Heat Treatment on Magnesium Aluminum Zinc Alloy AZ91D

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Overview

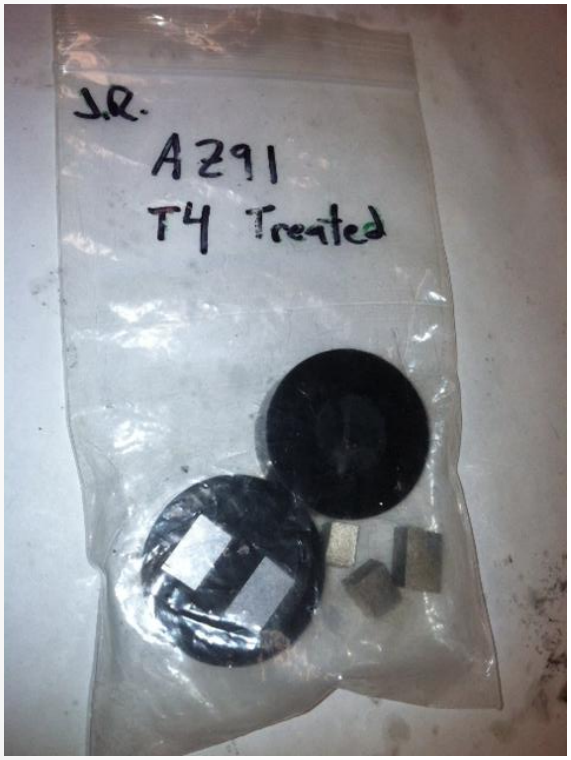
- Introduction to Composites and AZ91D
- Practical applications of Magnesium alloys and impetus for further exploration
- Experimental Tools
- Experimental procedure
- Results
- Conclusion

Composite Materials

- A composite material is a material comprised of more than one element, wherein they retain their physical and chemical identity.
  - Ex. Plywood, chocolate chip cookie
- Alloy is the specific term classifying metal composite materials
  - Ex. AZ91D

