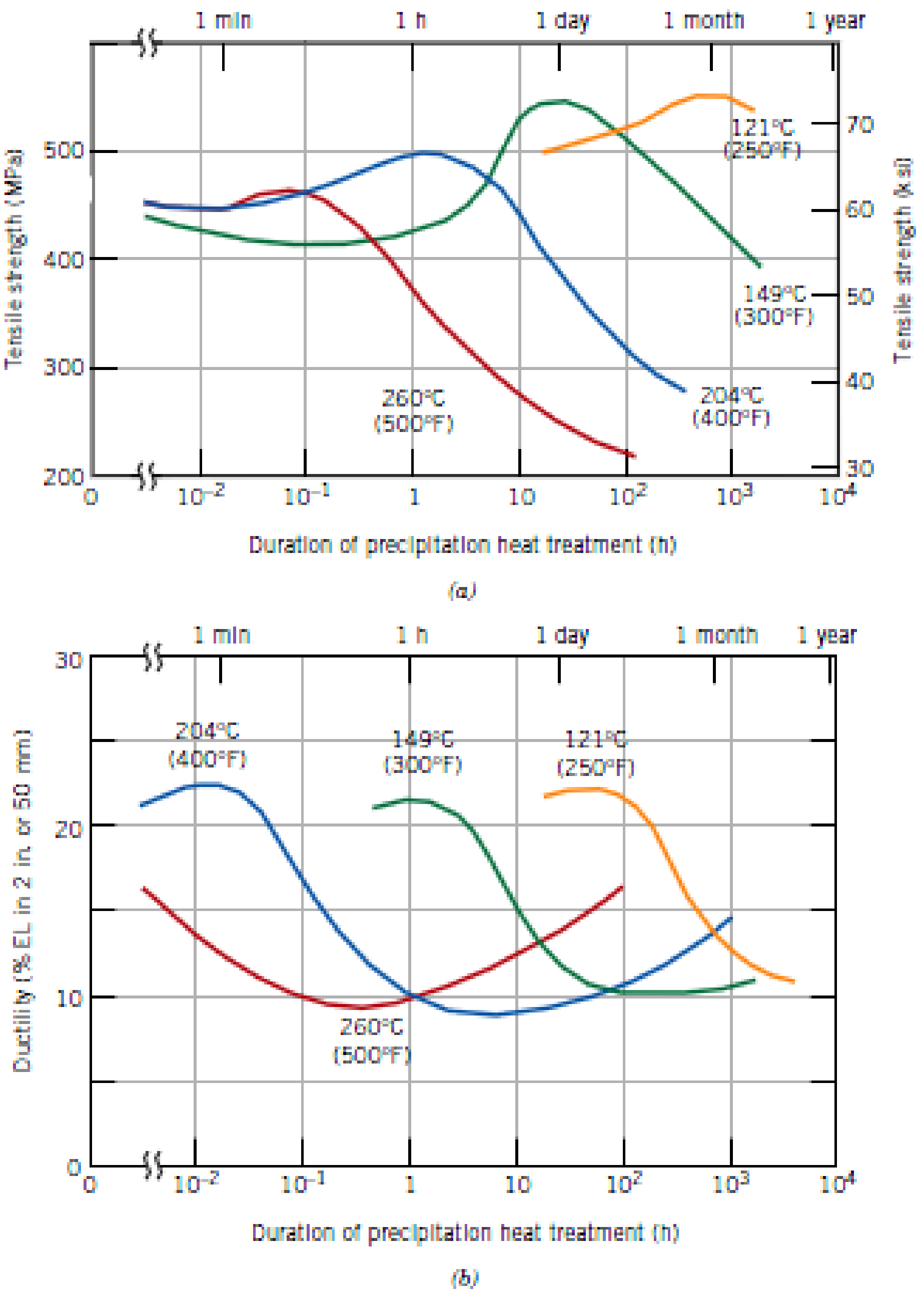
Schematic diagram showing strength and hardness as a function of the logarithm of aging time at constant temperature during the precipitation heat treatment.


STAZIONE FORI IMPERIALI
ROMA METROPOLITANE
LINEA C DELLA METROPOLITANA DI ROMA
Tratta T3
ROMA CAPITALE



Schematic depiction of several stages in the formation of the equilibrium precipitate (θ) phase. (a) A supersaturated α solid solution. (b) A transition, θ'', precipitate phase. (c) The equilibrium θ phase, within the α-matrix phase.

The precipitation hardening characteristics of a 2014 aluminum alloy (0.9 wt% Si, 4.4 wt% Cu, 0.8 wt% Mn, 0.5 wt% Mg) at four different aging temperatures: (*a*) tensile strength, and (*b*) ductility (%EL). [Adapted from *Metals Handbook: Properties and Selection: Nonferrous Alloys and Pure Metals*, Vol. 2, 9th edition, H. Baker (Managing Editor), American Society for Metals, 1979, p. 41.]



