



Niobium in Aluminium Cast Parts

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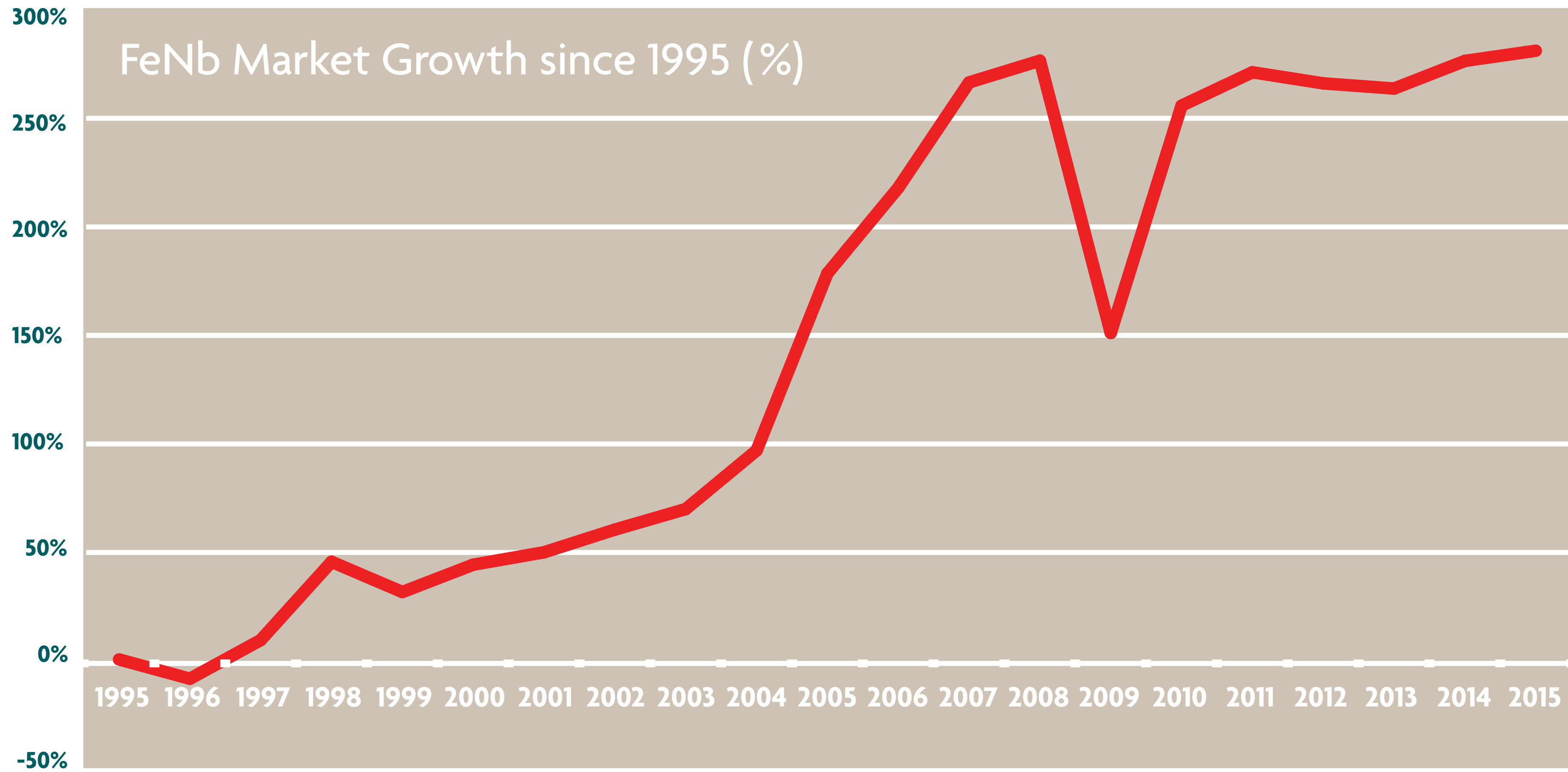
