Obróbka cieplna silnie odkształconego stopu AlSi10Mg wytworzonego techniką selektywnego stapiania w łożu proszkowym (SLM)

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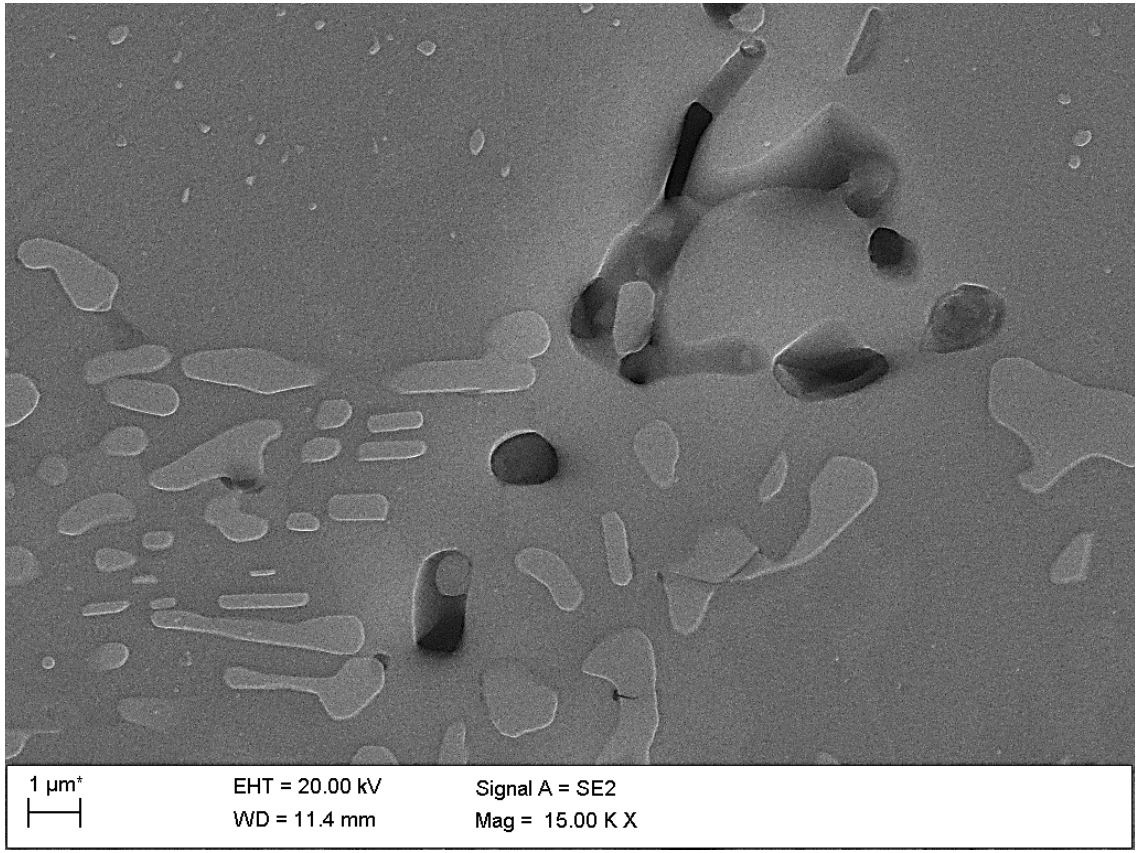
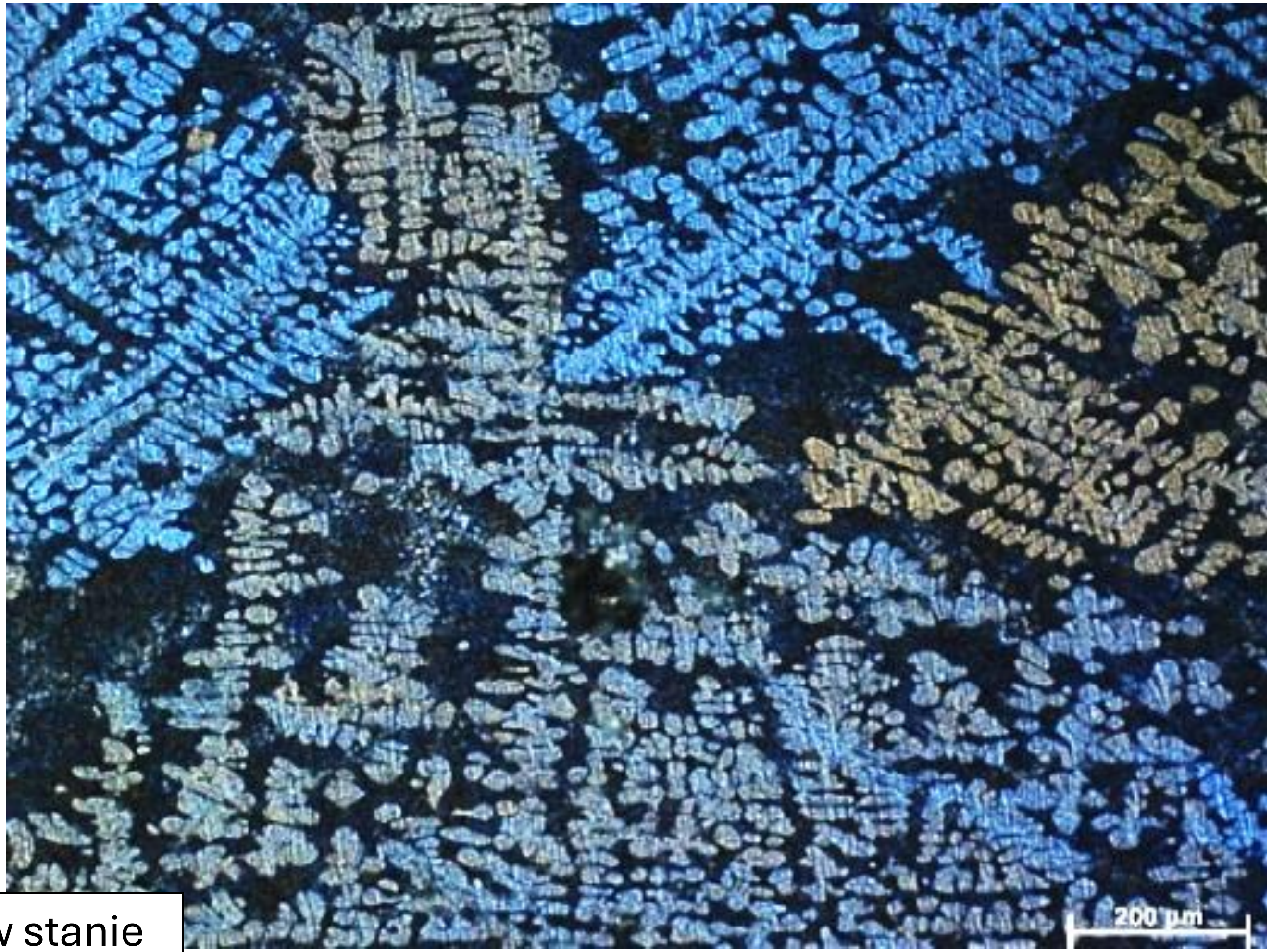
Silesian University of Technology

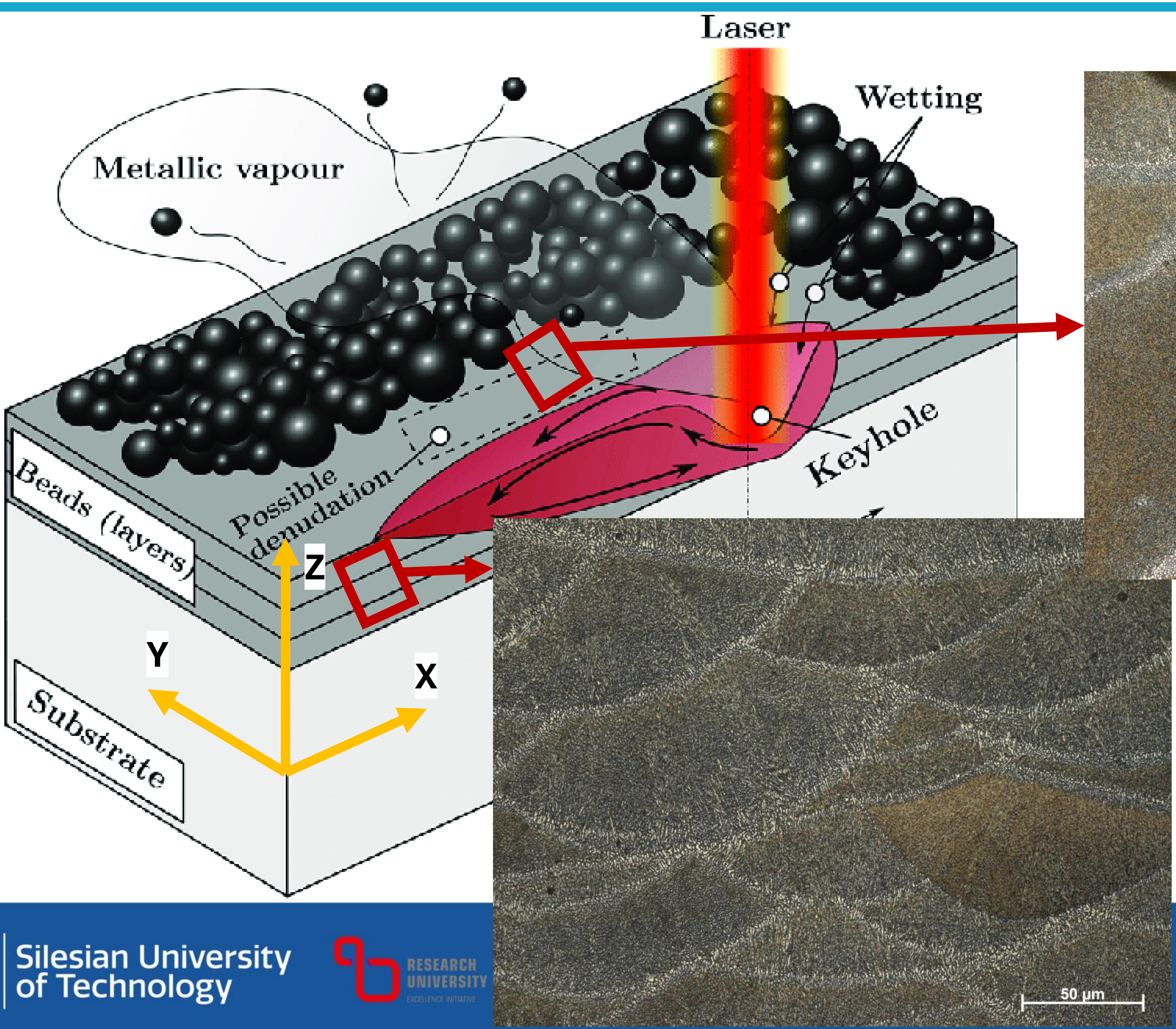
Mikrostruktura stopu AlSi10Mg (ODLEW)