Composite Materials Lab

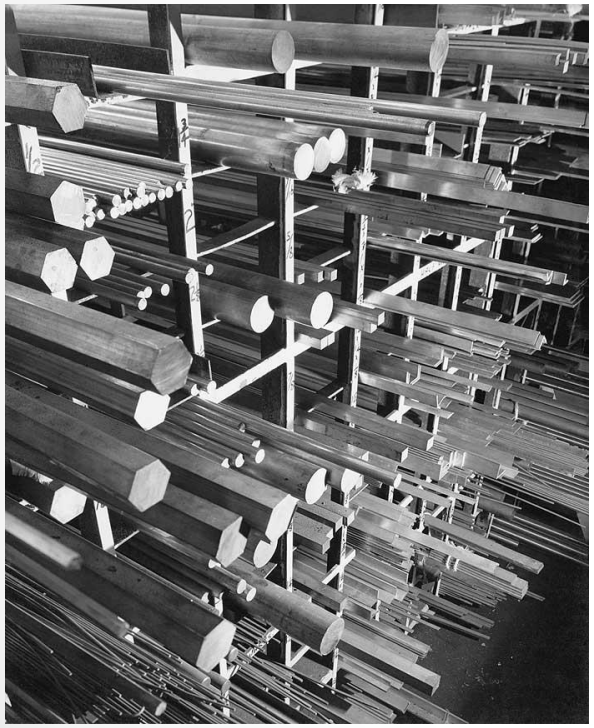
- Studying Forged Alloys



- Creating your own composites

Alloy Material Examples

- Steel

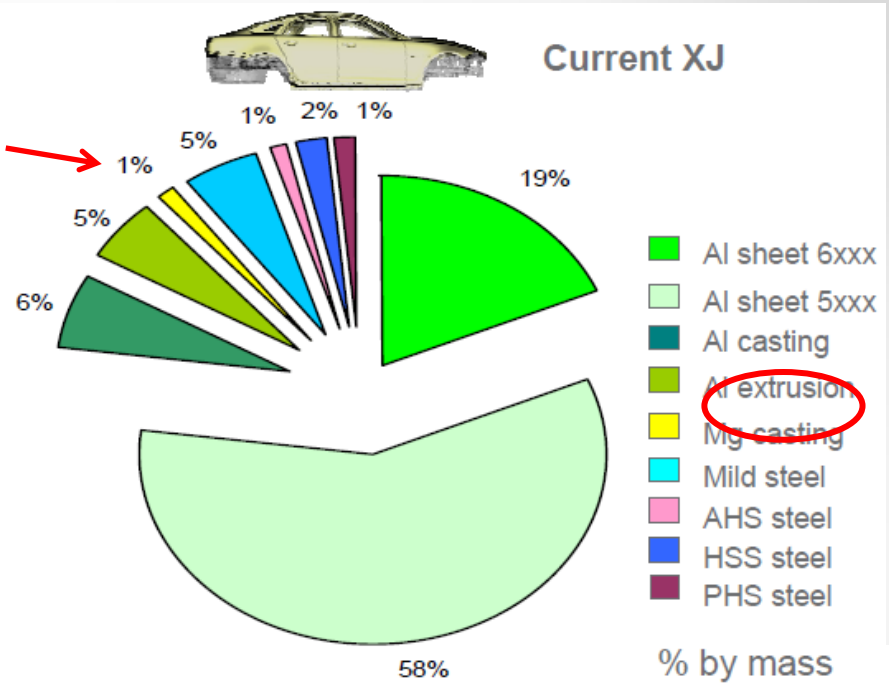


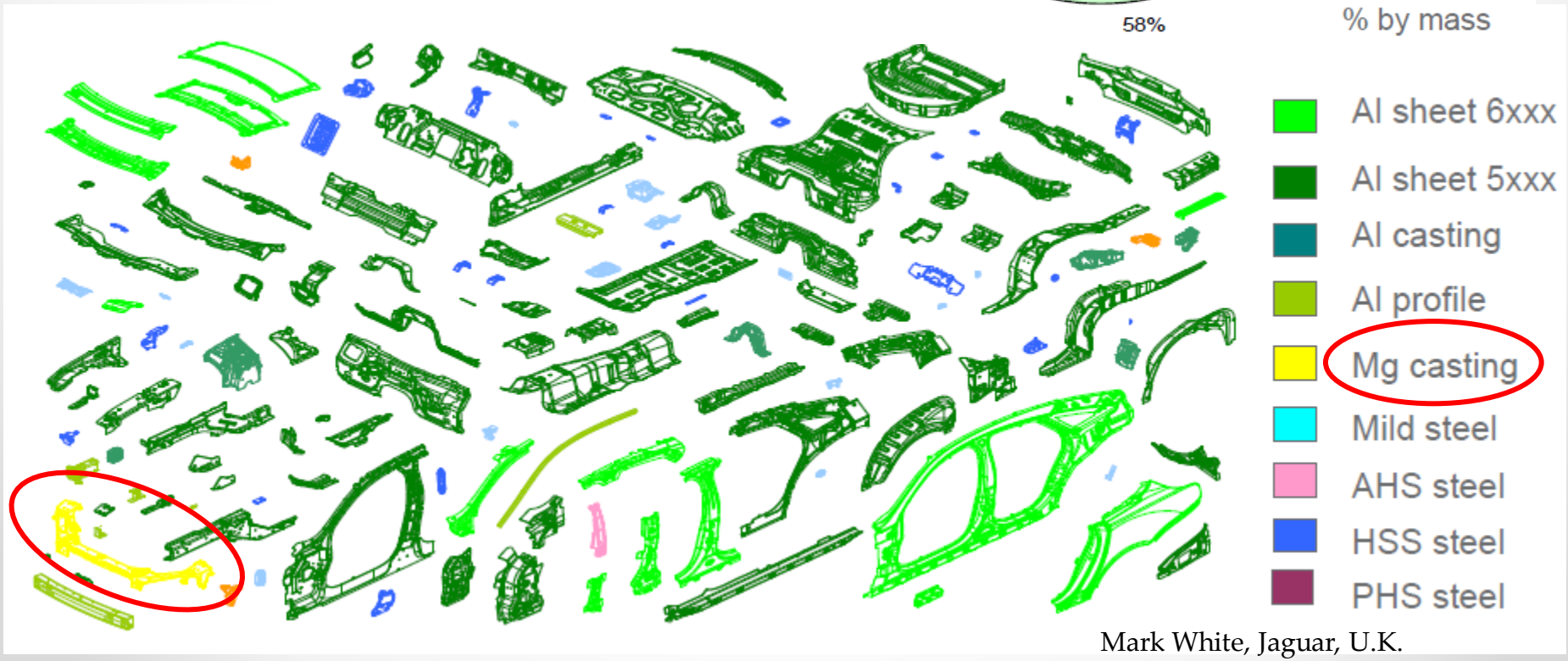
- Magnesium Alloy

Why study Magnesium Alloy?

- Magnesium is one of the most abundant elements on Earth.
- Harvested from the crust of the Earth and seawater.
- 20% as dense as steel
- High workability

Automotive application of Magnesium





Mark White, Jaguar, U.K.

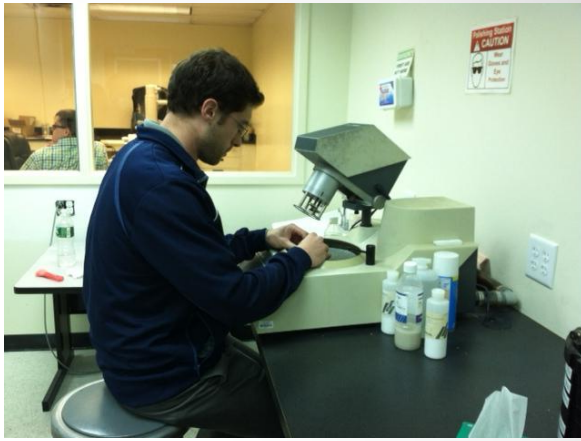
Military application of Magnesium Alloy

Drive train on Boeing engine for Apache attack helicopter

Gear Box on General Electric F110 engine for F-16 fighter jet.

Experimental Tools

- Optical Microscope
  - Nikon Epiphot 200
- Scanning Electron Microscope
  - Hitatchi S-3400N
- Vickers Hardness Tester
  - Future-Tech Microhardness Tester FM



Experimental Procedure

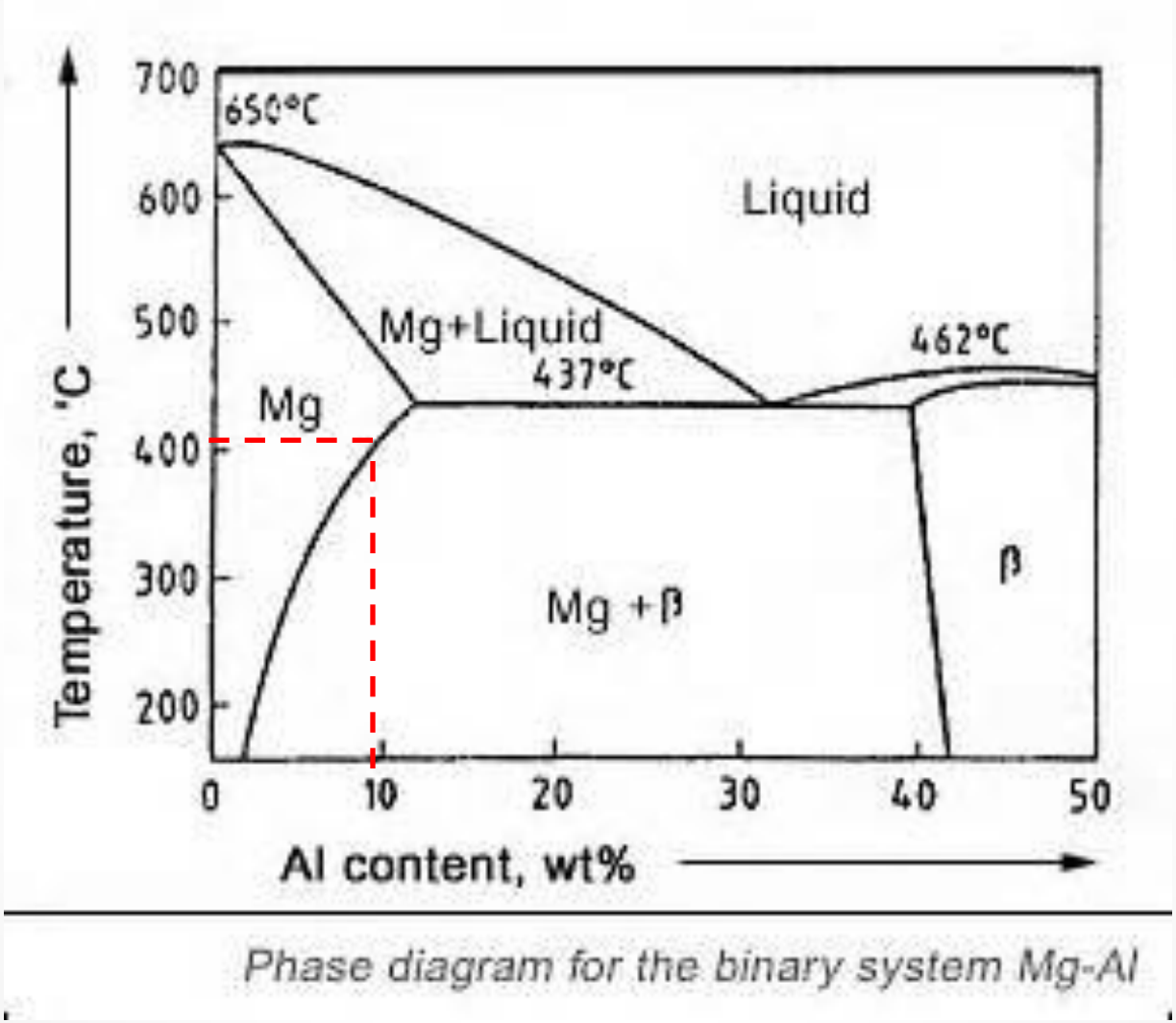
- Metallurgical sample preparation: Embedded all specimens in a polymer to aid handling
  - Steel, Aluminum, AZ91D control, AZ91D T4 treated, AZ91D T6 treated.

