Dominant strengthening mechanism of AlSi10Mg processed by Selective Laser Melting

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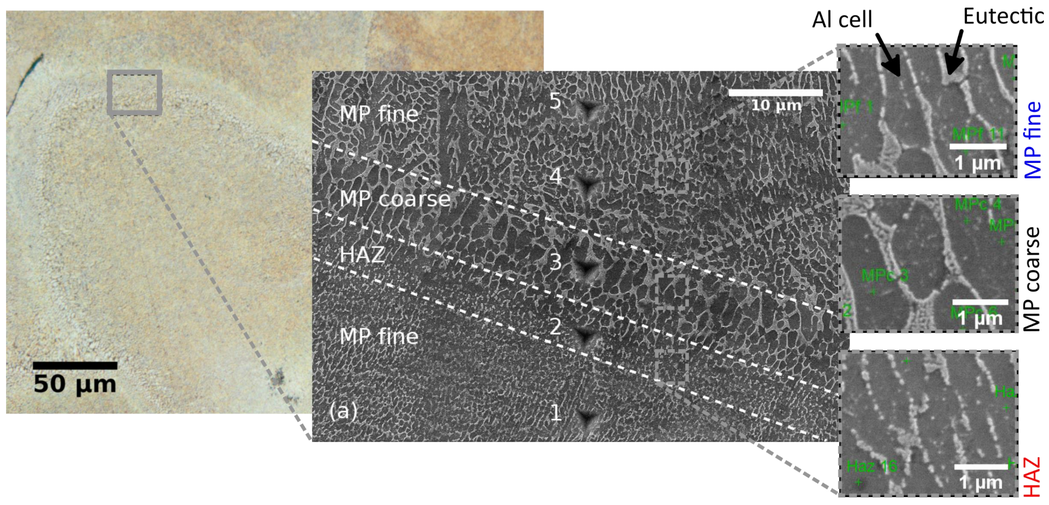
Abstract

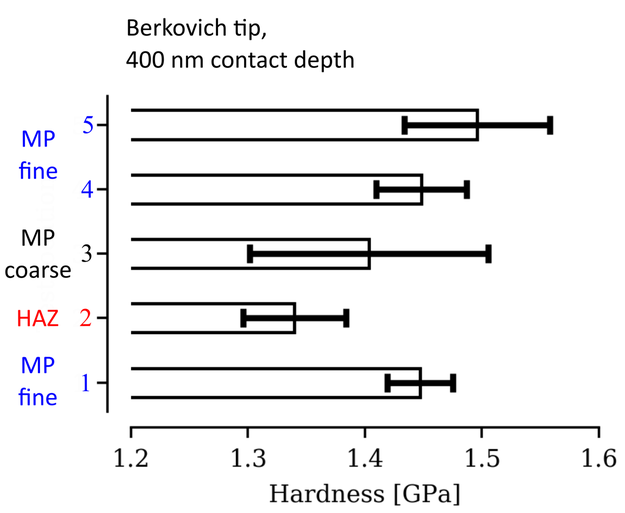
AlSi10Mg processed by Selective Laser Melting (SLM) exhibits a very fine cellular-eutectic microstructure due to the high cooling rate during the process [1]. This high cooling rate also results in an extended Si solute content in solid solution inside the Al cells. Both the Si in solid solution and the Si precipitated inside the eutectic contribute to the high strength of the alloy. The aims of this poster is to determined which one is the dominant strengthening mechanism through nanoindentation and SEM-EDX tests.

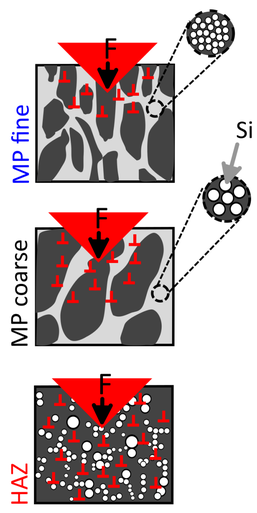
Microscale – microstructure & hardness

SLM



The inhomogeneous microstructure at the melt pool boundary (Melt Pool coarse, Melt Pool fine and Heat Affected Zone) is composed of Al cells surrounded by a discontinuous eutectic (Al+Si precipitates mixture). Destruction of eutectic walls in HAZ is observed as well by Si precipitate coarsening.