Struktura dendrytyczna stopu AlSi10Mg w stanie odlanym

Proces stapiania w łożu proszkowym (LPBF)



Mikrostruktura stopu AlSi10Mg (LPBF)

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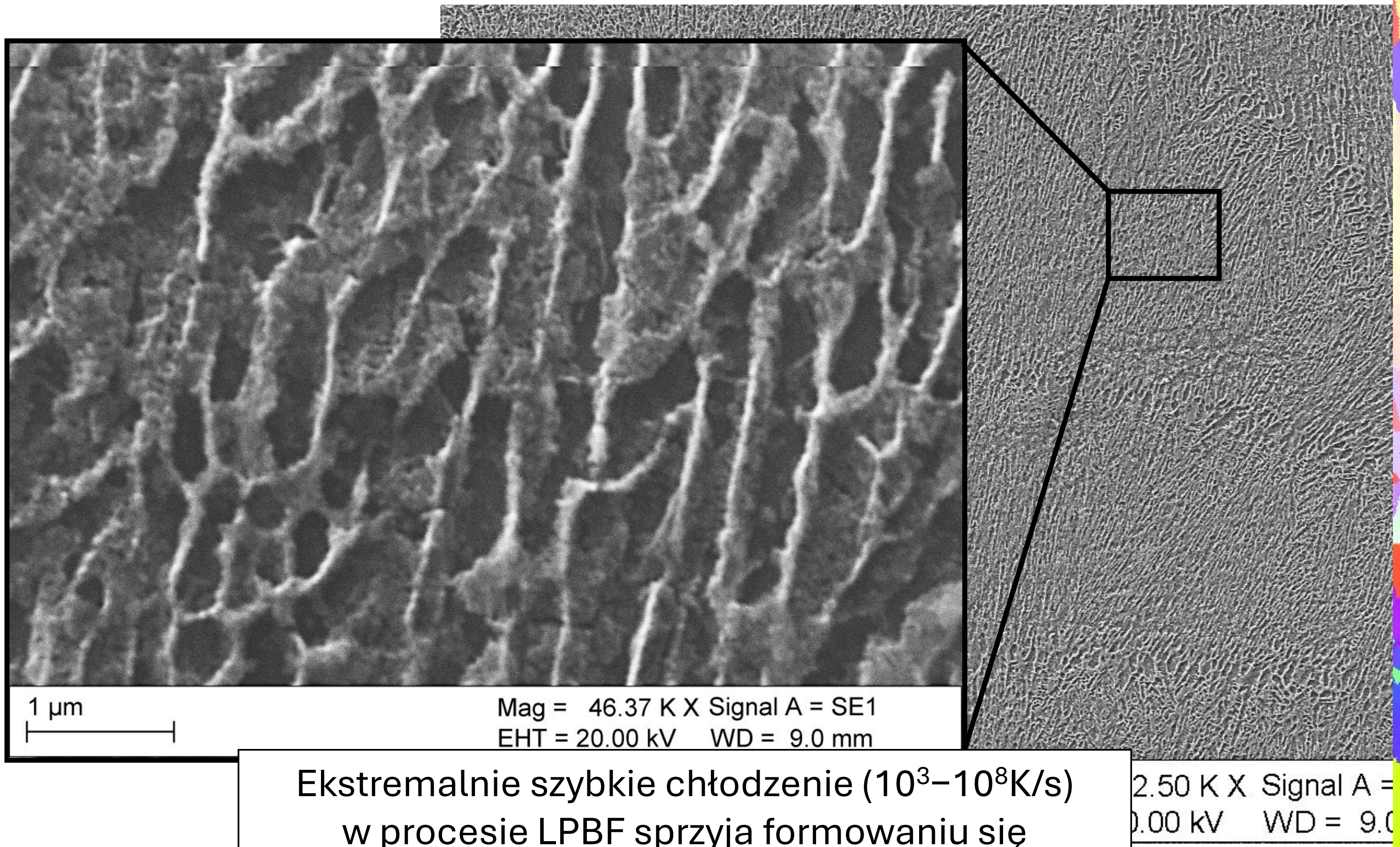
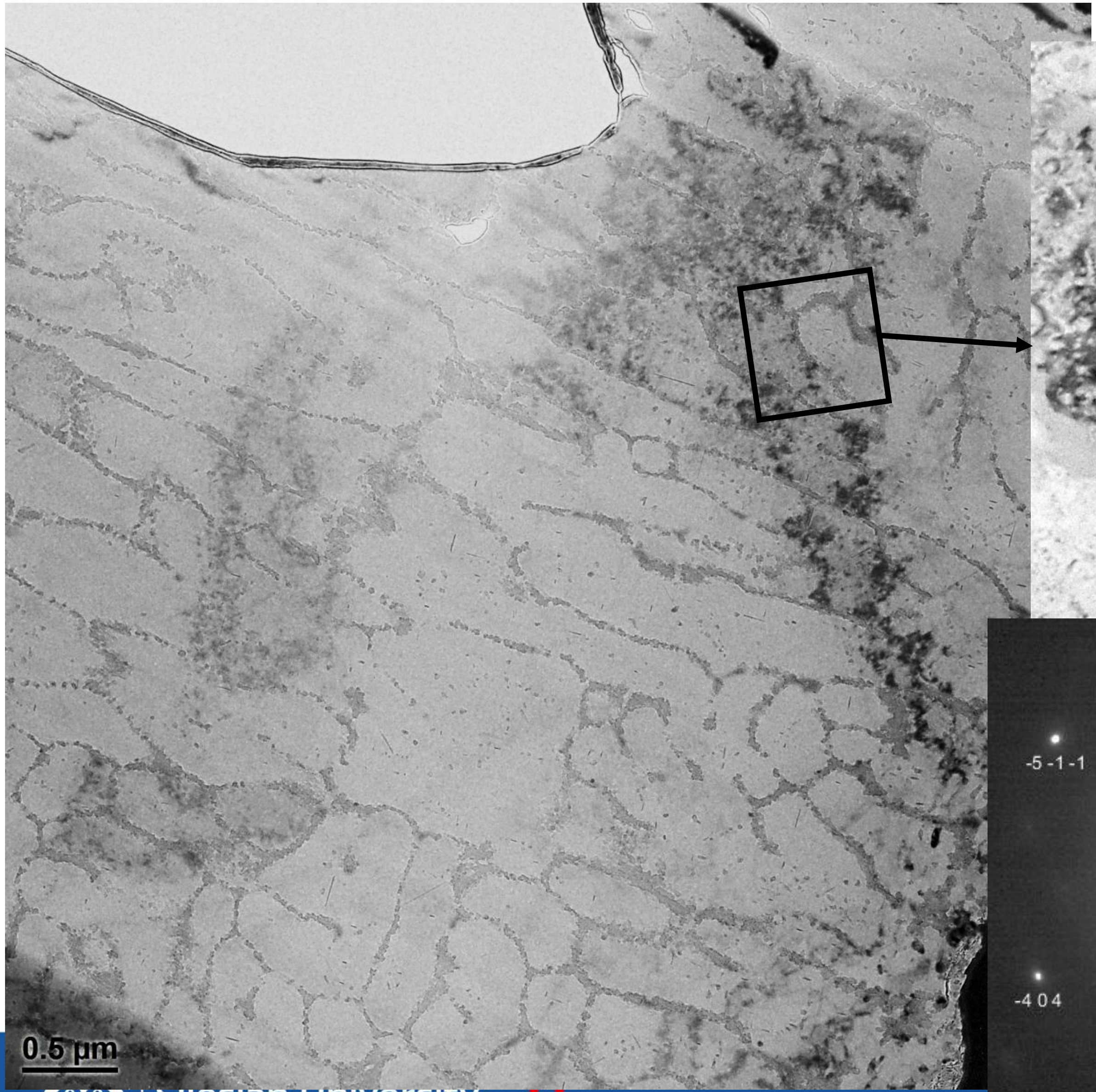
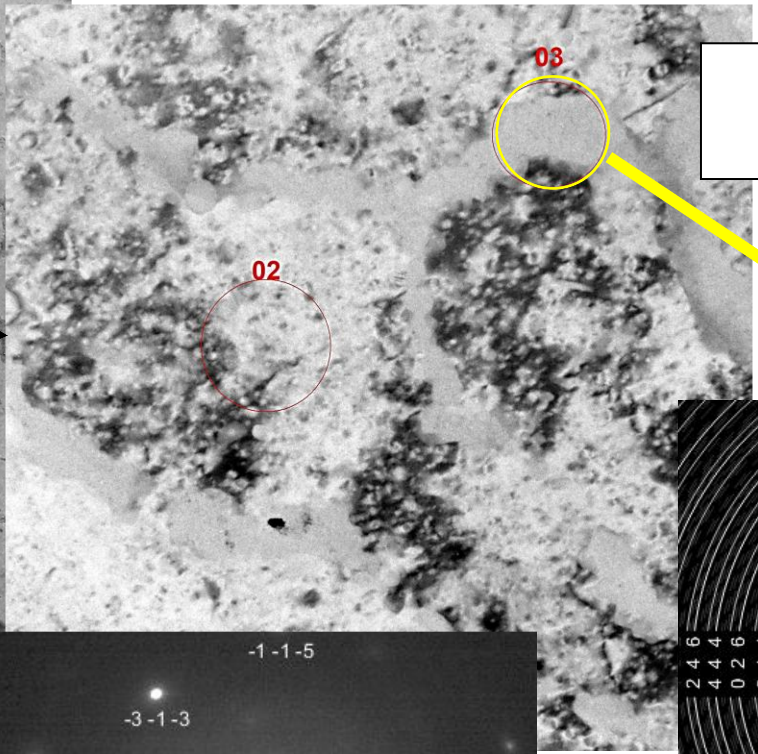


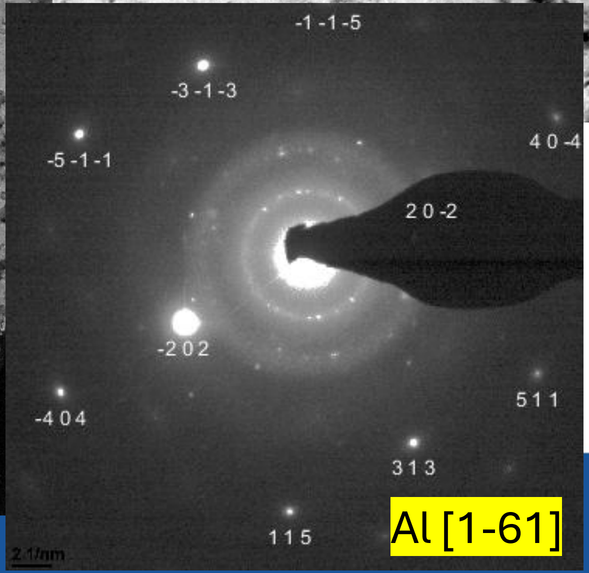
Ekstremalnie szybkie chłodzenie (10^3–10^8K/s) w procesie LPBF sprzyja formowaniu się drobnoziarnistej mikrostruktury oraz charakterystycznej struktury komórkowej eutektyki Al/Si.