1. Polished all specimens with a grit of 6 micron
2. Performed T4 and T6 heat treatment on select specimens of AZ91D
3. Performed Optical microscopy
4. Performed Electron microscopy
5. Calculated Vickers Hardness Value

T4 and T6 treatments

- T4 treatment heats the specimen to a temperature based on the phase diagram for a period of 16-24 hours.
- T6 heats the specimen to an aging temperature for 16 to 24 hours. (Pre-requisite: T4 treatment).

Magnesium-Aluminum Alloy Phase Diagram

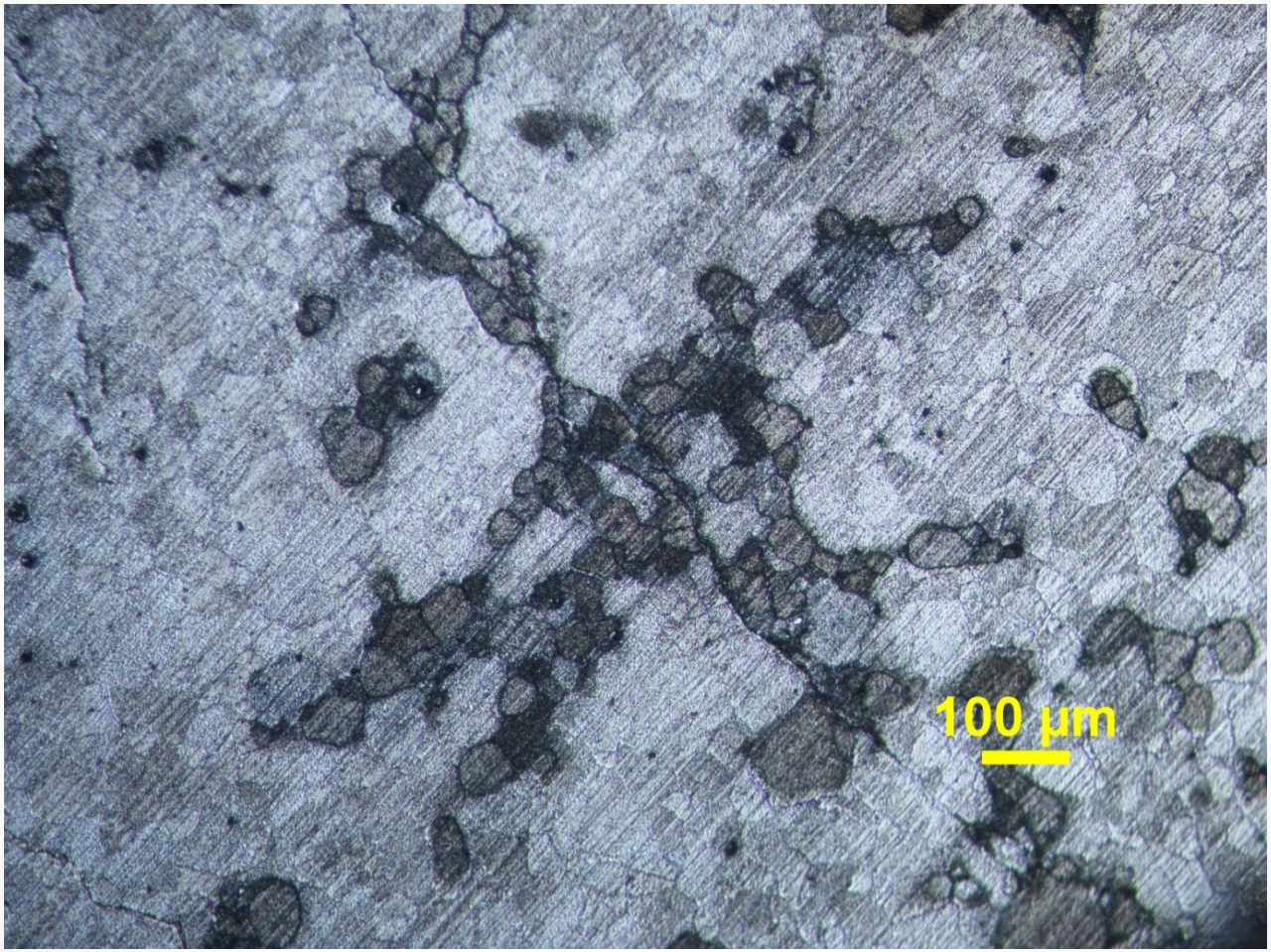


Phase diagram for the binary system Mg-Al

- Magnesium.com