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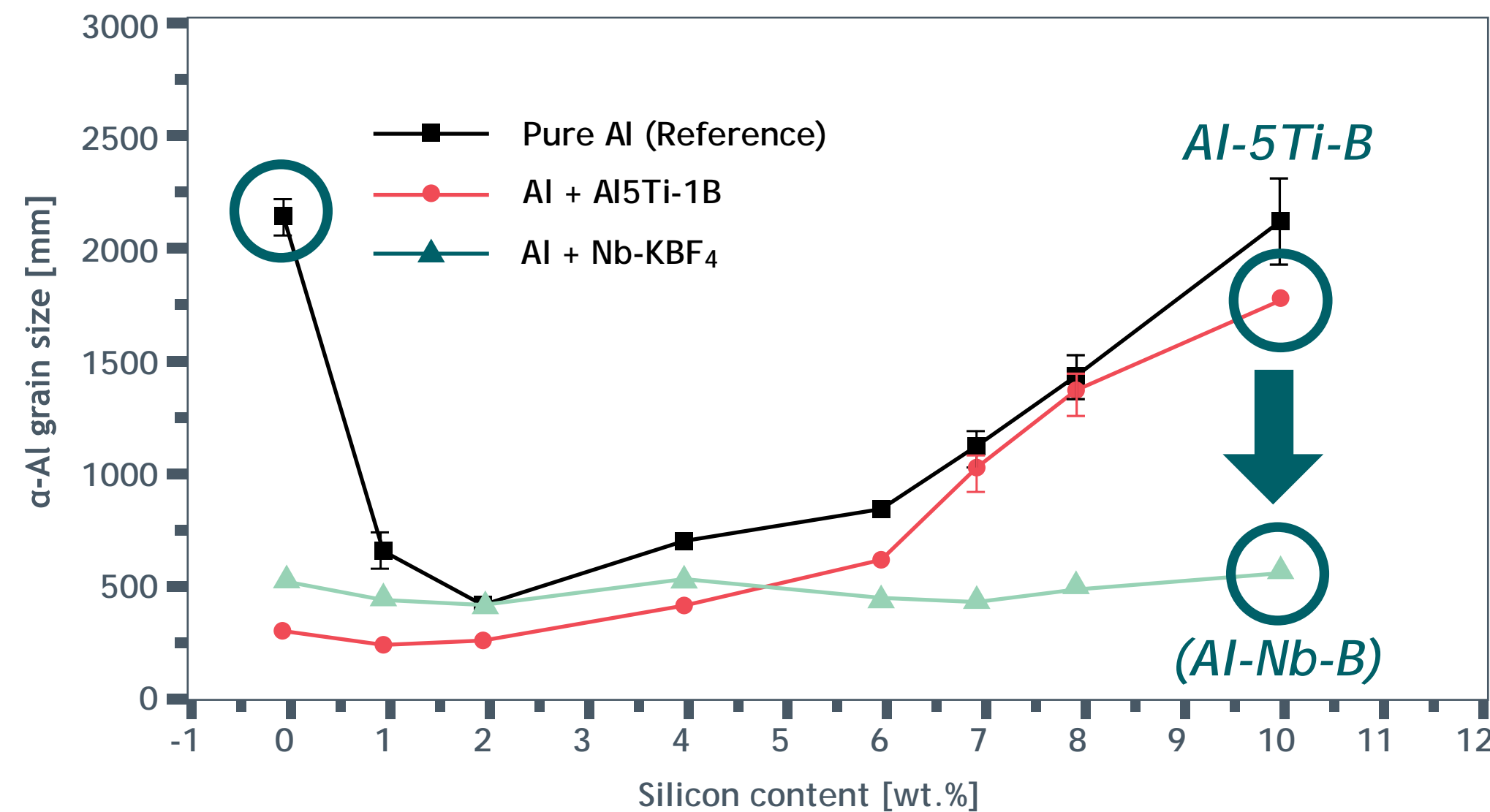
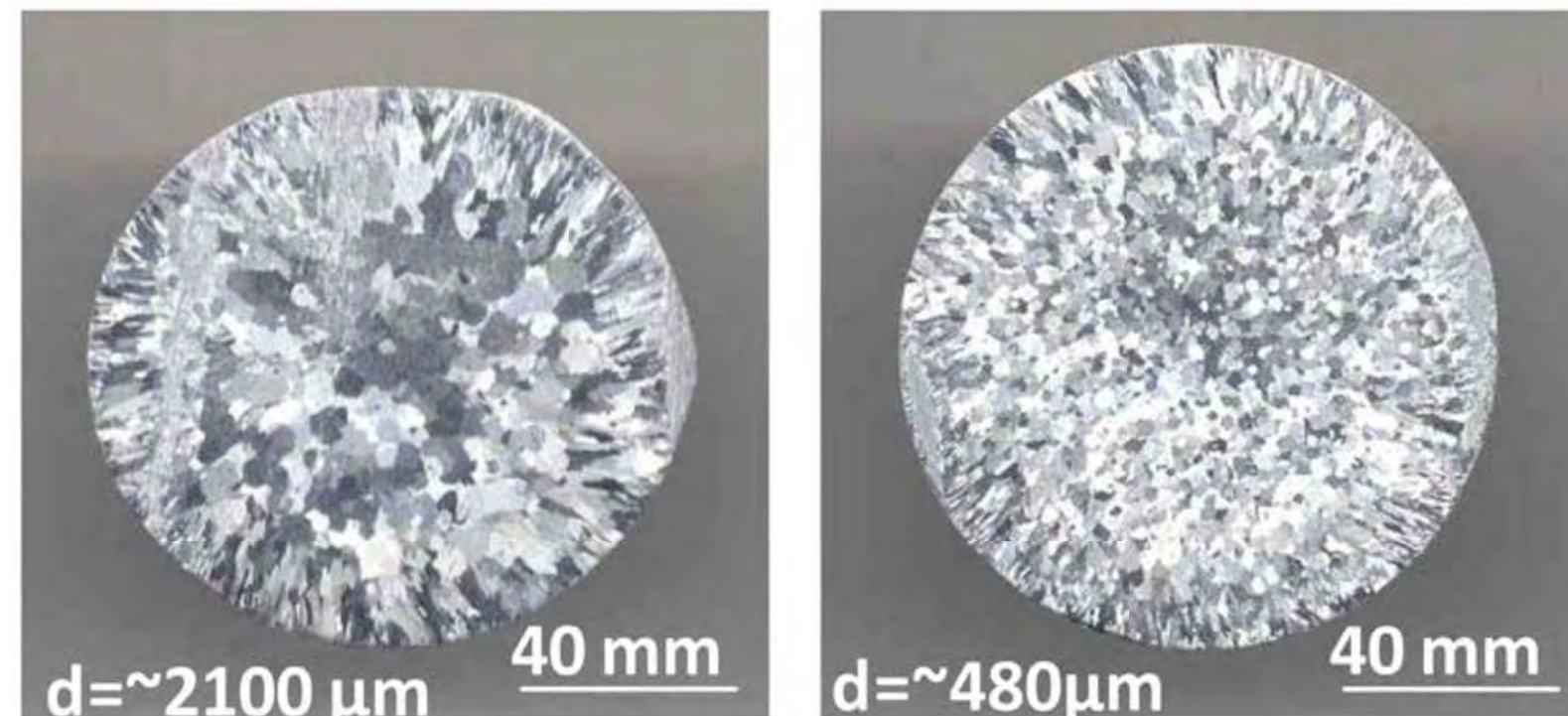
About Niobium