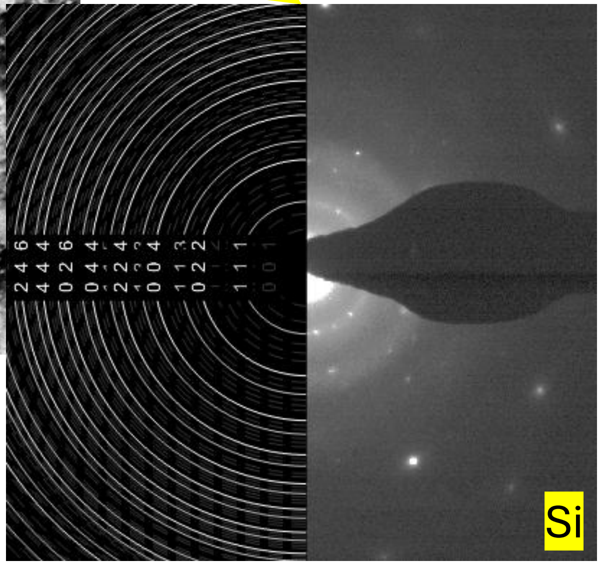
Mikrostruktura stopu AlSi10Mg





Eutektyka Al/Si zbudowana jest z drobnych cząstek.





Właściwości mechaniczne stopu AlSi10Mg

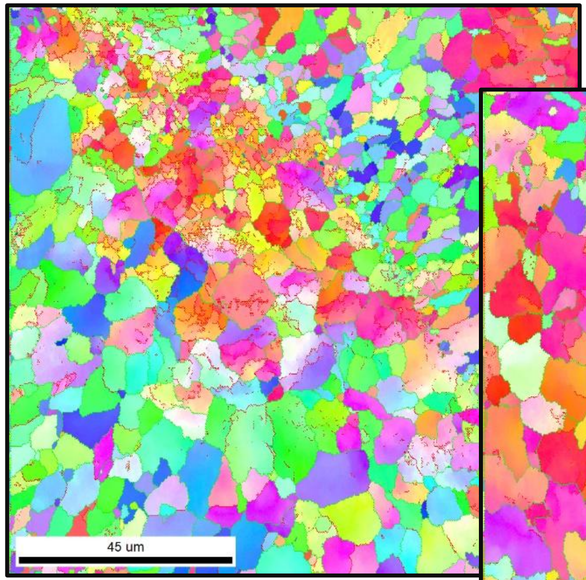
Table 2. Tensile results of as-cast and SLM AlSi10Mg.

Processing methods	Direction	Temperature	Tensile strength (MPa)	Elongation (%)
Casting	*XY*	25 °C	312.65 ± 1.34	12.60 ± 0.77
	YZ		315.13 ± 1.33	14.29 ± 0.19
SLM	*XY*		445.34 ± 11.36	8.68 ± 0.02
	YZ		430.04 ± 8.88	8.70 ± 0.82
Casting	*XY*	230 °C	237.16 ± 6.13	20.47 ± 1.70
	YZ		225.31 ± 5.46	18.67 ± 0.49
SLM	*XY*		266.59 ± 15.25	20.53 ± 1.55
	YZ		270.19 ± 15.86	21.73 ± 1.80

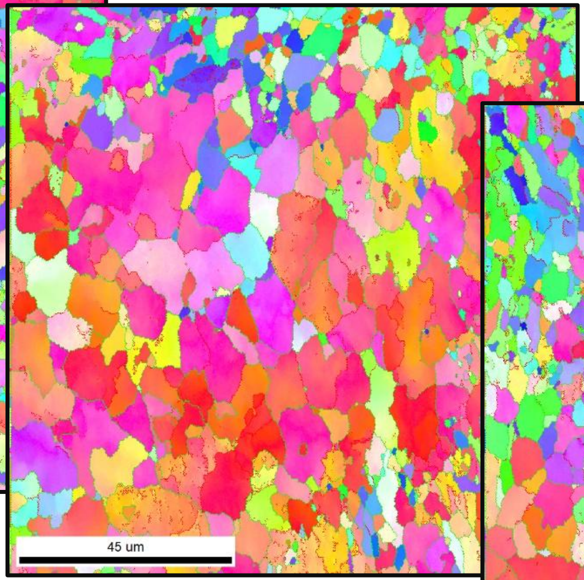
40% wyższe w porównaniu do stopu wytworzonego technologią odlewania.

[1]Qian Yan, Bo Song, Yusheng Shi, Comparative study of performance comparison of AlSi10Mg alloy prepared by selective laser melting and casting, Journal of Materials Science & Technology, Volume 41, 2020.

Stabilność termiczna mikrostruktury



300ºC 1h



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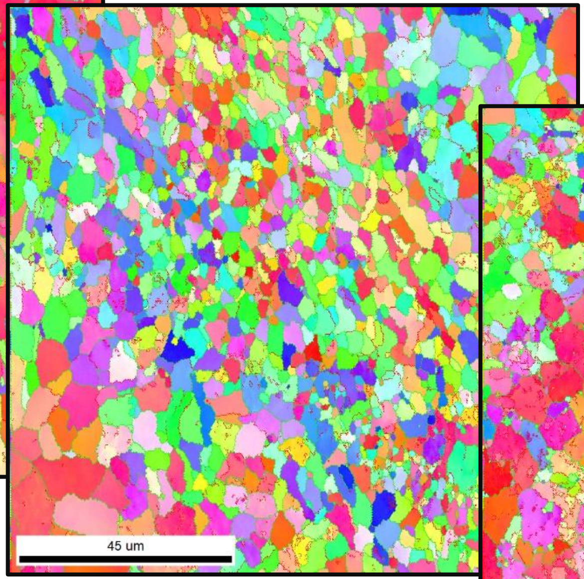
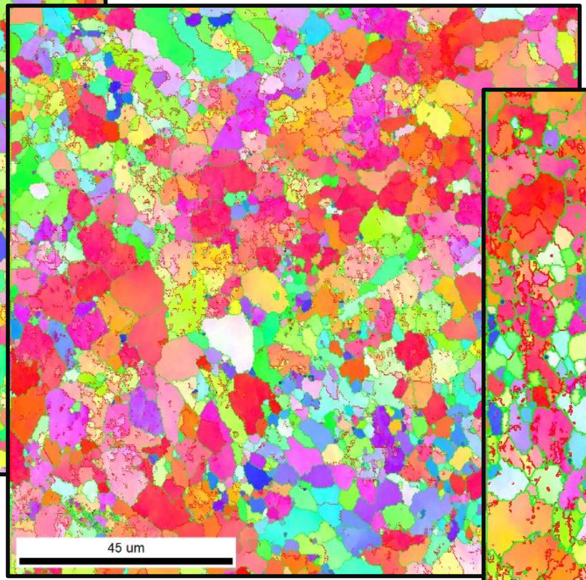
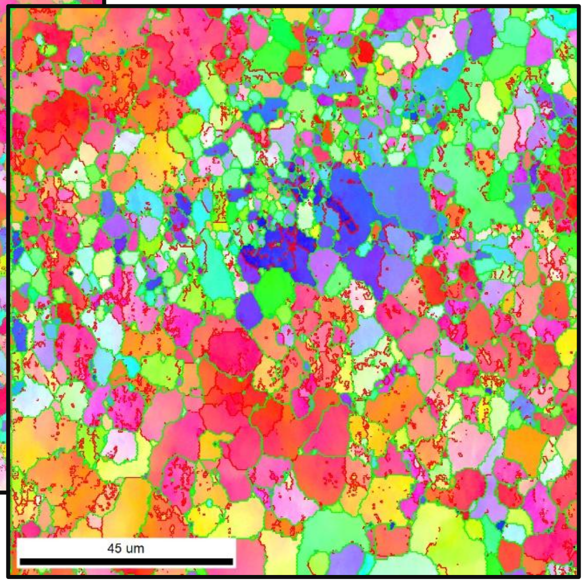


400ºC 1h



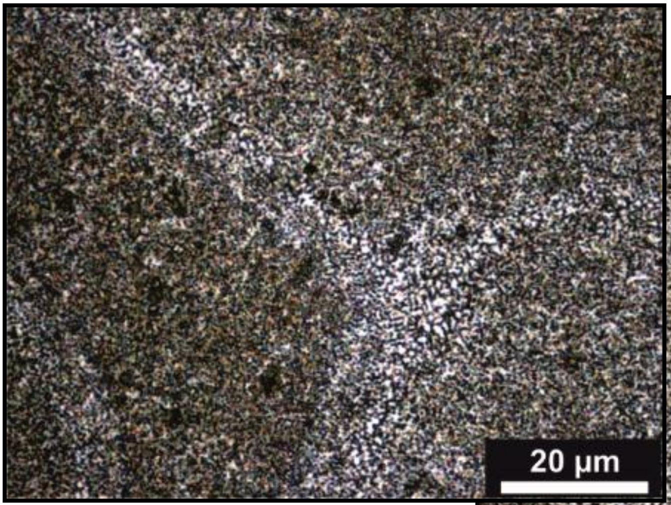
450ºC 1h



500ºC 1h

- Niska energia zmagazynowana w postaci dyslokacji,
- Segregacja pierwiastków hamuje ruchliwość granic ziaren,
- Cząstki Si działają jak punkty kotwiczenia hamując migrację granic,

