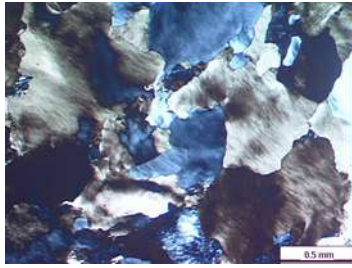
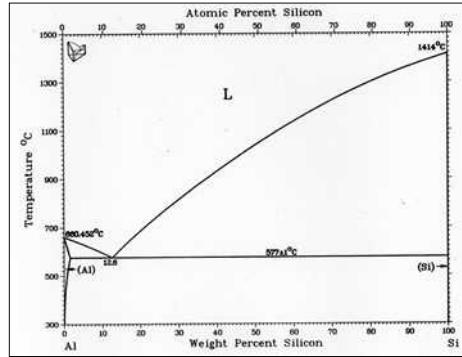


The Aluminum-Silicon Phase Diagram and Eutectic Modifications



Deformed grain structure of 99.999% Al; Barker's Reagent, Polarized Light



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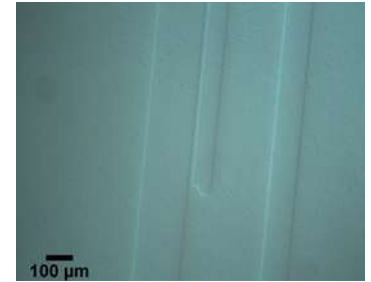
The Al-Si phase diagram is a straightforward, classic example of a eutectic system where each element has little, if any solubility in the other. Aluminum melts at 660.452 °C while silicon melts at 1414 °C. The diagram, from Murray and McAlister (Vol. 8, Metals Handbook, 8th ed., 1973, p. 263), shows the eutectic at 12.6 wt. % Si and 577 °C. The maximum solubility of Si in Al is ~1.65% at 577 °C, and the solubility decreases with decreasing temperature. There is virtually no solubility for Al in Si at any temperature to the melting point.

The addition of silicon to aluminum improves fluidity; hence there are a number of commercially important alloys with ~7 wt. % Si. These alloys are used as sand castings or as permanent mold castings. There are also commercial alloys made at and above the eutectic Si content, mainly by injection molding, sometimes under pressure. These alloys solidify quickly and exhibit no long-range segregation. To obtain better properties, both hypoeutectic and quasi-eutectic alloys are modified by the addition of Sr or Na which affect the shape of acicular Si eutectic particles producing a globular shape. Phosphorous is added to quasi-eutectic and hypereutectic alloys so as to disperse and reduce the size of primary silicon cuboids. Ti and B are added to hypoeutectic alloys which decreases the size of primary α -Al dendrites in hypoeutectic compositions. Faster cooling rates, as achieved by gravity or pressure die casting, promote greater than equilibrium amounts of proeutectic α -Al and a finer eutectic particle spacing.

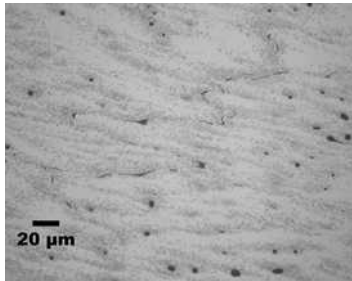
The table illustrates the procedure used to prepare the micrographs shown. While standard etchants, such as Keller's or 0.5% aqueous HF, can be used to reveal the Si particles, other reagents are more useful. Weck's reagent for Al (100 mL water, 4 g KMnO₄ and 1 g NaOH) colors the α -Al structure revealing segregation while the "Si-Blue" etch (90 mL water, 4 mL HF, 4 mL H₂SO₄, 2 g CrO₃) will color the Si particles blue gray.