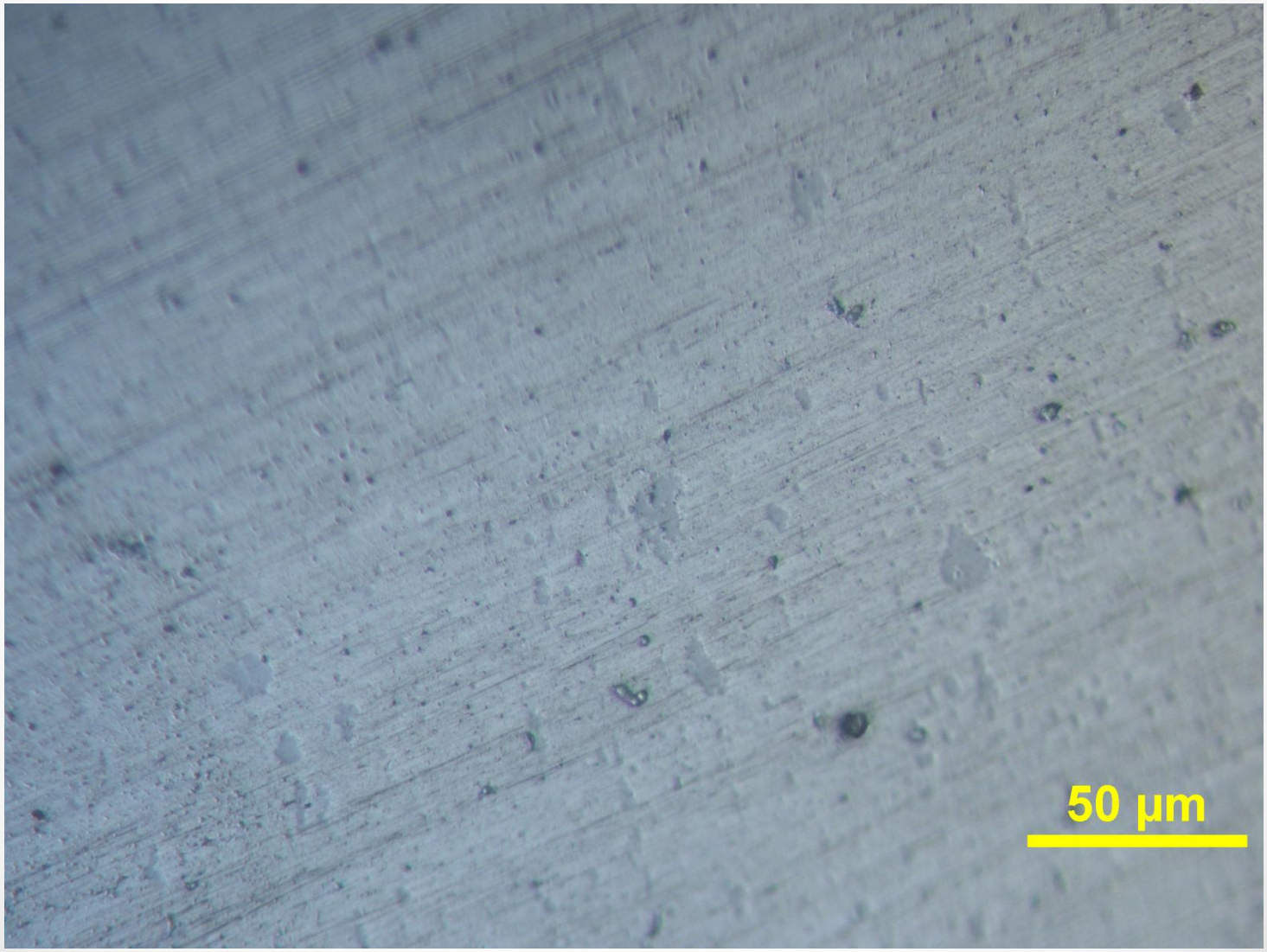
Results – Control specimens

Steel



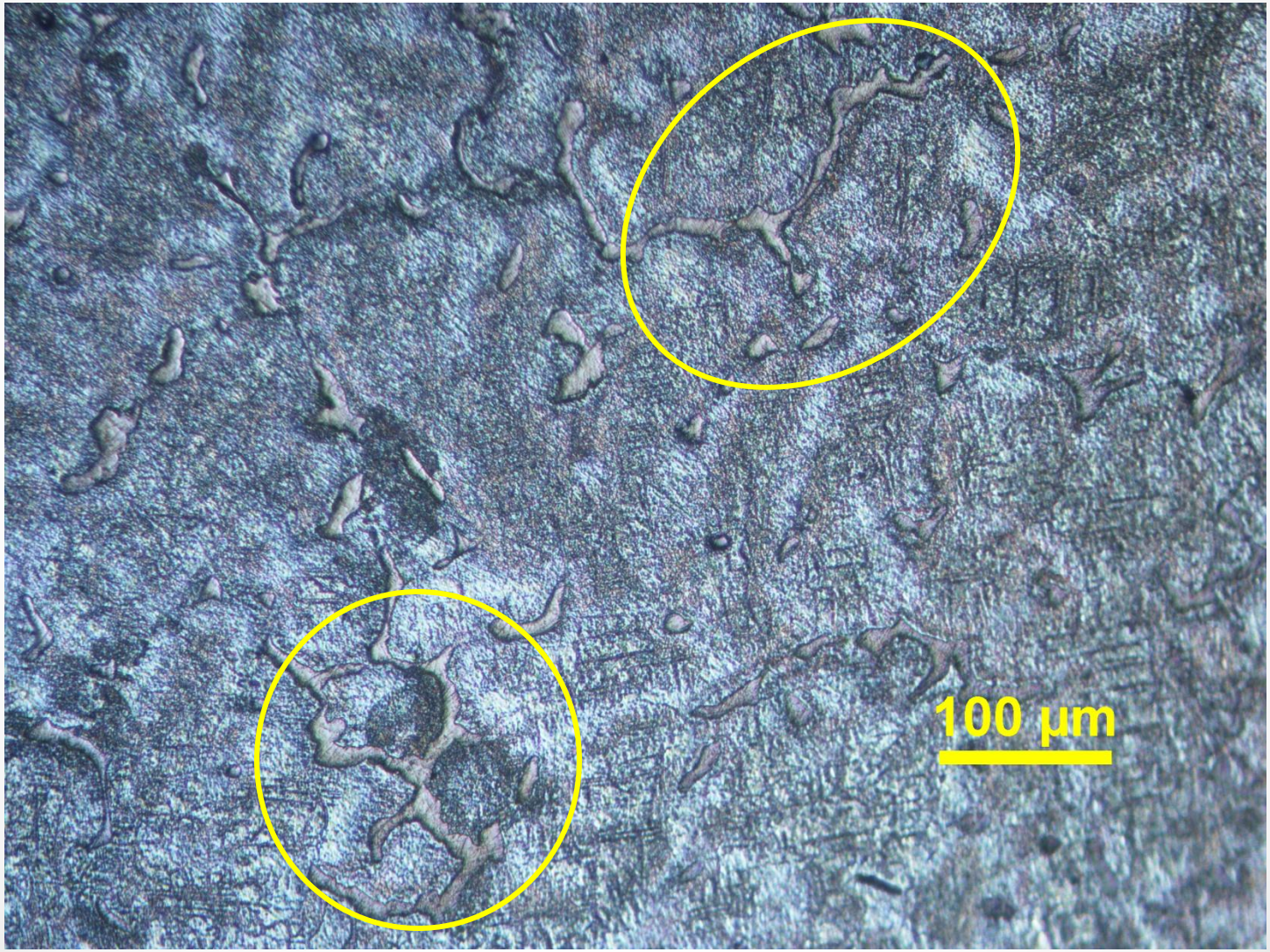
Results - Control Specimens

Aluminum



Results – Control Specimens

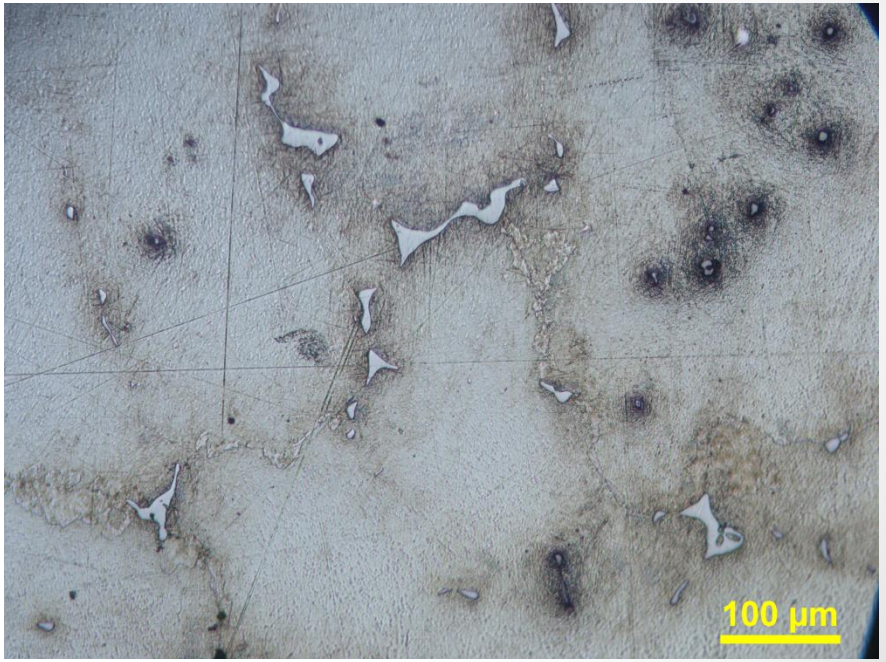
AZ91D



Results – Evolution of AZ91D through Optical Microscopy