Stabilność termiczna mikrostruktury



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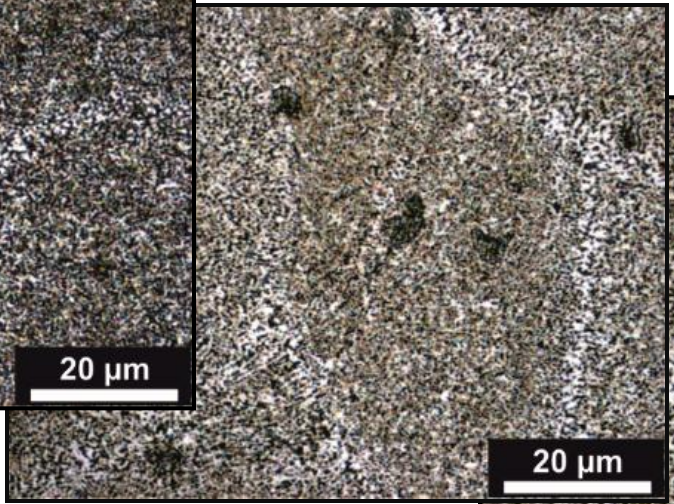

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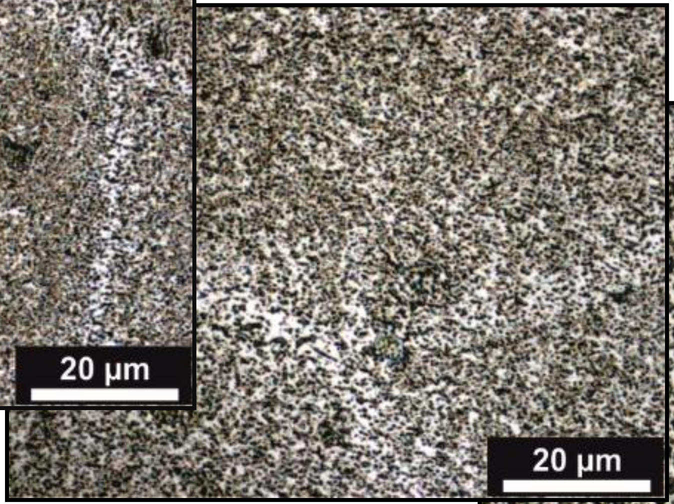

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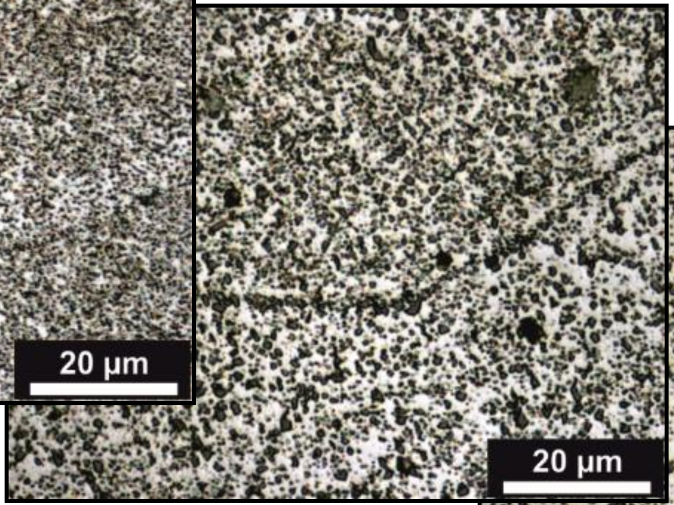

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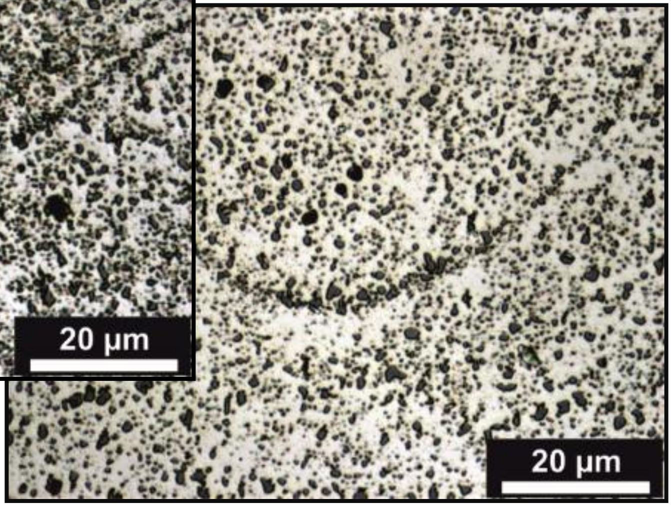

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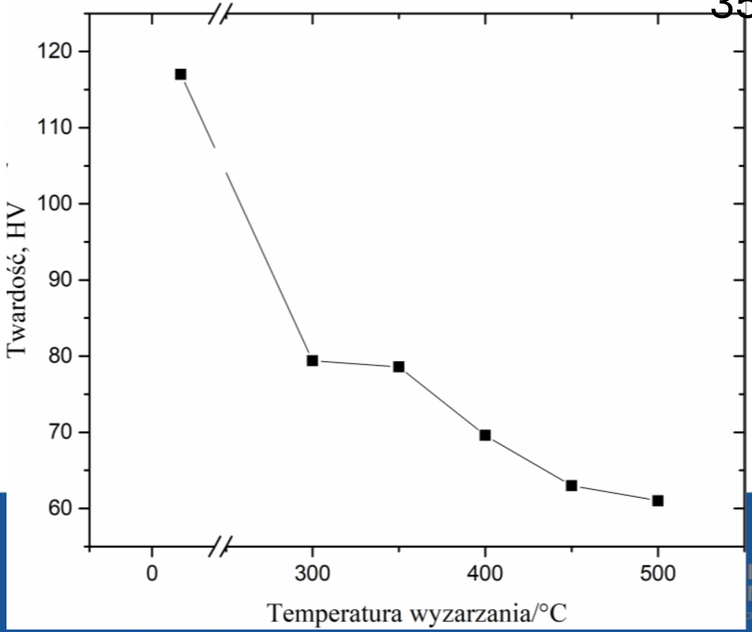
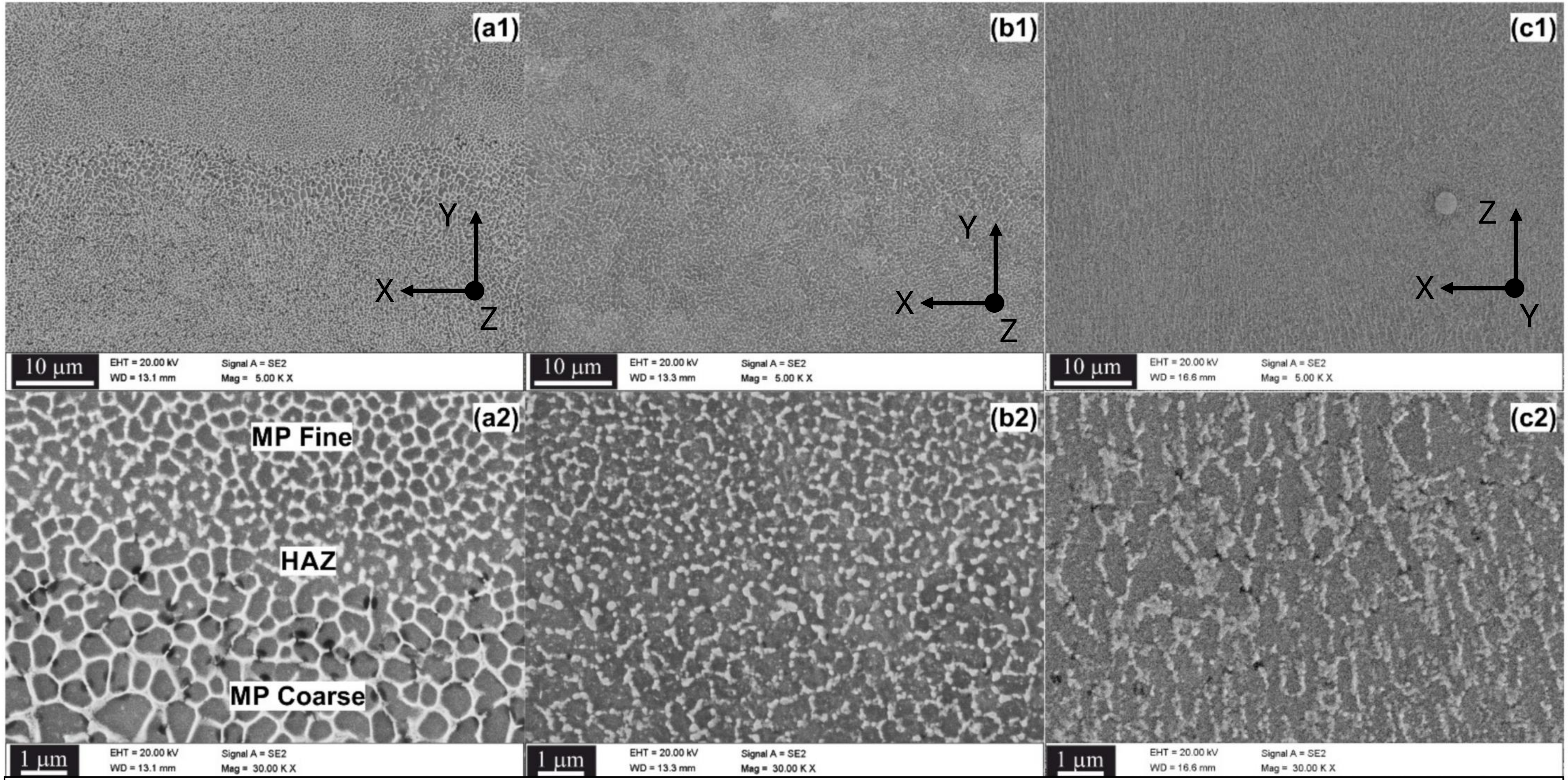
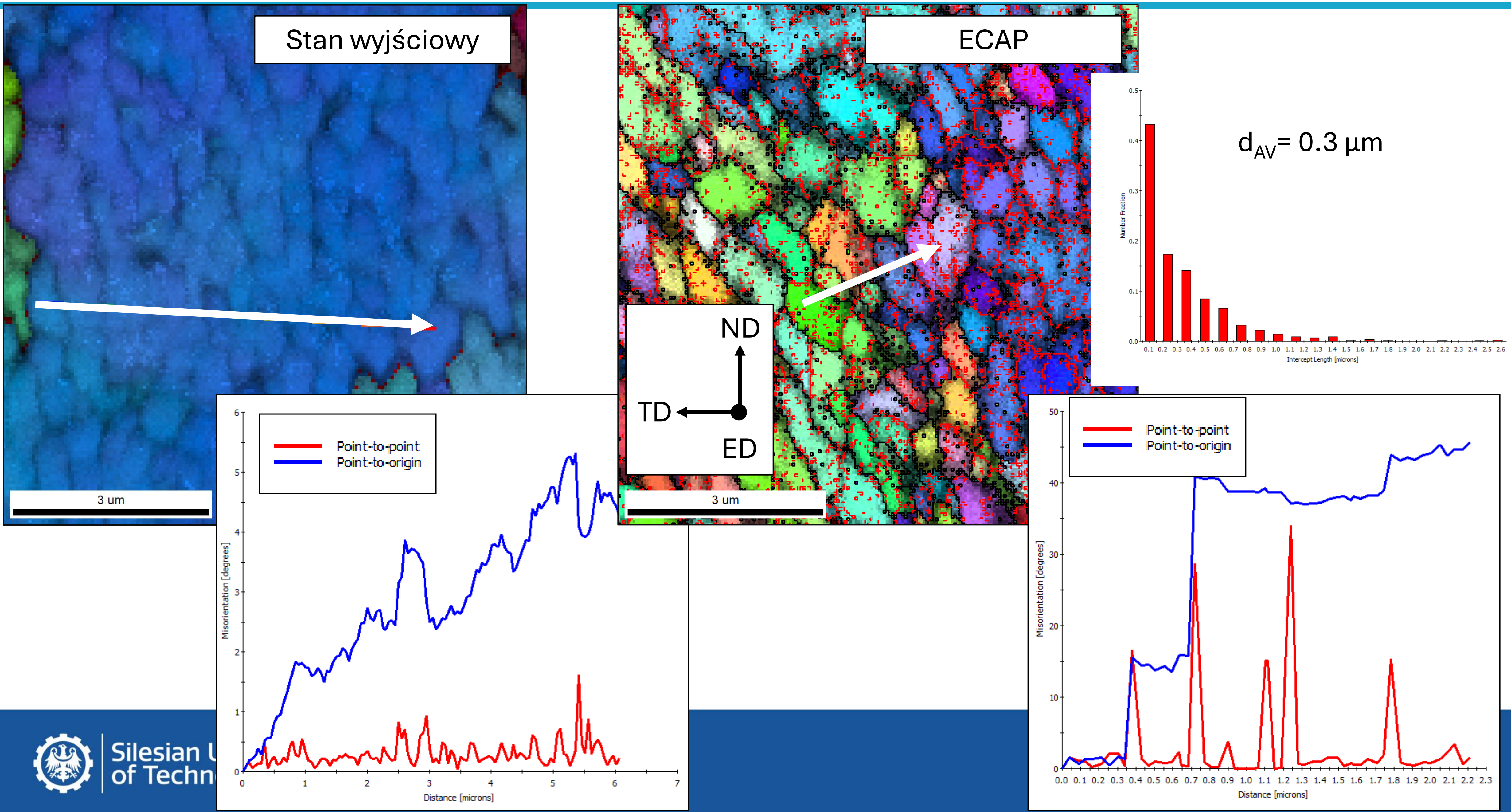