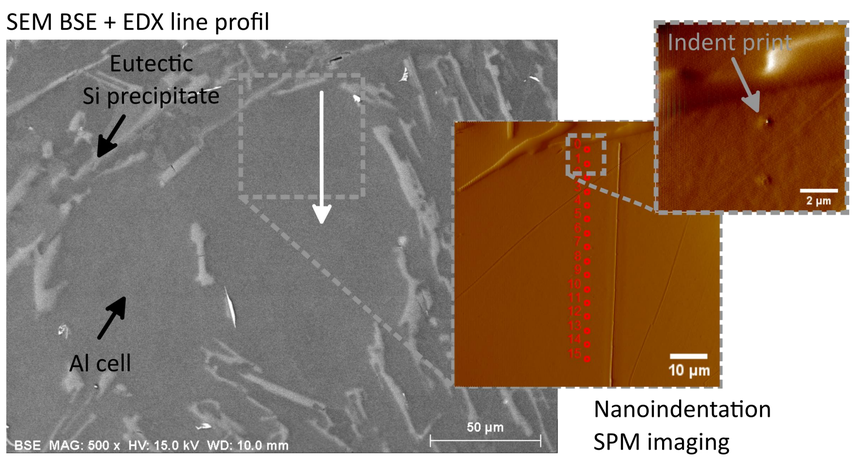


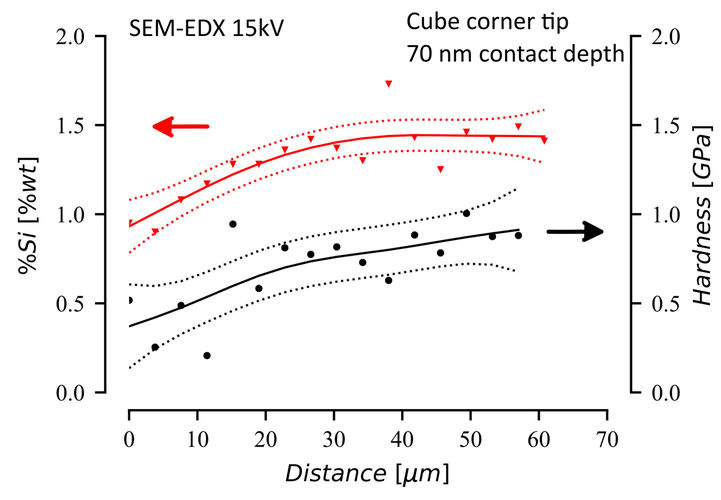
- Eutectic network
- Eutectic network (less efficient due to Si precipitate size)
- "Low" hardness, broken network with big Si precipitate

Eutectic network prevents dislocation slip.