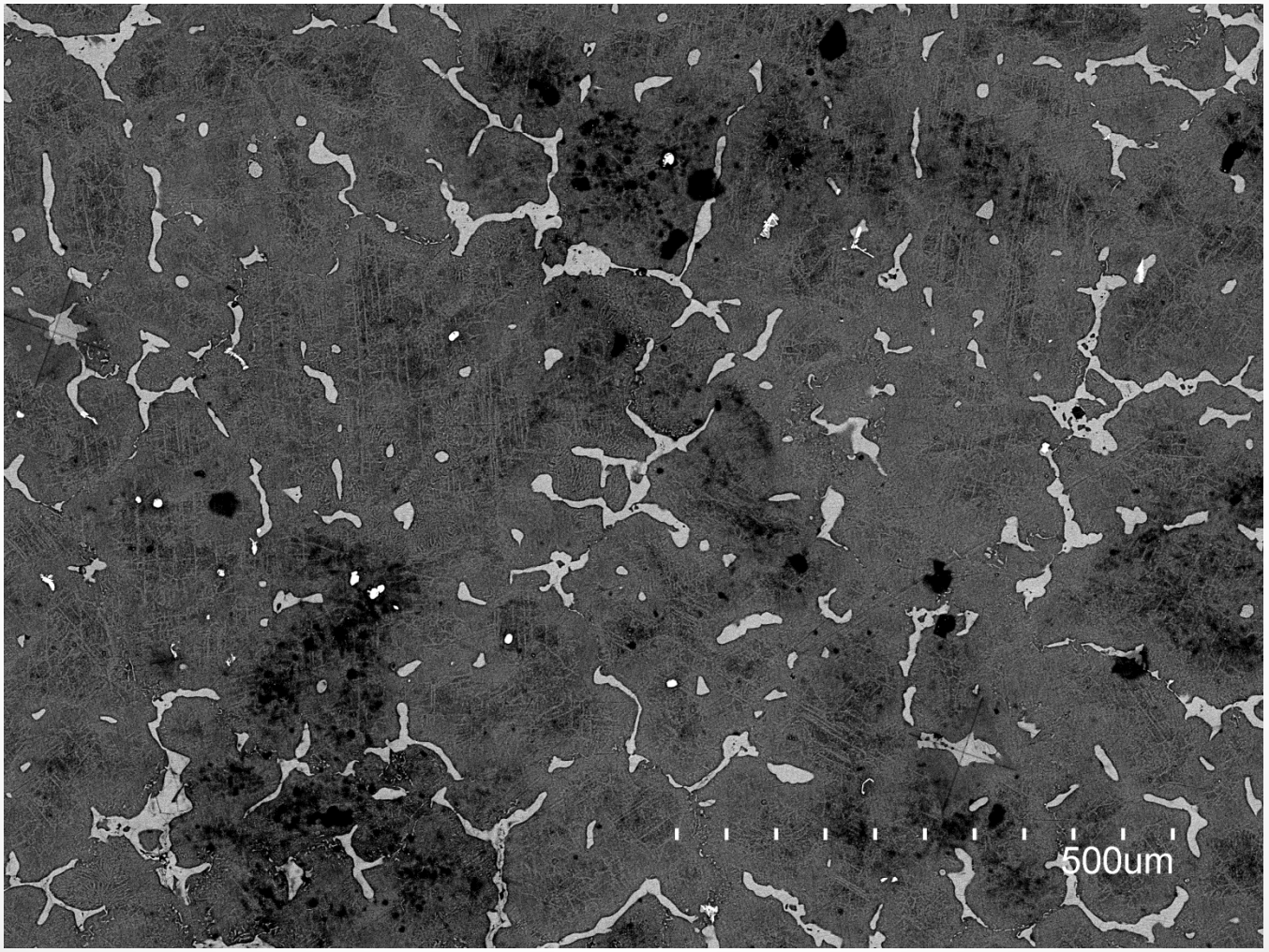
T4 Treatment

T6 Treatment



Results – Evolution of AZ91D through Electron Microscopy

AZ91D control



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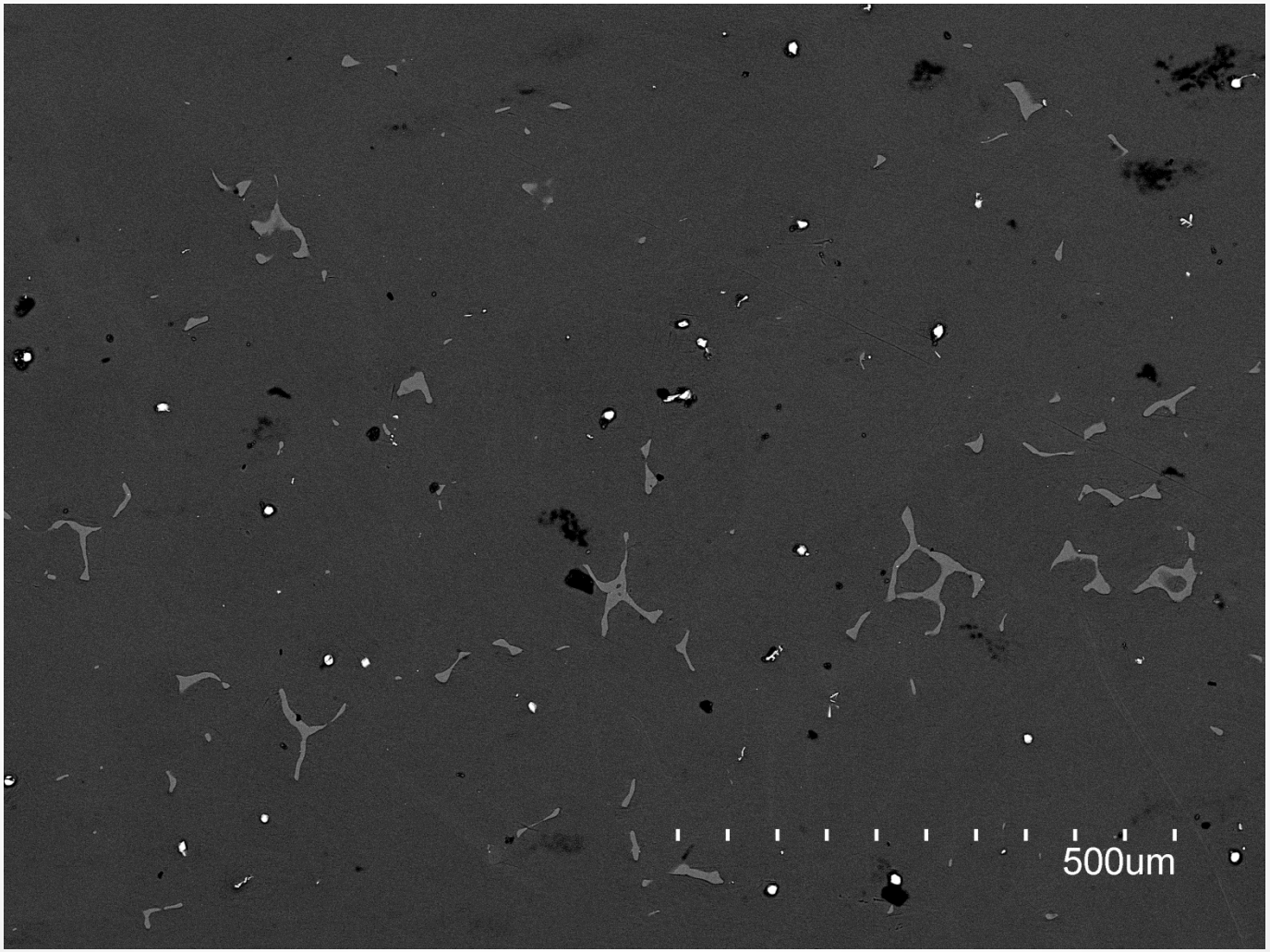
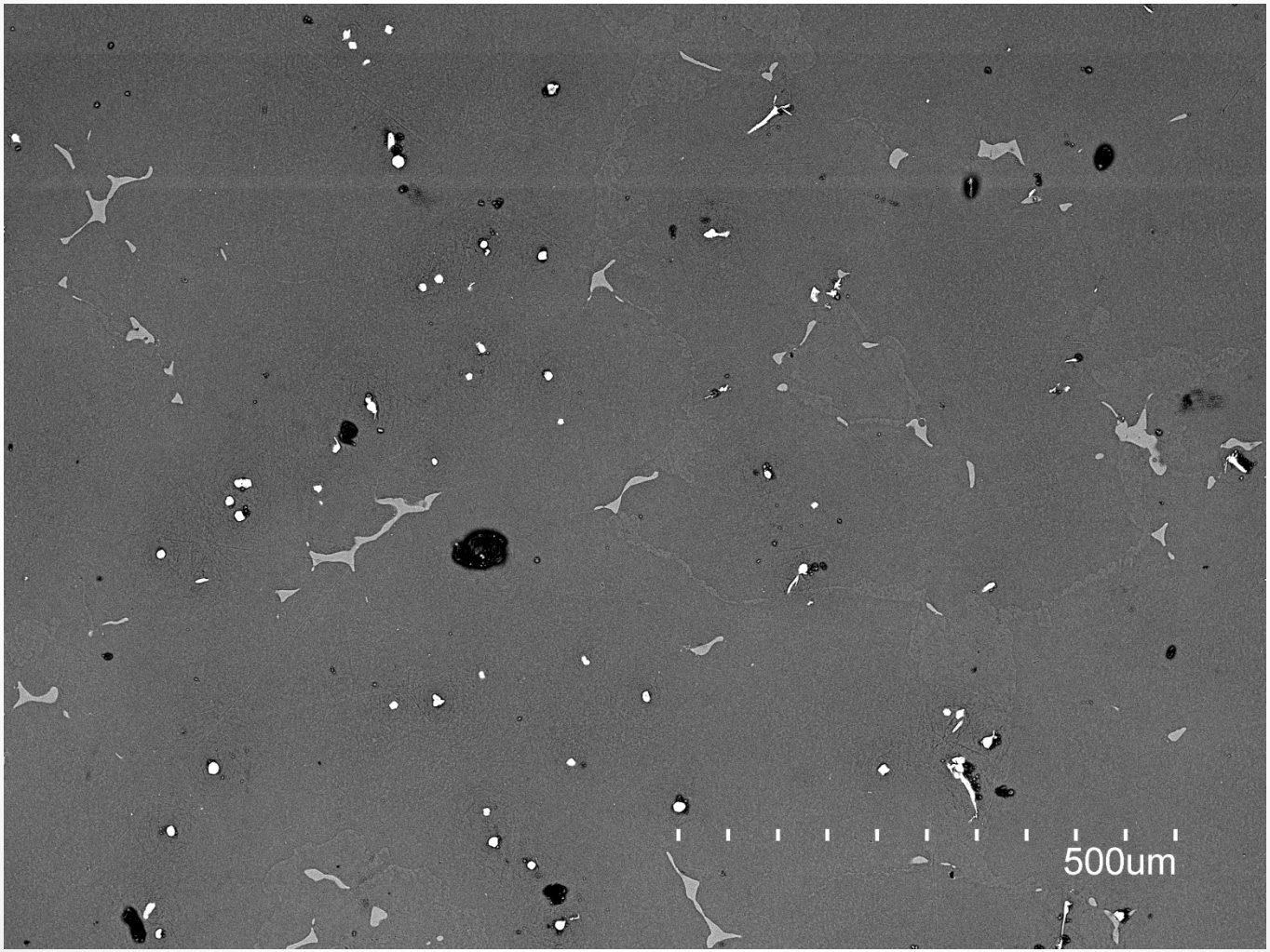
T4 Treatment