Stabilność termiczna mikrostruktury

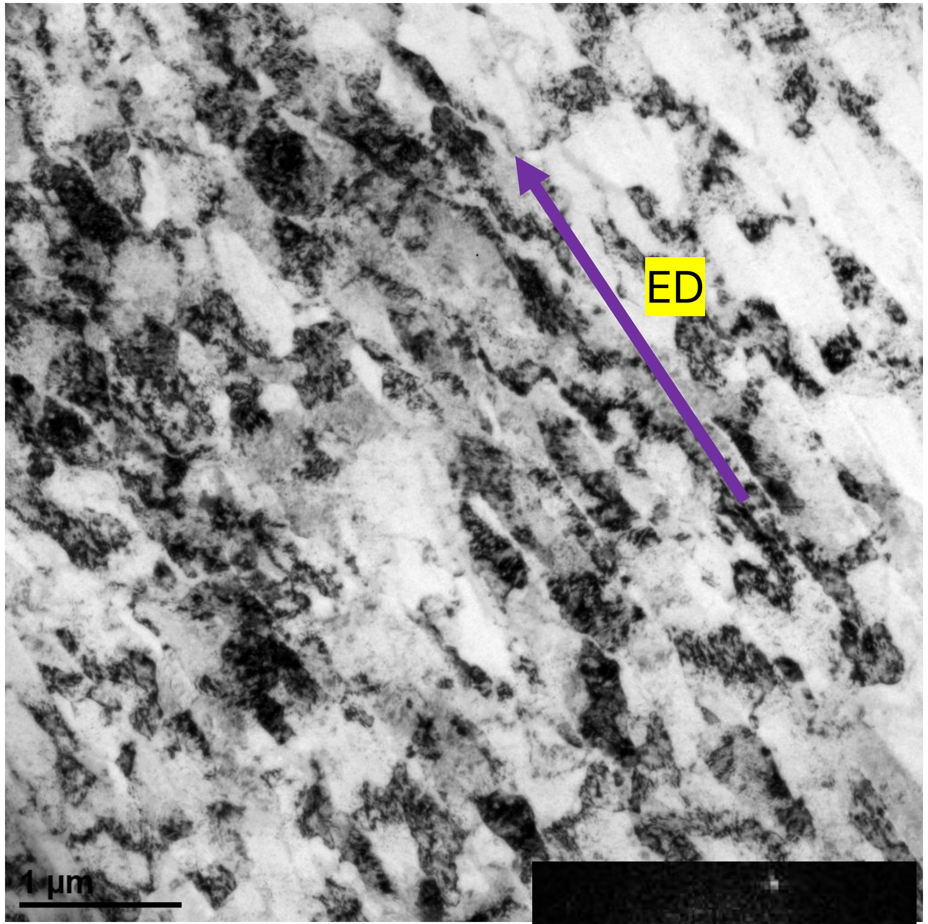


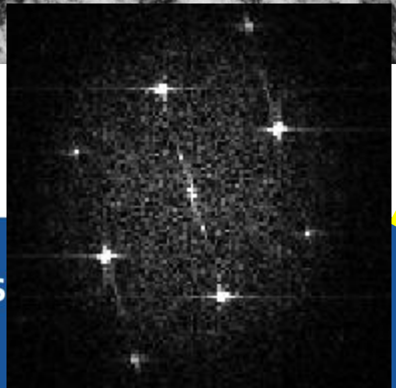
Morfologię eutektyki Al/Si zmodyfikować można stosując krótkotrwałe niskotemperaturowe wyżarzanie. a) stan wyjściowy, b) i c) obrobiony cieplnie 320 ºC 9 min

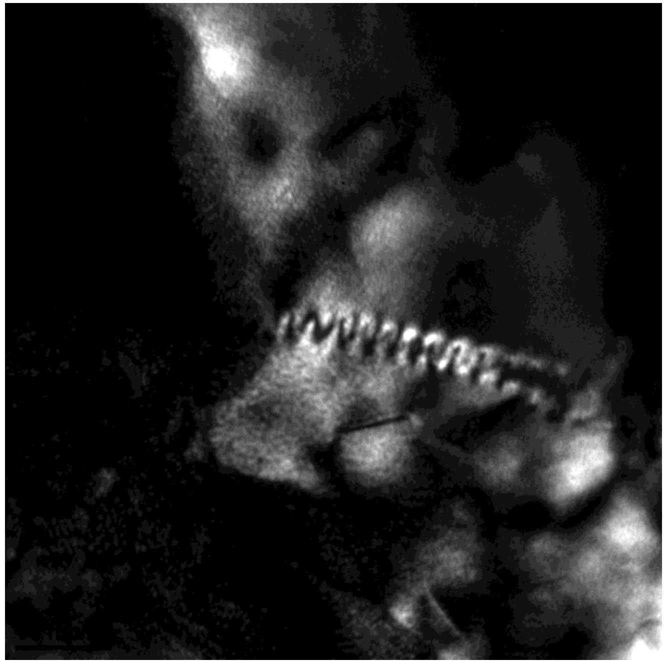
Intensywne odkształcenie plastyczne – LPBF AlSi10Mg

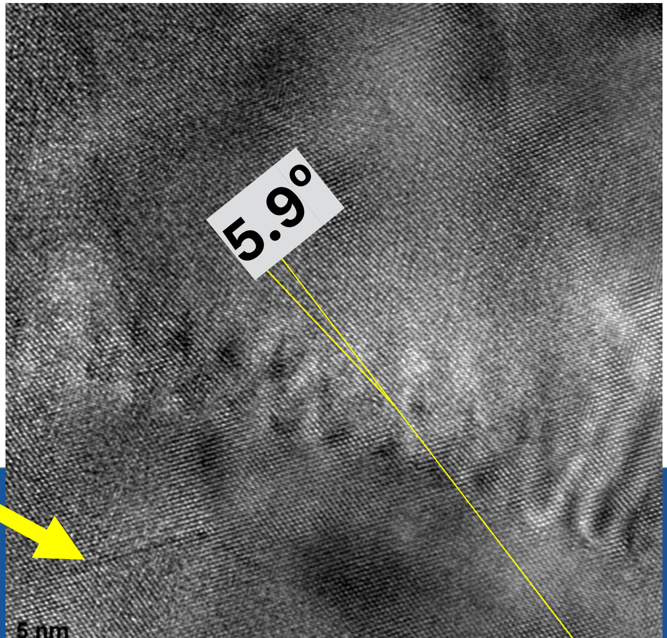


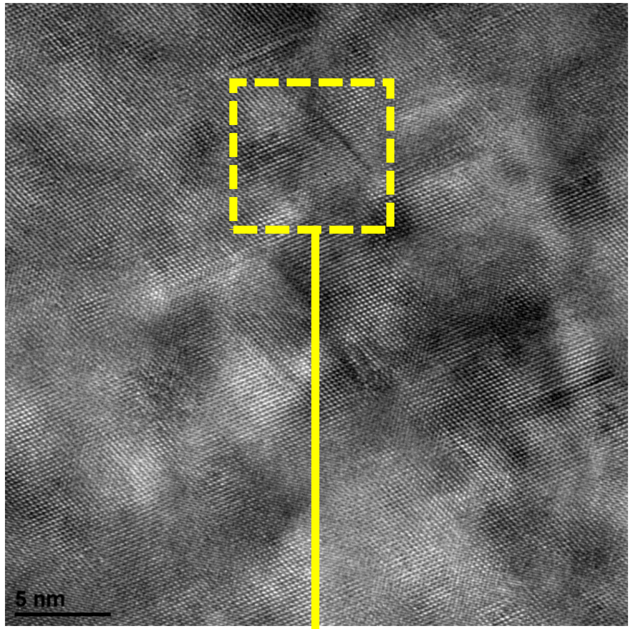
Intensywne odkształcenie plastyczne – LPBF AlSi10Mg