- Naturally occurring chemical element (Nb) discovered in 1801
- Available and reliable supply
- Soft, metal which is ductile, malleable, and highly resistant to corrosion
- Mined, processed and formulated to products for alloying to create a range of high performance materials
- Small amounts combined with aluminium improves integrity, strength and elongation

Niobium's Growth Story



How Niobium works in Aluminium



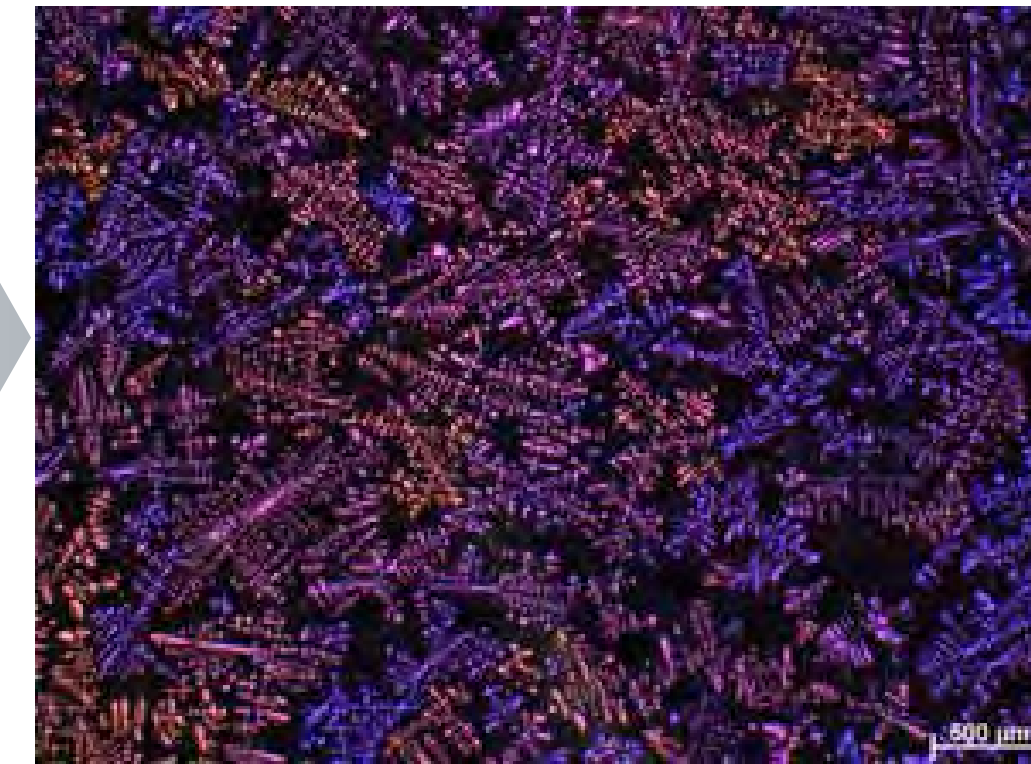
- Aluminium silicon casting technology used widely in automotive industry
- Addition of Niobium via Aluminium-Niobium-Boron master alloy reduces grain size and significantly improves performance by
 - Increasing integrity of thin and complex parts
 - Reducing porosity and hot tearing
 - Increasing and improving homogeneity of mechanical properties
- Potential for weight savings without loss of strength
- Also, important additional benefits from Niobium
 - Improves inhouse recycling rates
 - Tolerates iron impurity
 - Retains fine grain structure in several remelt cycles