Ligas de Alumínio - CFC

- Densidade relativamente baixa: 2.7g/cm³
- Densidade do aço: 7.9g/cm³
- Condutividade térmica e elétrica elevada
- Resistência a corrosão em alguns ambientes comuns, incluindo atmosfera ambiente
- Elevada ductilidade
- Principais elementos de liga é o Cobre, Magnésio, silício, Manganês e Zinco

Ligas de Alumínio - CFC

- Classificadas: fundidas e forjadas
- As composições para ambos os tipos são designadas por um número com quatro dígitos, o qual indica quais as principais impurezas presentes e, em alguns casos, o nível de pureza. Para as ligas forjadas, existe uma vírgula, decimal localizada entre os dois últimos dígitos. Após esses dígitos, existe um hífen e a **designação de revenimento** básica – uma letra e, possivelmente, um número de um a três dígitos, que indica o tratamento macânico e/ou térmico ao qual a liga foi submetida.

Ligas de Alumínio - CFC

- Exemplo: F, H e O representam, respectivamente, os estados “como fabricado”, “encruado” e “ recozido”; T3 significa que a liga foi tratada termicamente por solubilização, submetida a deformação plástica a frio, e então envelhecida naturalmente (endurecida por envelhecimento).
- T6 solubilização e envelhecimento artificial

Ligas de Alumínio

Aluminum Association Number	*UNS Number*	*Composition (wt%)*[a]	*Condition (Temper Designation)*	*Mechanical Properties* Tensile Strength [MPa (ksi)]	*Mechanical Properties* Yield Strength [MPa (ksi)]	*Mechanical Properties* Ductility [%EL in 50 mm (2 in.)]	*Typical Applications/ Characteristics*
			Wrought, Nonheat-Treatable Alloys				
1100	A91100	0.12 Cu	Annealed (O)	90 (13)	35 (5)	35–45	Food/chemical handling and storage equipment, heat exchangers, light reflectors
3003	A93003	0.12 Cu, 1.2 Mn, 0.1 Zn	Annealed (O)	110 (16)	40 (6)	30–40	Cooking utensils, pressure vessels and piping
5052	A95052	2.5 Mg, 0.25 Cr	Strain hardened (H32)	230 (33)	195 (28)	12–18	Aircraft fuel and oil lines, fuel tanks, appliances, rivets, and wire

Ligas de Alumínio

Aluminum Association Number	UNS Number	Composition (wt%)[a]	Condition (Temper Designation)	Mechanical Properties: Tensile Strength [MPa (ksi)]	Mechanical Properties: Yield Strength [MPa (ksi)]	Mechanical Properties: Ductility [%EL in 50 mm (2 in.)]	Typical Applications/ Characteristics
Wrought, Heat-Treatable Alloys							
2024	A92024	4.4 Cu, 1.5 Mg, 0.6 Mn	Heat-treated (T4)	470 (68)	325 (47)	20	Aircraft structures, rivets, truck wheels, screw machine products
6061	A96061	1.0 Mg, 0.6 Si, 0.30 Cu, 0.20 Cr	Heat-treated (T4)	240 (35)	145 (21)	22–25	Trucks, canoes, railroad cars, furniture, pipelines
7075	A97075	5.6 Zn, 2.5 Mg, 1.6 Cu, 0.23 Cr	Heat-treated (T6)	570 (83)	505 (73)	11	Aircraft structural parts and other highly stressed applications

Ligas de Alumínio

Aluminum Association Number	UNS Number	Composition (wt%)[a]	Condition (Temper Designation)	Mechanical Properties: Tensile Strength [MPa (ksi)]	Mechanical Properties: Yield Strength [MPa (ksi)]	Mechanical Properties: Ductility [%EL in 50 mm (2 in.)]	Typical Applications/ Characteristics
			Cast, Heat-Treatable Alloys				
295.0	A02950	4.5 Cu, 1.1 Si	Heat-treated (T4)	221 (32)	110 (16)	8.5	Flywheel and rear-axle housings, bus and aircraft wheels, crankcases
356.0	A03560	7.0 Si, 0.3 Mg	Heat-treated (T6)	228 (33)	164 (24)	3.5	Aircraft pump parts, automotive transmission cases, water-cooled cylinder blocks

Ligas de Alumínio

Aluminum Association Number	UNS Number	Composition (wt%)[a]	Condition (Temper Designation)	Mechanical Properties: Tensile Strength [MPa (ksi)]	Yield Strength [MPa (ksi)]	Ductility [%EL in 50 mm (2 in.)]	Typical Applications/ Characteristics
			Aluminum–Lithium Alloys				
2090	—	2.7 Cu, 0.25 Mg, 2.25 Li, 0.12 Zr	Heat-treated, cold-worked (T83)	455 (66)	455 (66)	5	Aircraft structures and cryogenic tankage structures
8090	—	1.3 Cu, 0.95 Mg, 2.0 Li, 0.1 Zr	Heat-treated, cold-worked (T651)	465 (67)	360 (52)	—	Aircraft structures that must be highly damage tolerant