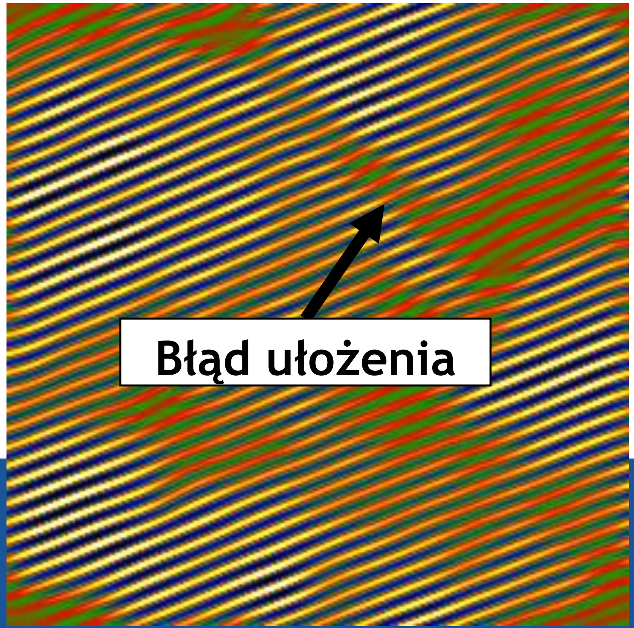




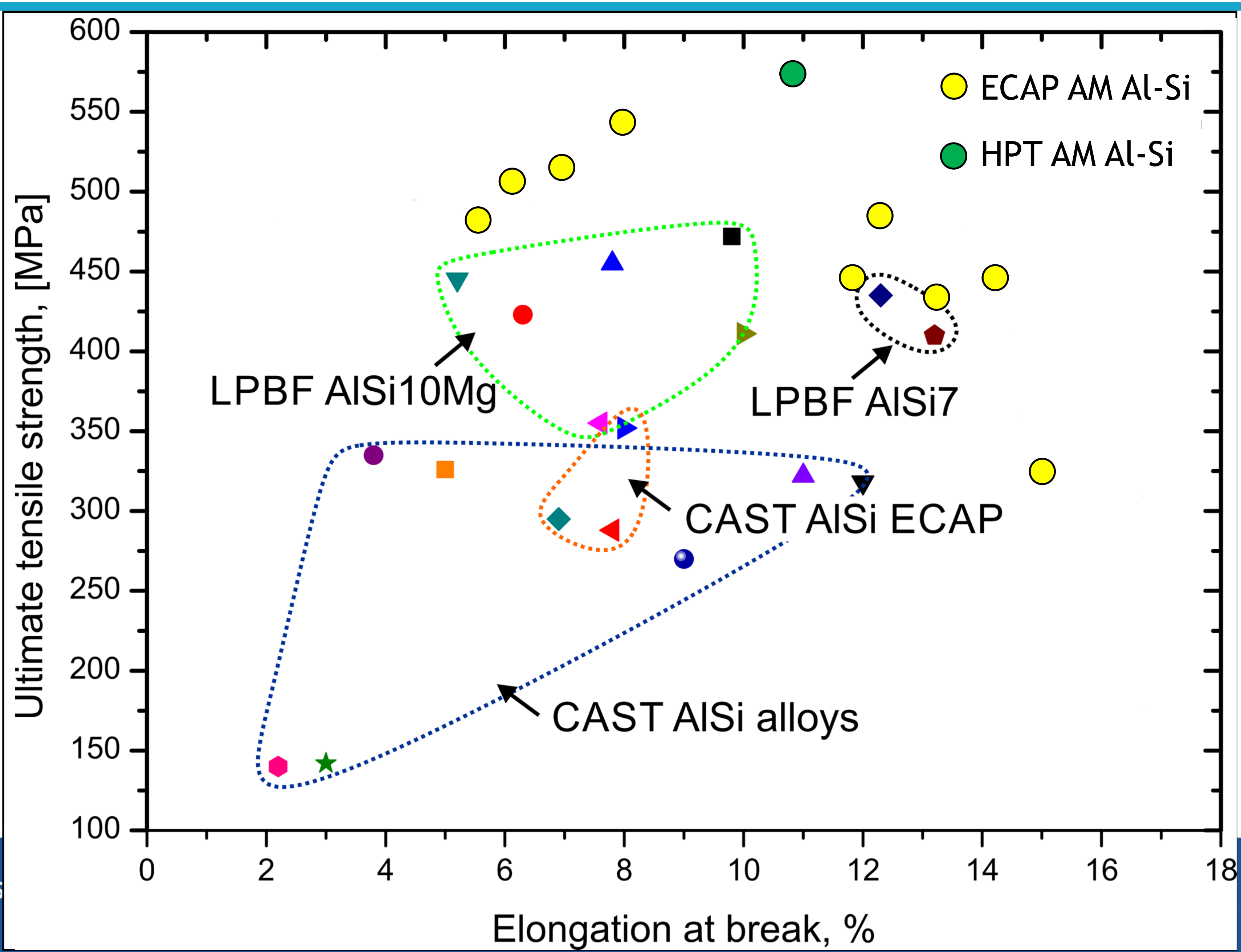








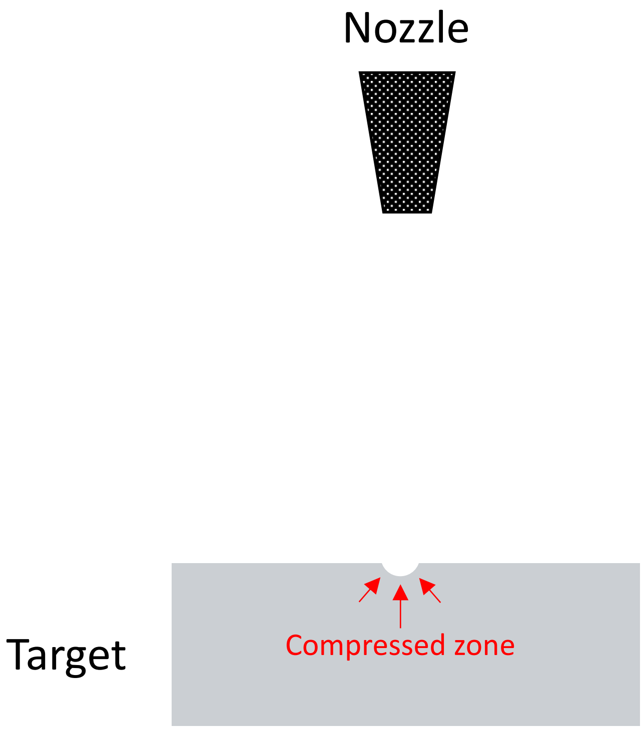
Intensywne odkształcenie plastyczne – LPBF AlSi10Mg

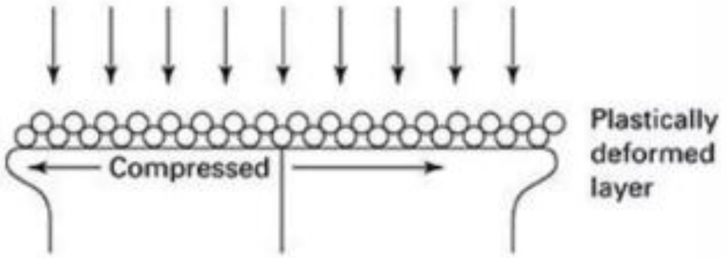


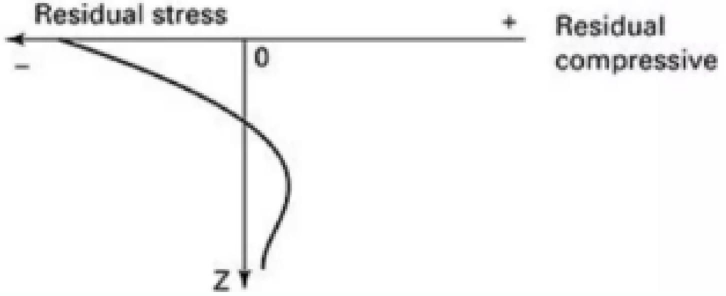
STABILNOŚĆ TERMICZNA MIKROSTRUKTURY STOPU ALSI10MG PO PROCESIE ŚRUTOWANIA (SHOT PEENING)

Proces śrutowania (shot peening)

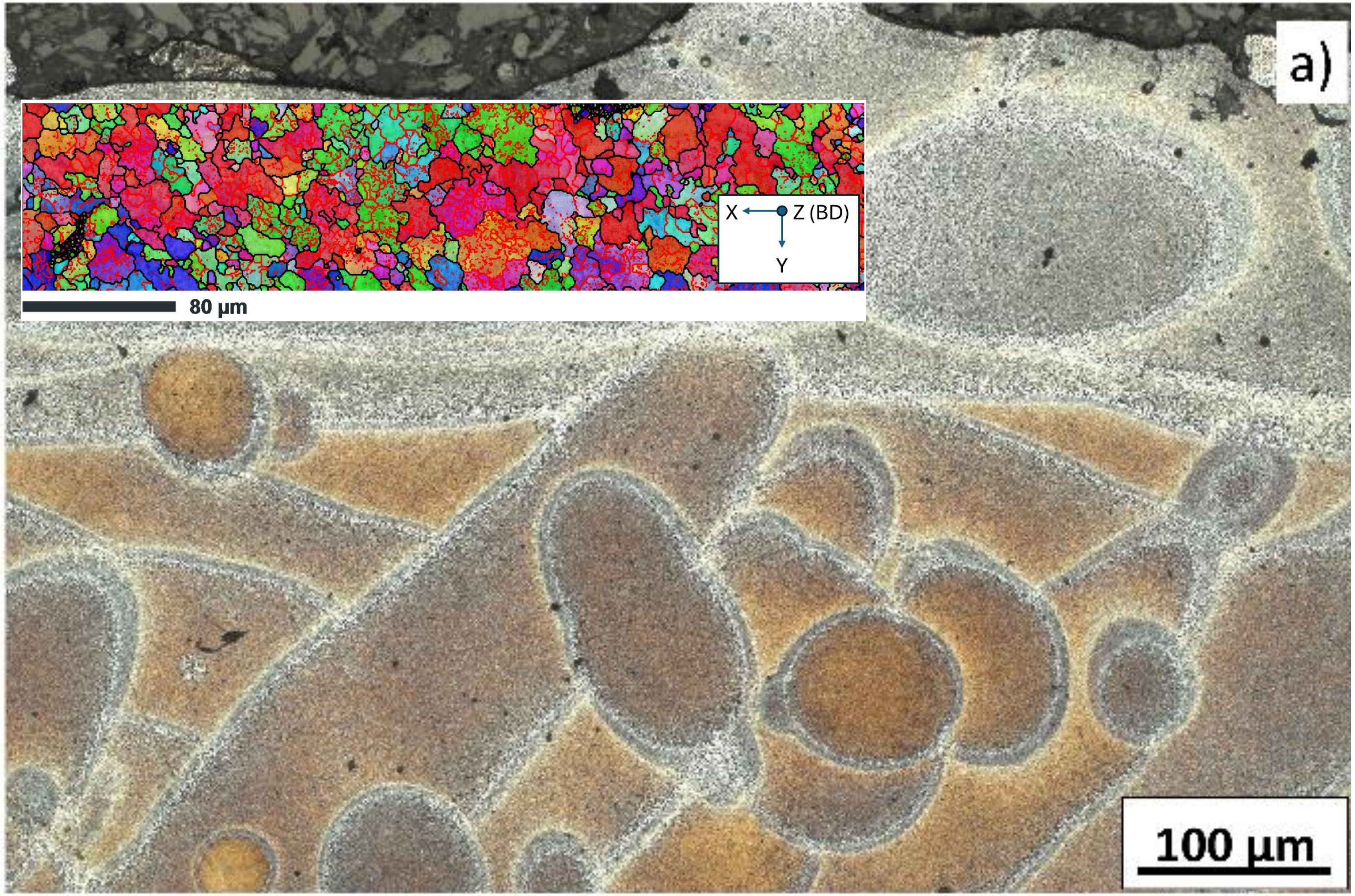
- Jest to proces obróbki plastycznej na zimno,
- Cel – wytworzenie naprężeń ściskających,
- Zastosowanie – poprawa wytrzymałości zmęczeniowej komponentów z druku 3D,