Niobium grain refinement in Al-Si alloys

A354 alloy used widely in production of cylinder heads and other powertrain parts



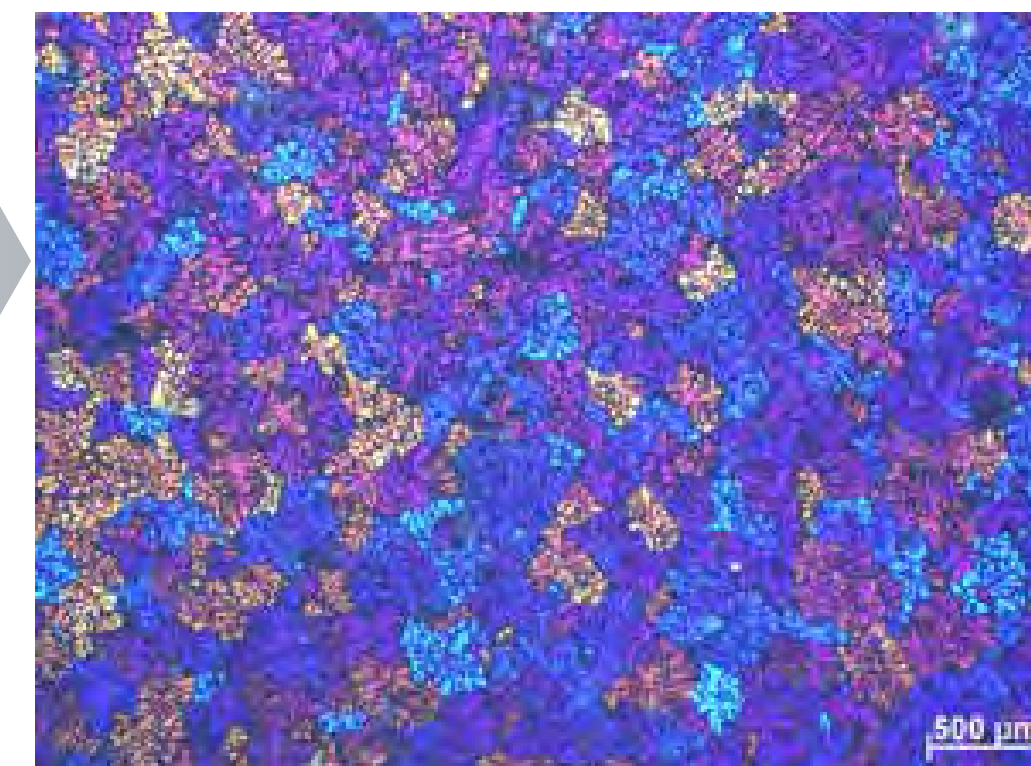
Ai-Nb-B addition



A357 alloy used in production of aluminium wheels powertrain and suspension parts