Results – Evolution of AZ91D through Electron Microscopy

- T6 Treatment



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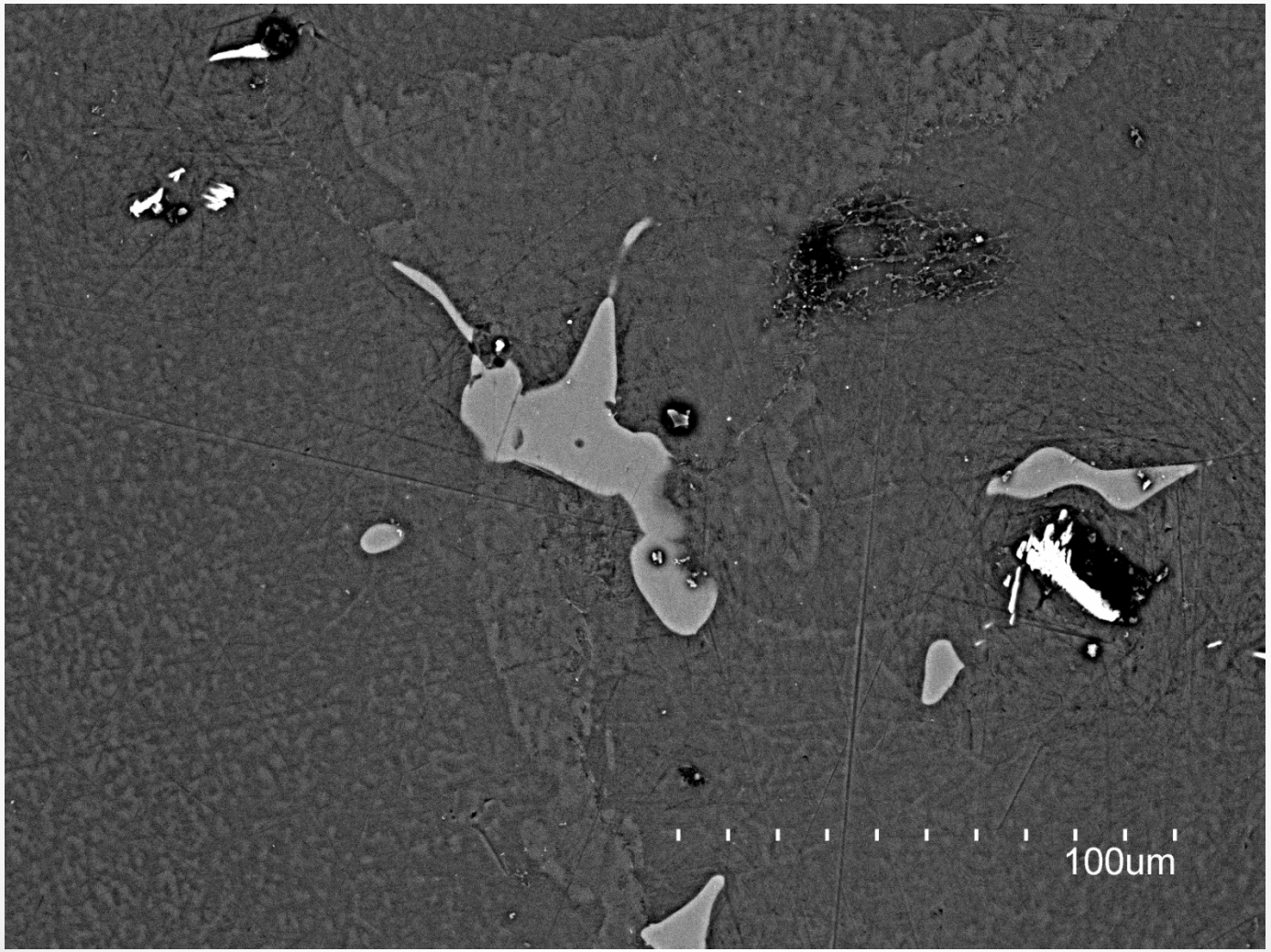
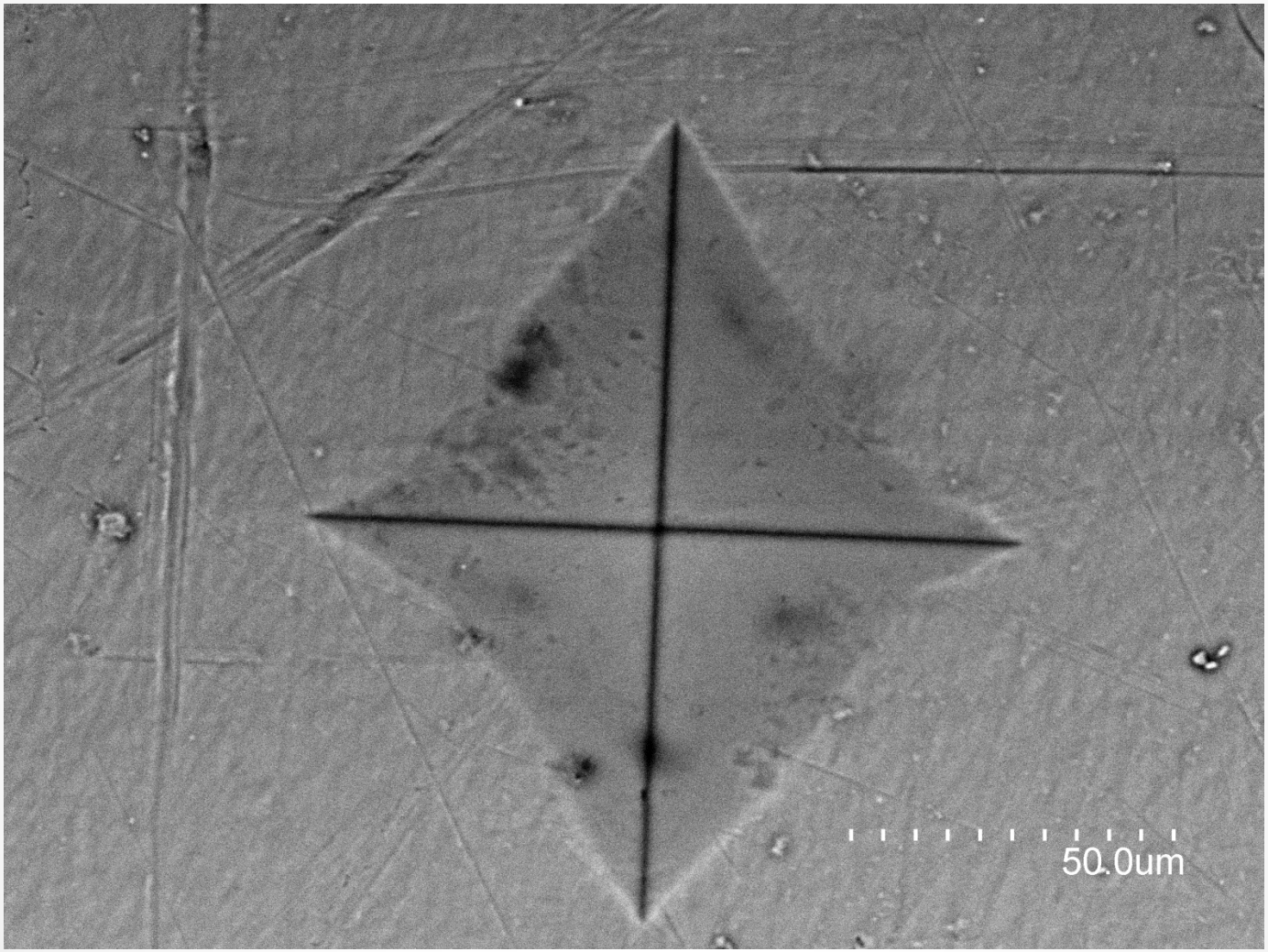