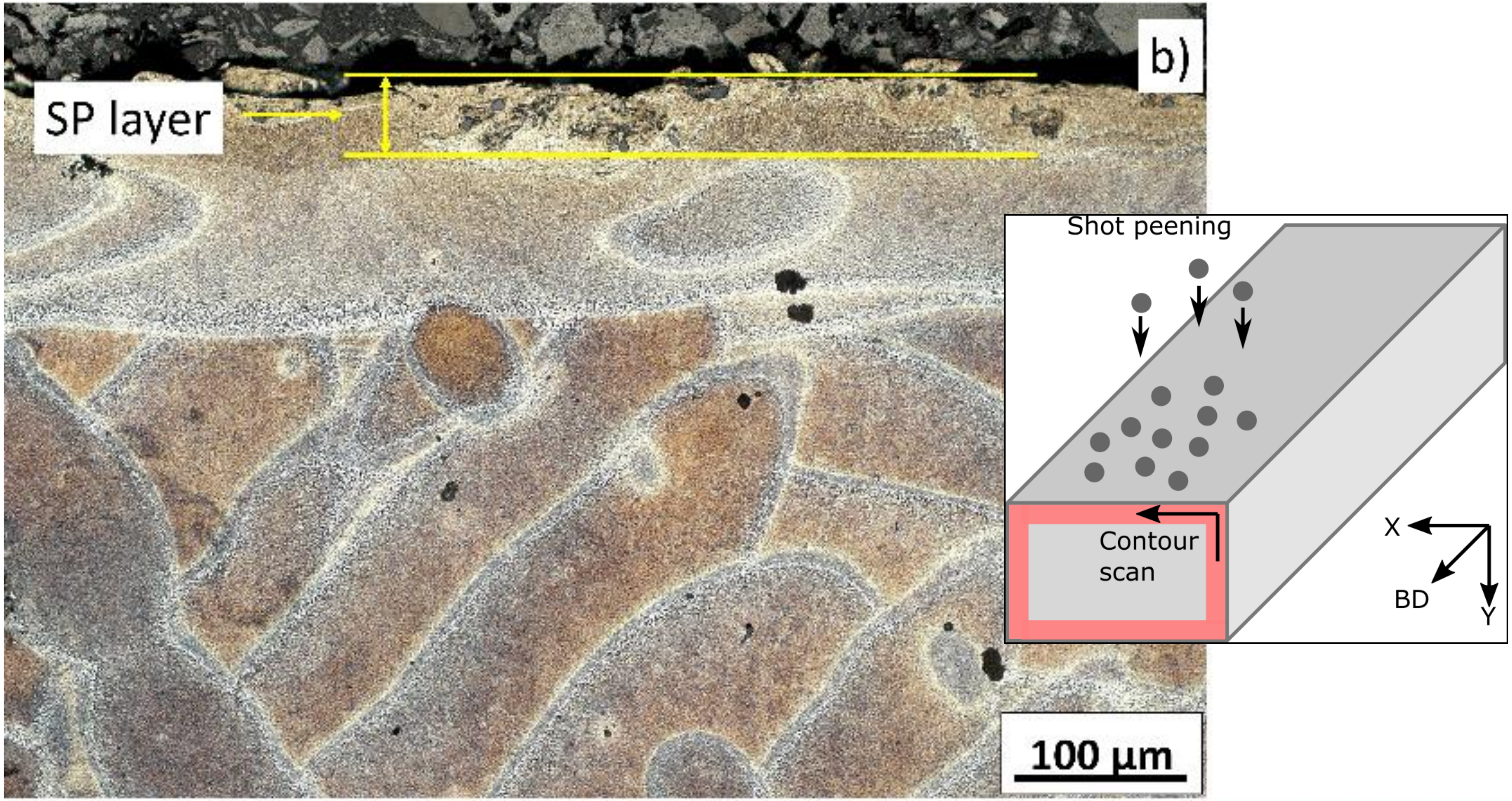




Mikrostruktura stopu AlSi10Mg przed procesem śrutowania



Mikrostruktura stopu AlSi10Mg po procesie śrutowania



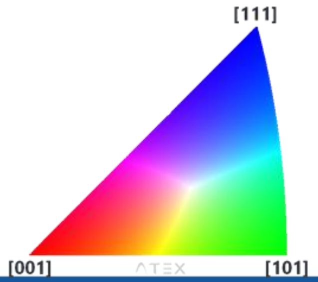
Mikrostruktura stopu AlSi10Mg po procesie śrutowania