Ai-Nb-B addition



Development of Niobium aluminium technologies

- Brunel University (UK) patented Niobium master alloy for use with Aluminium-Silicon (Al-Si) and Magnesium-Aluminium casting alloys
- Further research found master alloy showed much greater grain refinement in widely used Aluminium-Silicon alloys than titanium
- Niobium master alloy delivered significant improvements in both tensile strength and ductility in Aluminium and Magnesium based alloys
- Brunel researchers believe Niobium could deliver potentially weight savings of up to 30% in Al-Si alloy applications by improving integrity and mechanical properties
- Also, potential for increased recycling as Niobium master alloy could offset iron contamination which causes embrittlement
- Additional, detailed research into applications and benefits ongoing with industry partners
- Won Institute of Materials Charles Hatchett Prize and the Cast Metal Federation's 2015 Innovation Award

Niobium improves mechanical performance

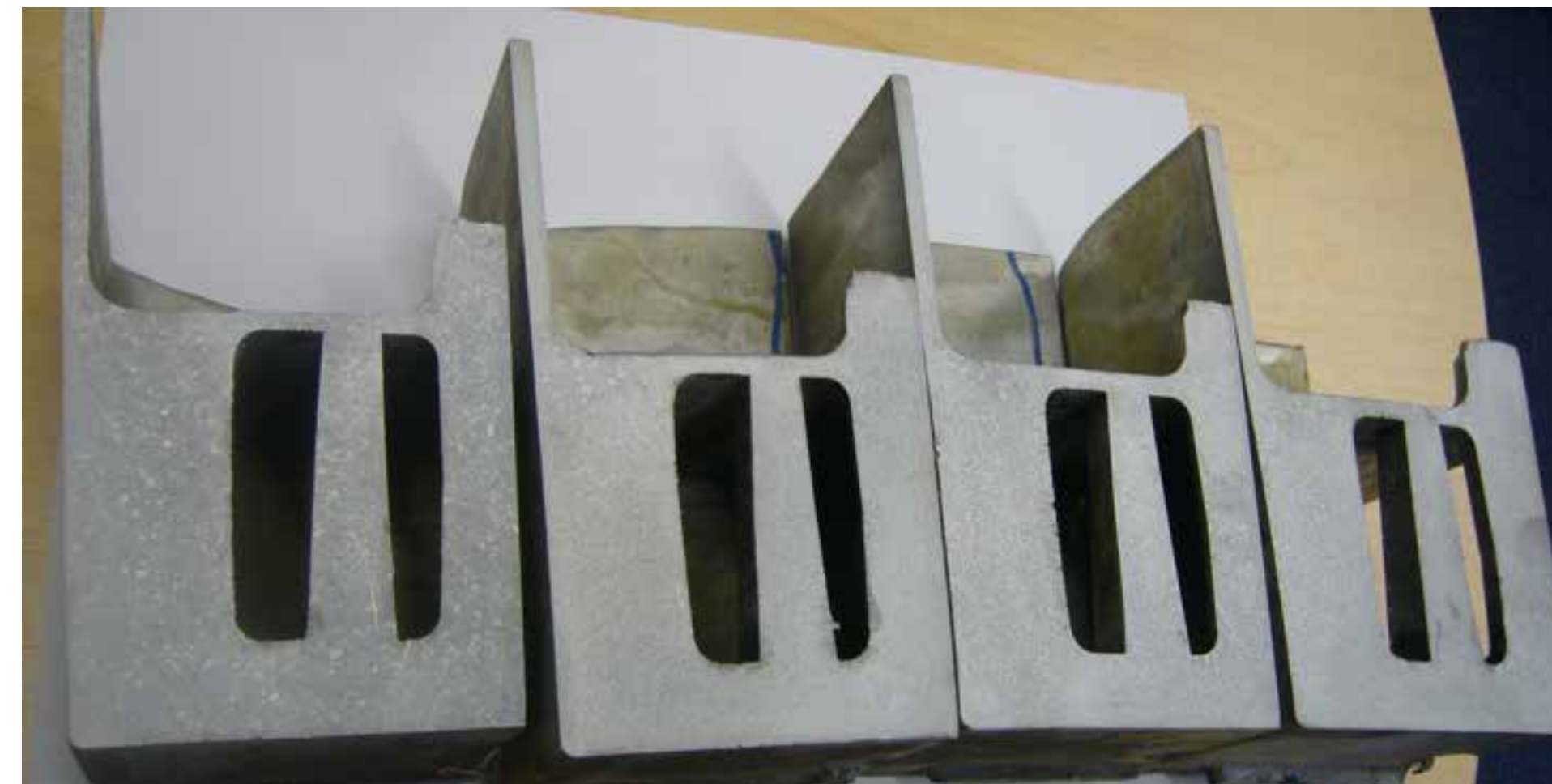
- Niobium addition creates fine and uniform grain structure
 - Improving strength
 - Reducing casting defects and shrinkage porosity
 - Consistent across thin and thick sections
- Enables lightweighting