Reference for hardness vs Si in solid solution

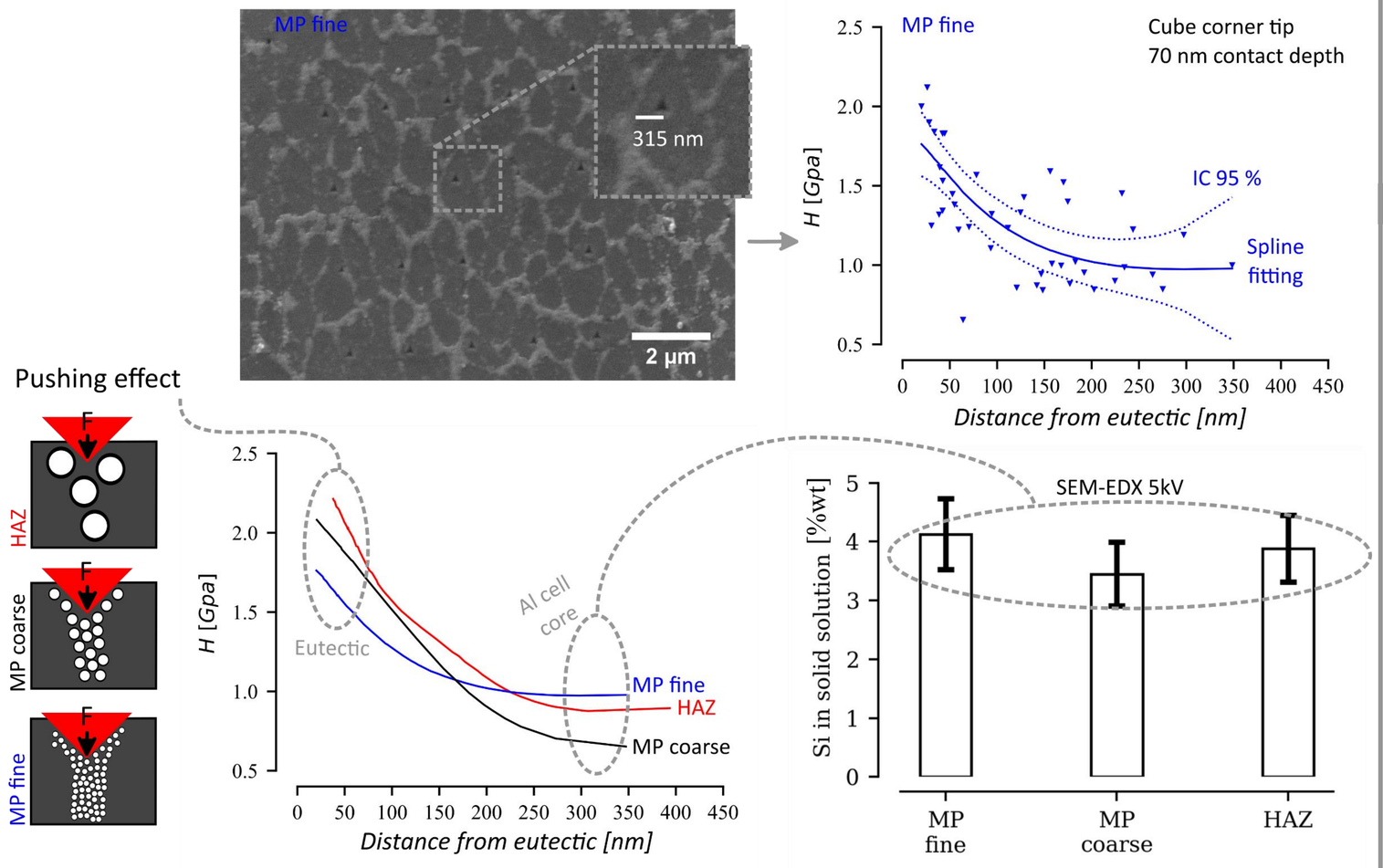
Cast

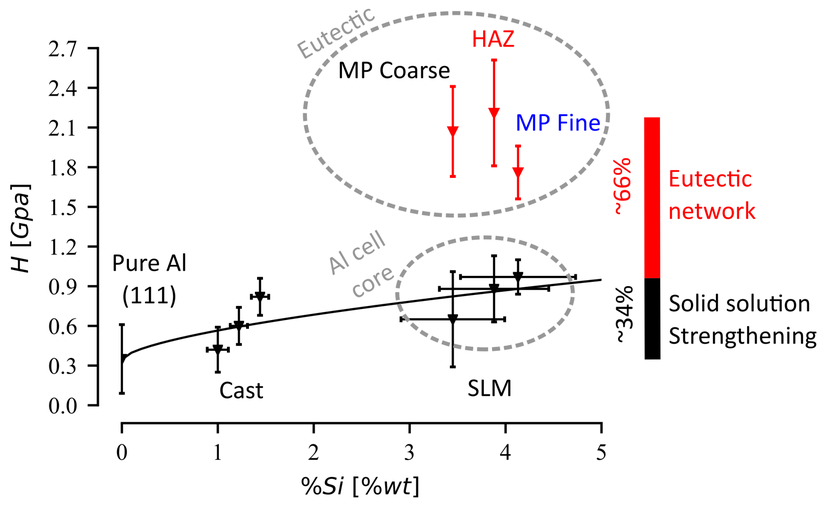




Good correlation between hardness and Si in solid solution.

Sub-micro (Al cell) scale – Si in solid solution & hardness





- Si precipitate inside the eutectic "wall"-> dominant strengthening mechanism (66% of total hardness).
- Limited effect of Si solution strengthening (34% of total hardness).
- H=f(%Si) model trend in good agreement with literature [3].

- Si solute trapping inside Al cells related to high cooling rate ($\dot{T}$) -> ↑ hardness (H). $\dot{T}_{MPcoarse} < \dot{T}_{Mpfine/Haz}$ [2] -> $H_{Al\_MPcoarse} < H_{Al\_Mpfine/Haz}$.
- ↑ hardness when indents close to eutectic -> Si precipitate strengthening.
- Hardness sensitive to Si precipitate size when indents inside eutectic -> "pushing effect".

Conclusions

- Si precipitates inside eutectic mainly responsible for AlSi10Mg SLM strength
- Eutectic network configuration prevents dislocation slip
- **Future work :** Impact of in situ age hardening during the building process. Determining the kinetic of Si coarsening inside HAZ through Phase Field modeling

[1] A.I. Mertens, J. Delahaye, J. Lecomte-Beckers, Adv. Eng. Mater. 19 (2017) 1–13.
[2] J. Delahaye et al., THERMEC'2018 (2018) http://hdl.handle.net/2268/227349.
[3] E. Sjölander et al., Int. J. Cast. Metal. Res. 24 (2011) 338–346.