Vickers Hardness



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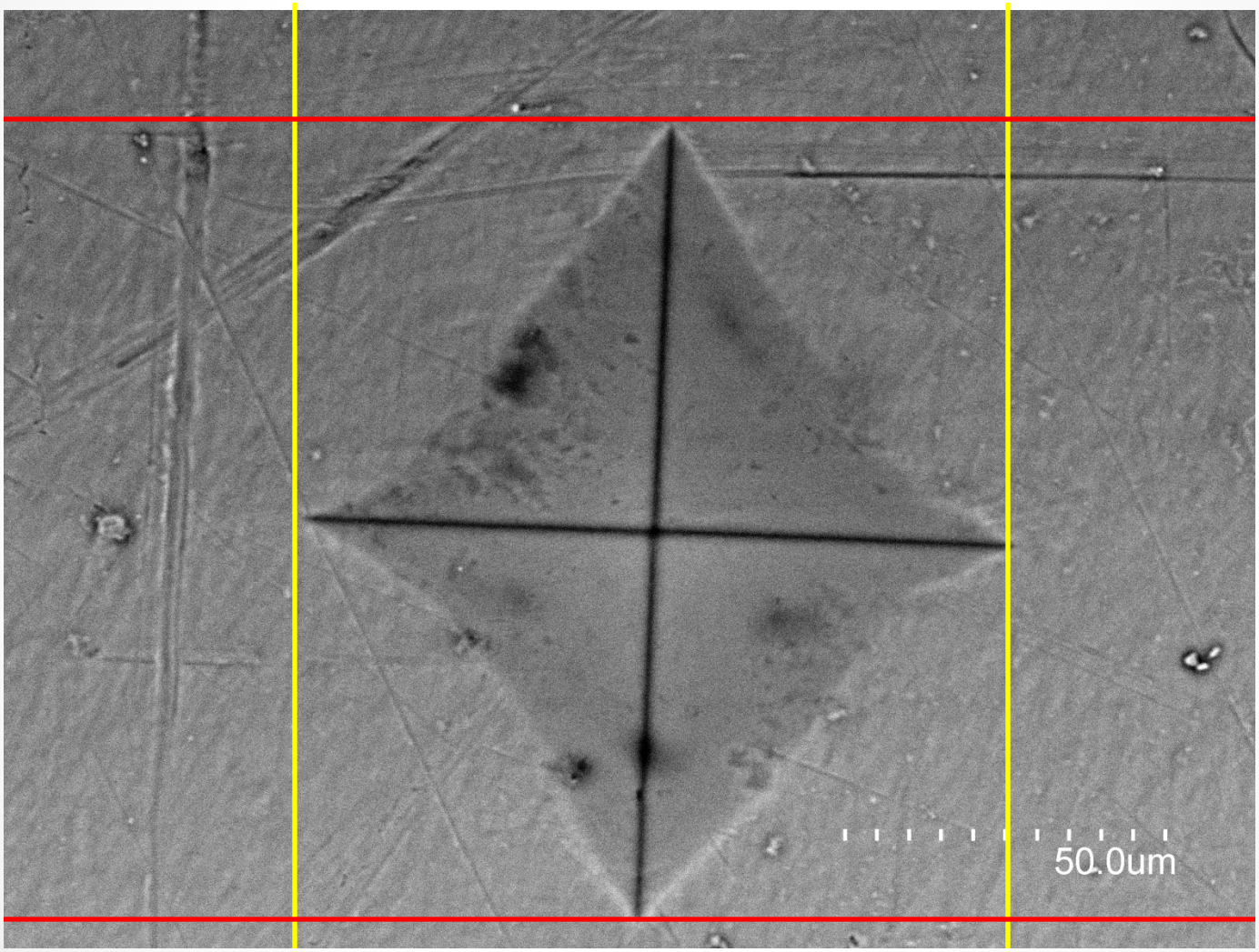

Vickers Hardness Data

SPECIMEN	Test Load	Sample Size Matrix	Hardness Matrix	Standard Deviation Matrix
	Dwell Time	Sample Size Precipitate	Hardness Precipitate	Standard Deviation Precipitate
Steel	1961 mN	18	95.7	9.4
	56s	22	100.7	10.9
Aluminum	4903 mN	30	152.3	4.4
	56s	----------	----------	----------
AZ91 Control	4903 mN	20	62.0	6.7
	56s	20	79.6	8.9
AZ91 T4 treated	4903 mN	20	61.7	9.1
	56s	20	70.1	7.8
AZ91 T6 treated	4903 mN	20	62.0	6.6
	56s	20	87.2	12.5

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Conclusion

- The heat treatment process expedited the natural rate of precipitate reconfiguration. The strength of the material INCREASED after the T4 treatment and DECREASED after the T6 treatment
- The decrease in precipitates from control to T4 treated AZ91 as well as the decrease in the difference between hardness values indicates the material increase in strength.
- The increase in the difference between hardness values between the T4 specimen and the T6 specimen indicate an decrease in strength

Conclusion Continued

- As the AZ91 ages (naturally or through an expedited heating process) the specimen will first see an increase in strength until it reaches its maximum point of strength at an undetermined time after creation. From that point, instead of plateauing, the strength will then begin to decrease as the specimen ages.
- Engineers can use this data to tailor a material to best fit a project.
  - Ex. Making a sample weaker to be placed in the crumple zone in an automobile
  - Ex. Making a sample stronger to be used as a load bearing member in a structure.

Potential for Further Investigation

- The relationship between heat treatment aging rate and natural aging rate is still unknown
- An investigation into the compression strength, elasticity modulus and tensile strength will yield more data on the effect of heat treatments.
- More applications in the production world (commercial, industrial, or militaristic)

Acknowledgements

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- I would like to thank my colleagues in the Composites Materials and Mechanics lab for helping me in accomplishing the research work.