Al-9Si-2Cu alloy

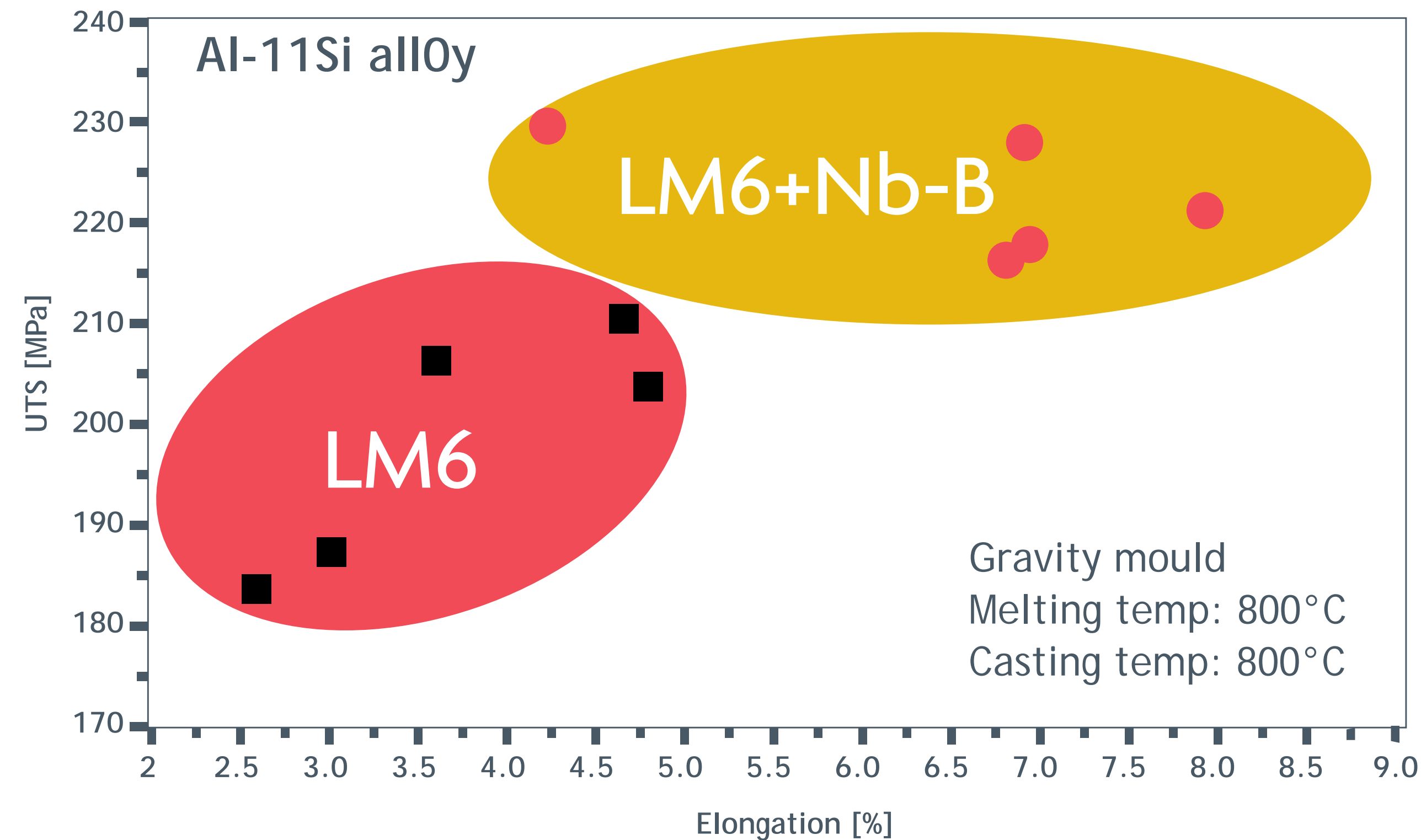


Al-9Si-2Cu alloy with Al-Nb-B



Fine and uniform grain structure in Al-Si alloy with Al-Nb-B master alloy addition

Niobium Niobium grain refinement improves strength and ductility in laboratory tests



