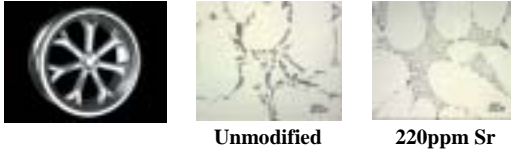


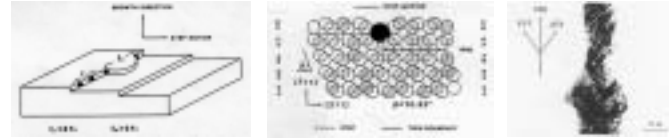
The role of segregation in the eutectic modification of hypoeutectic Al-Si alloys

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Modification of Al-Si foundry alloys



Mechanism of modification



Objective

- To determine the Sr segregation pattern in modified hypoeutectic Al-Si alloys by micro-XRF in SPring-8 radiation
- To understand the mechanism of eutectic modification with trace element additions

Remaining questions

There is no mechanism to explain the difference between the theoretical best radius ($r/r_{Si}=1.65$) vs. practical performance of modifier elements.

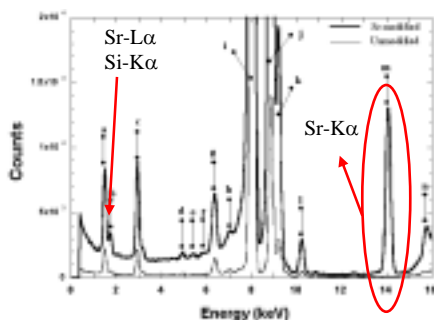
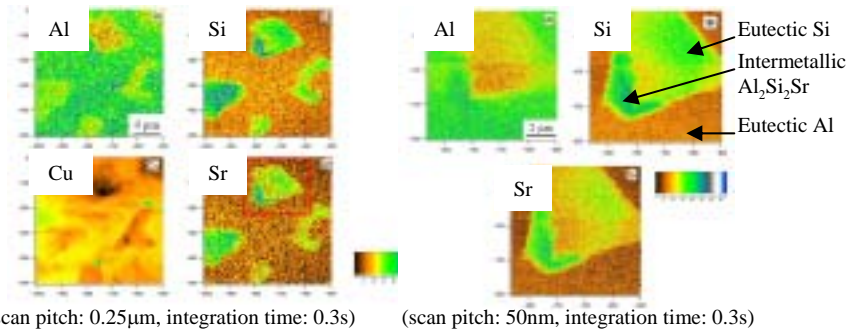
$Na (r/r_{Si}=1.59) > Ca (r/r_{Si}=1.68) \text{ or } Yb (r/r_{Si}=1.66)$

There is no mechanism to explain the difference between fibrous modification (by Na, Sr, Ba and Ca) or short needle-like modification (by Sb, Y, Yb).



Reconsider “Twin Plane Re-entrant Edge (TPRE)” theory

SPring-8 synchrotron radiation - Micro-XRF results



Micro-XRF spectra of Sr-modified and unmodified alloys

First-principle calculations

Elemnt	Chemical potential of impurity atom doping (eV/atom)									
	Isolated Atom			Atom-Atom pair			Vacancy-Atom pair			change
	Al	Si	(ϕ)	Al	Si	(ϕ)	Al	Si	(ϕ)	
Sr	2.96	3.56	0.60	0.40	2.11	1.71	0.64	(0.28)	(0.93)	(1.53)
Na	0.82	3.75	2.93	0.81	1.72	0.91	0.76	0.51	(0.25)	(3.18)
Ca	0.18	3.12	2.93	0.19	1.55	1.36	0.00	(0.58)	(0.58)	(3.52)
Eu	0.05	2.96	2.90	(0.22)	1.29	1.51	(0.37)	(0.92)	(0.55)	(3.45)
Ba	2.12	3.85	1.73	1.05	2.39	1.34	0.81	0.08	(0.73)	(2.46)
Yb	0.11	3.12	3.01	0.09	1.41	1.32	(0.06)	(0.57)	(0.51)	(3.52)
Sb	0.92	1.03	0.11	0.85	1.28	0.43	0.68	(0.46)	(1.14)	(1.26)
Y	(0.61)	2.62	3.23	(0.46)	0.88	1.35	(0.69)	(1.26)	(0.57)	(3.80)

All the impurity atoms are more favorably dissolved into Al rather than Si when vacancies are absent.

Conclusions

- Sr segregation in hypoeutectic Al-Si alloys has been investigated using micro-XRF in the SPring-8 facility.
- Sr strongly segregates to the Si phase and a small number of Sr-rich intermetallics.
- Sr is of negligible concentration in the Al phases.
- Sr is relatively homogeneously distributed in the eutectic Si.
- These results support, but not exclusively, the major eutectic modification mechanism based on impurity-induced twinning.
- Any modification mechanisms involving segregation of Sr in the liquid ahead of the advancing Si interface can be discounted.