Table 1: Preparation Method for Al-Si Specimens

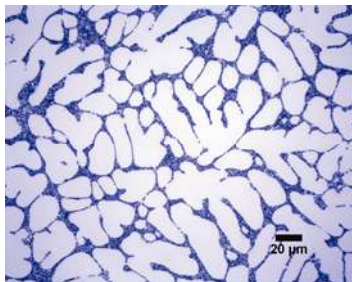
Surface	Abrasive Size	Load Lb (N)	Platen Speed/Direction	Time (min)
CarbiMet® 2 psa paper	220-320-grit SiC water cooled	5 (22)	200-240 rpm Contra	1 each
UltraPol® silk cloth	9- μ m Diamond with MetaDi® Fluid	5 (22)	150 rpm Contra	5-10
TriDent® polyester cloth	3- μ m Diamond with MetaDi® Fluid	5 (22)	150 rpm Contra	5-7
MicroCloth® pad	MasterMet® Colloidal Silica	5 (22)	100-150 rpm Contra	3
MicroCloth® pad	MasterMet® Colloidal Silica	-	VibroMet® 2 Vibratory Polisher	≥ 30



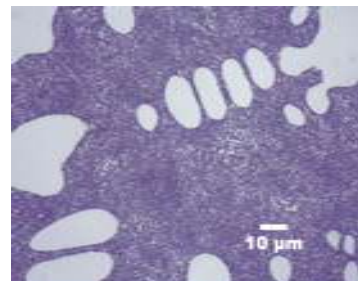
Twins in polycrystalline 99.9999% Si, as-cast, aqueous 75% NaOH, Nomarski DIC



Al – 1% Si as-cast specimen with Si particles in an α -Al matrix; "Si Blue" etch



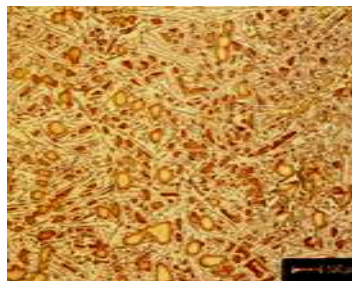
Al – 7.12% Si, as-cast, with primary α -Al dendrites and an α -Al/Si eutectic; "Si Blue" etch



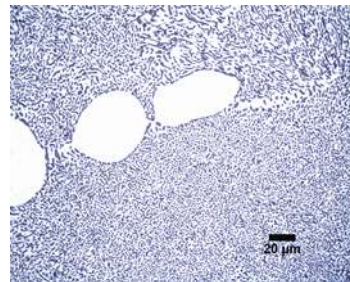
Al – 11.7% Si, as-cast, with primary α -Al dendrites and an α -Al/Si eutectic; "Si Blue" etch



Al – 12% Si, as-cast, near eutectic, "Si Blue" etch



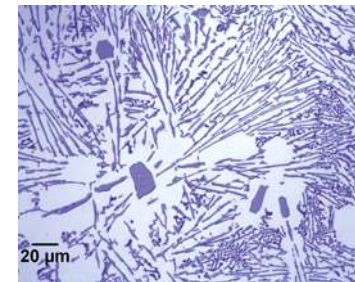
Al – 12% Si, as-cast, near eutectic; Weck's Reagent, Polarized Light



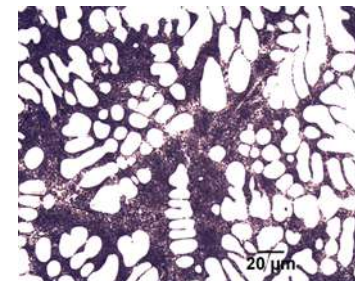
Na-Modified Al – 12% Si, as-cast, near eutectic, "Si Blue" etch



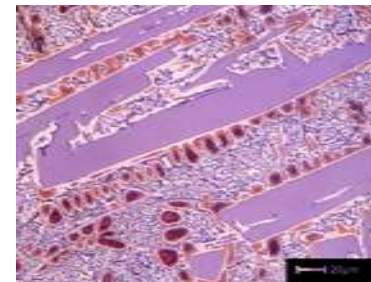
Na-Modified Al – 12% Si, as-cast, near eutectic, Weck's Reagent, Polarized Light



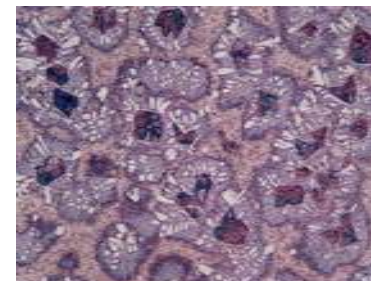
Al – 12.9% Si, gravity die cast, "Si Blue" etch



Al – 12.9% Si – 0.04% Sr, gravity die cast, "Si Blue" etch



Al – 25% Si, as-cast, hypereutectic, primary Si and an α -Al/Si eutectic, Weck's Reagent



Al – 19.85% Si, as-cast, hypereutectic, primary Si plus eutectic, Weck's Reagent - eutectic cells, 200X



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