Machined from cast bars

Improved

- Crash Performance
- Fatigue performance

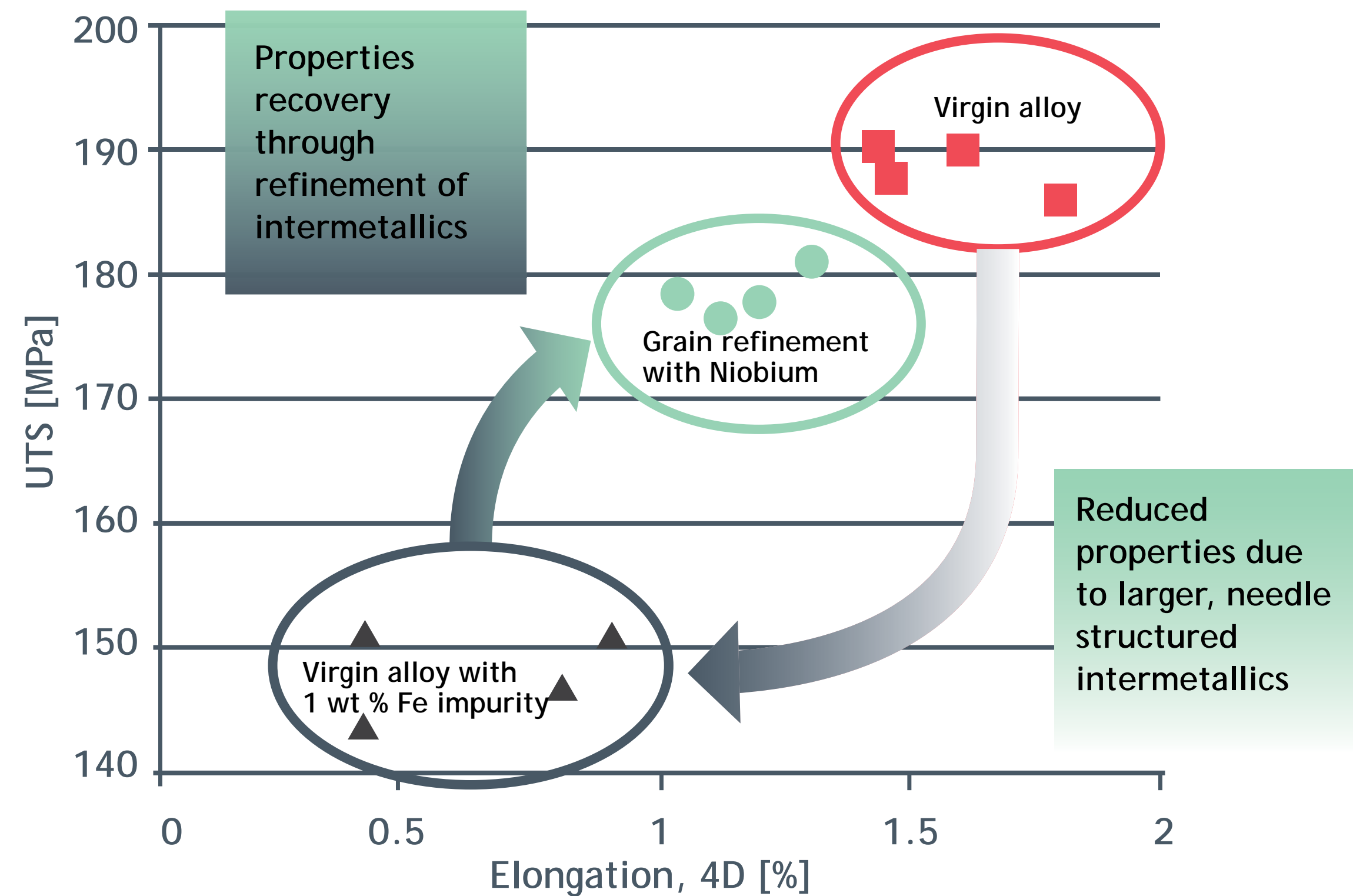
Yield 82.4Mpa → 102Mpa

Grain refinement of Al-Si alloys by Nb-B inoculation: M. Nowak, L. Bolzoni and H.B. Nadendla. BCAST, Brunel University London. The Charles Hatchett Award 2016 Lecture.

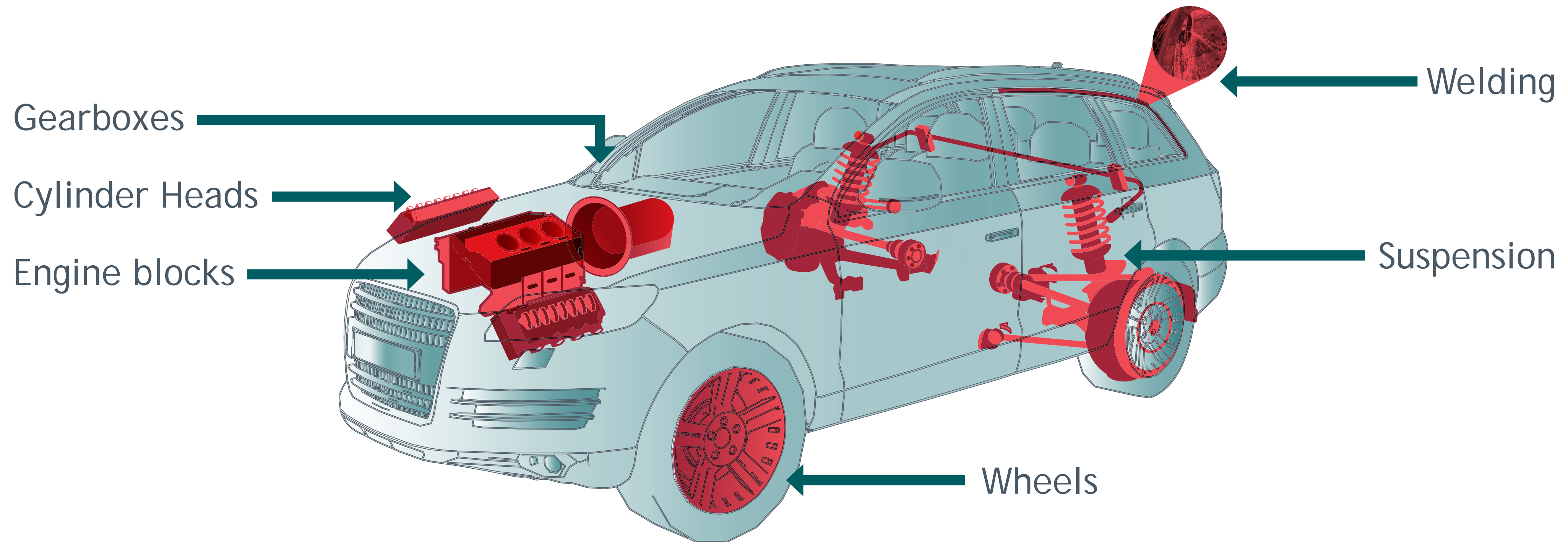
Niobium improves Aluminium scrap recovery

- Iron can occur in Aluminium casting alloys either from contamination or casting techniques
- Iron reduces the tensile strength and elongation of Aluminium alloys
- Grain refinement with Niobium reduces this problem
 - Enables increased onsite recovery of scrap without need for reprocessing
- Niobium containing Aluminium ingots retain fine grain structure in several remelt cycles

Recovery of properties in Fe-rich aluminium scrap



Potential Niobium Applications



Niobium in Wheels

- Research underway to confirm real world benefits of Niobium master alloy to wheels with leading wheel producers
- Potential to reduce thickness of rim and disc material to
 - Reduce weight
 - Improve design
 - Increase fatigue resistance
 - Extend wheel life

Niobium in Engine Parts

- Niobium master alloys can deliver significant grain reductions in Al-Si alloys used in engine blocks and cylinder heads
- Potential to **improve the integrity** of the part and reduce porosity
- Industrial scale research and testing with leading OEM is underway
- Leading to possible weight reduction and improved wear characteristic

Niobium in Gearboxes

- Niobium master alloys can deliver significant grain reductions in Al-Si alloys
- Potential to improve integrity and reduce porosity, creating parts that are
 - Thinner, with more complex designs
 - Tougher and harder wearing

Niobium in Suspension

- Research underway to confirm that Niobium grain refinement increases strength and elongation
- Potential to reduce part thickness to
 - Reduce weight
 - Improve design
 - Increase fatigue resistance
 - Extend life

Niobium in Welding

- Aluminium welding faces major challenges
 - Can reduce the strength of Aluminium by up to 50%
 - Cracking during weld solidification
- Applying Niobium to the weld creates grain refinement that has potential to
 - Reduce the base metal's susceptibility to solidification cracking
 - Improve weldability
 - Increase yield strength, ductility and in some cases tensile strength of the weld metal

Conclusion

- Niobium-Boron addition to Aluminium-Silicon alloys refines the grain structure of cast parts
- End-user benefits
 - Improved strength and ductility: lighter and thinner structures
 - Homogenous properties (thick and thin sections): complex structures
 - Tolerant to Fe contamination: closed loop recycling of scrap containing higher Fe
 - Reduced shrinkage porosity - improved soundness: reduces component rejection ratio