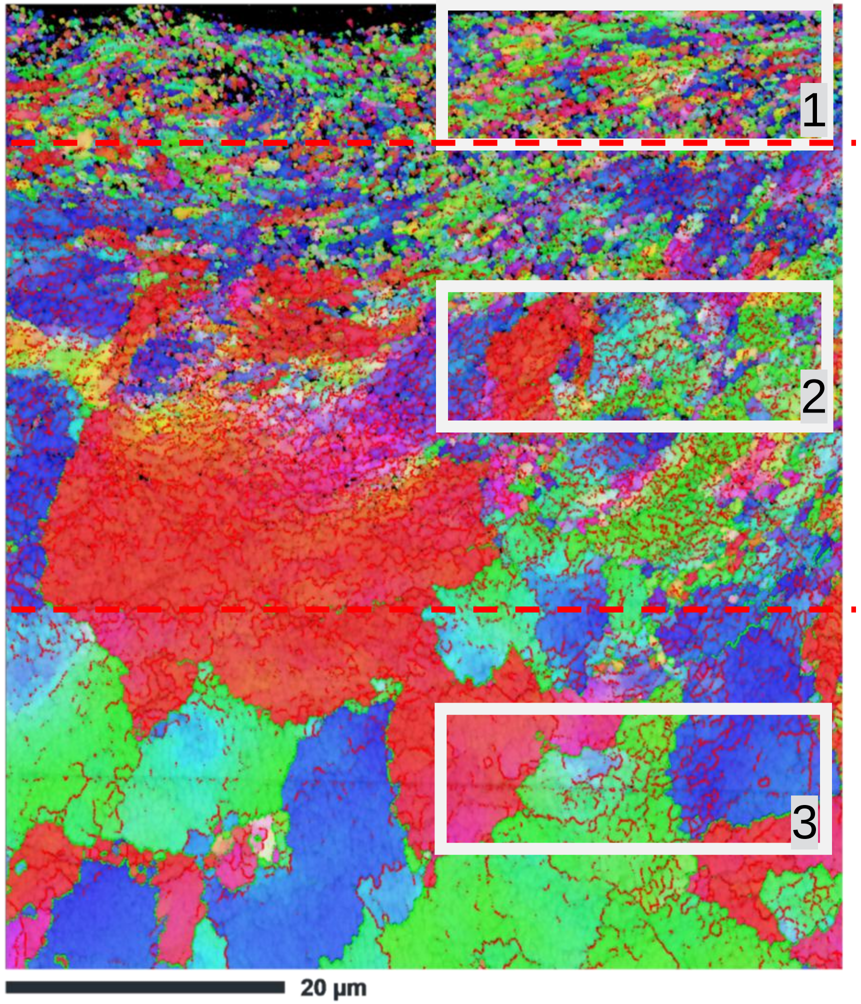
Plastically deformed layer

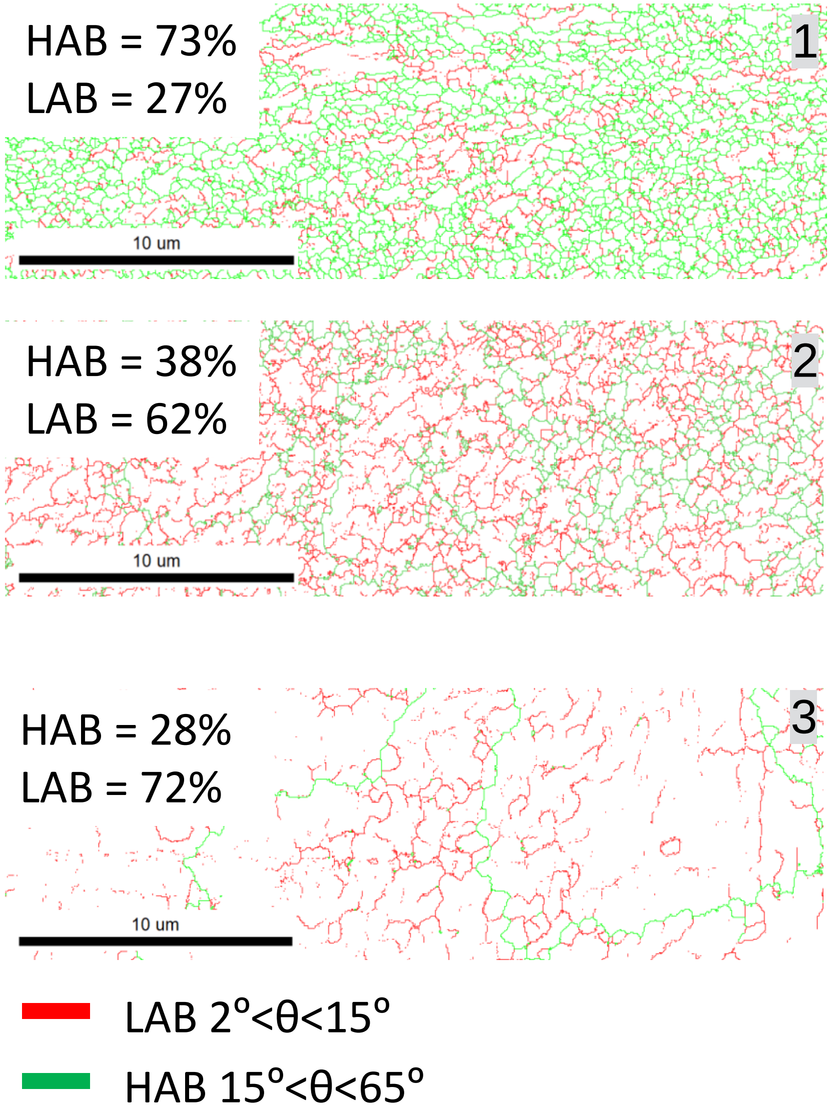
- Wysoka energia odkształcenia,
- Duża powierzchnia granic ziaren,
- Gradient naprężeń (ściskające/rozciągające).

Sub-surface region

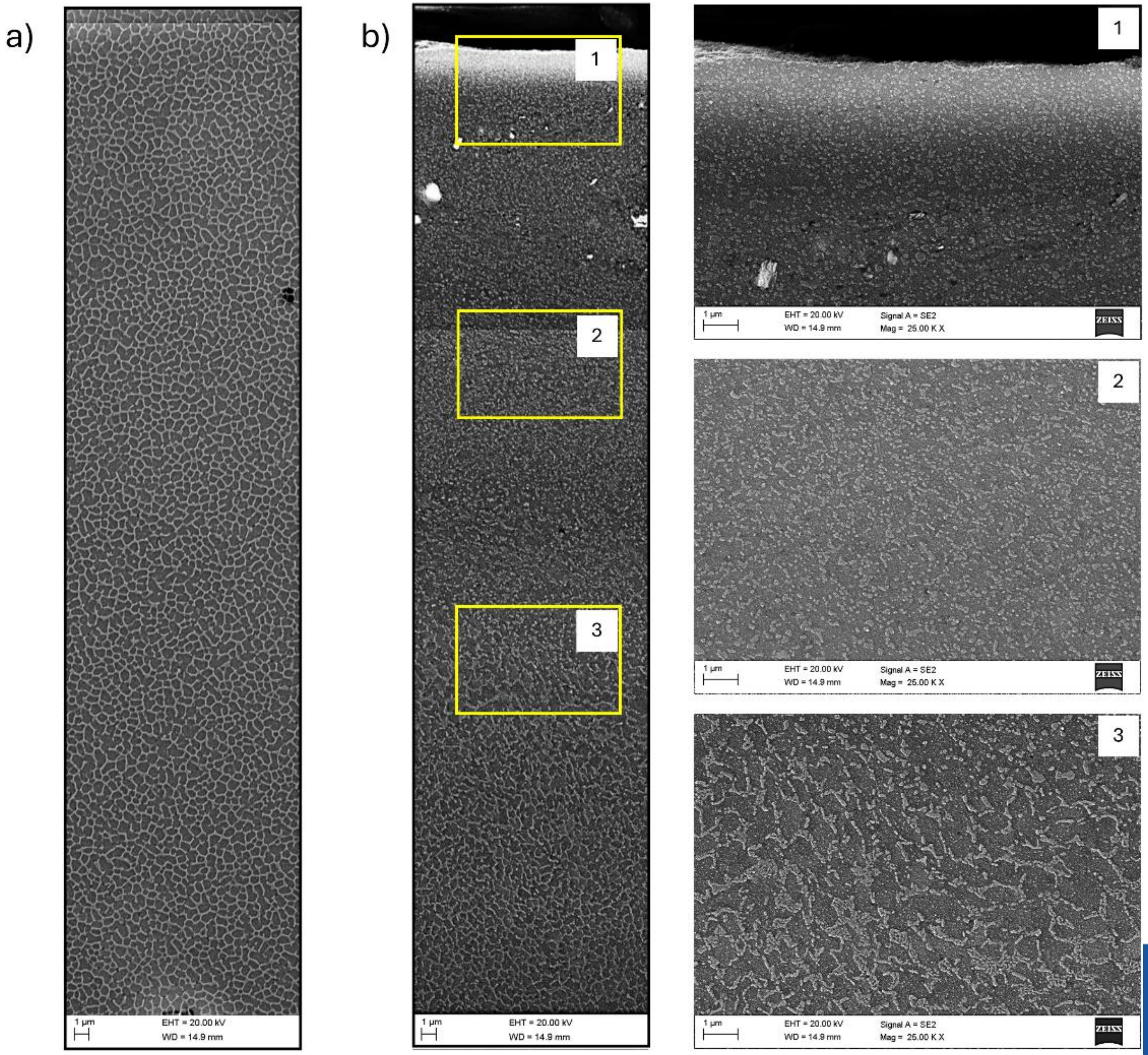
Base material







Mikrostruktura stopu AlSi10Mg po procesie śrutowania



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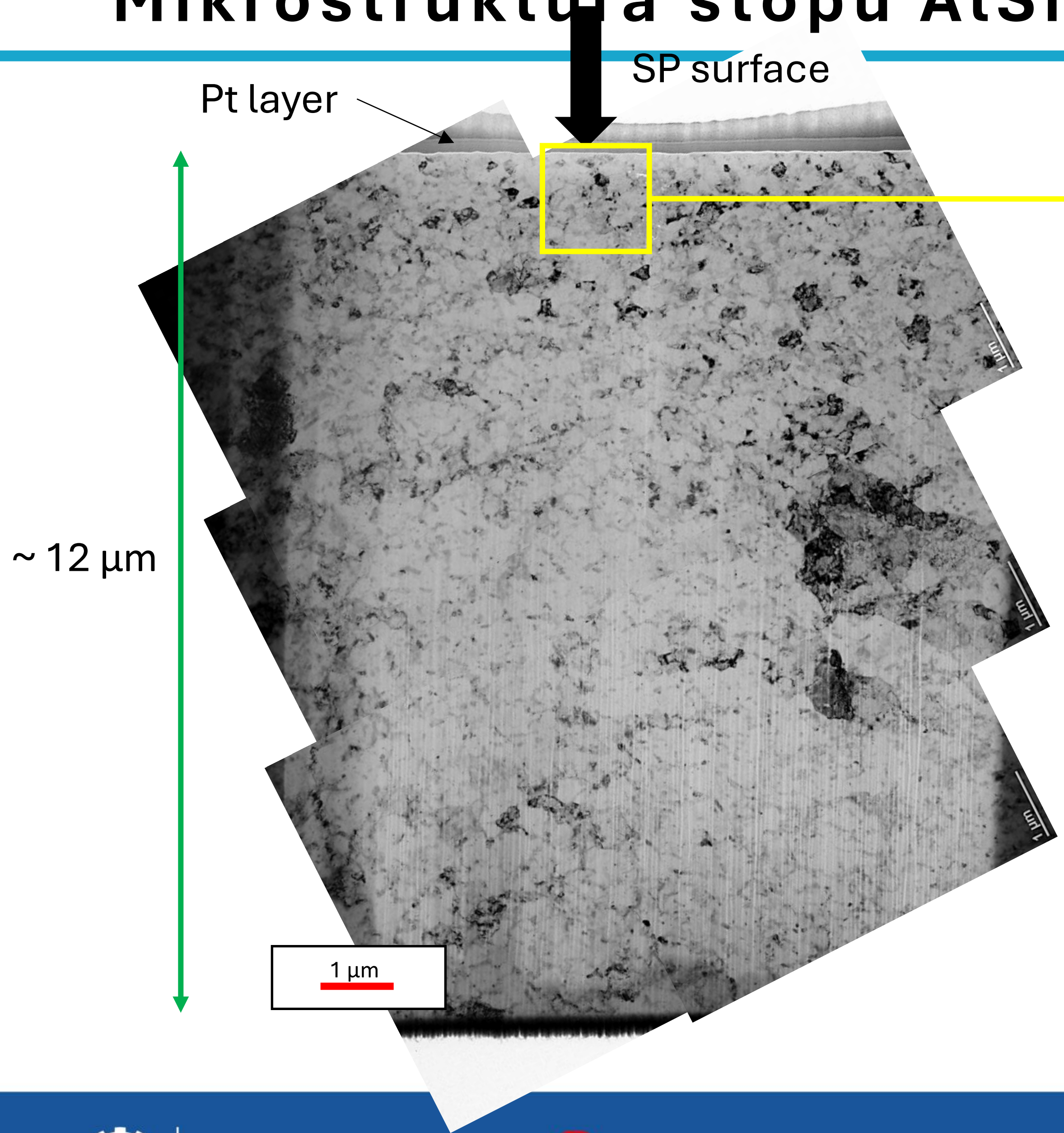
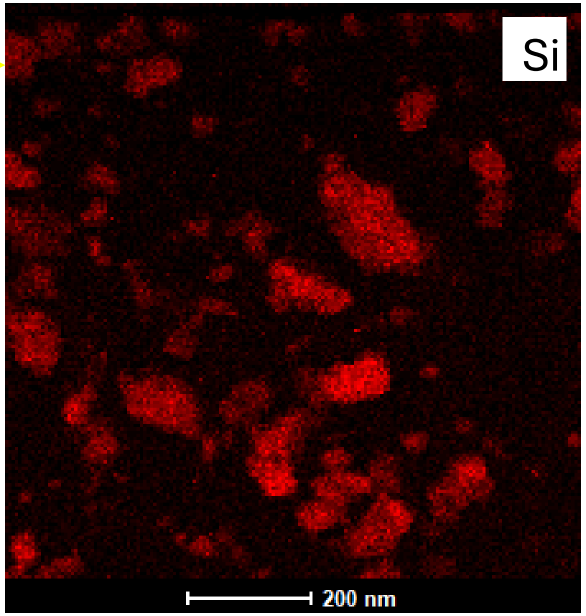
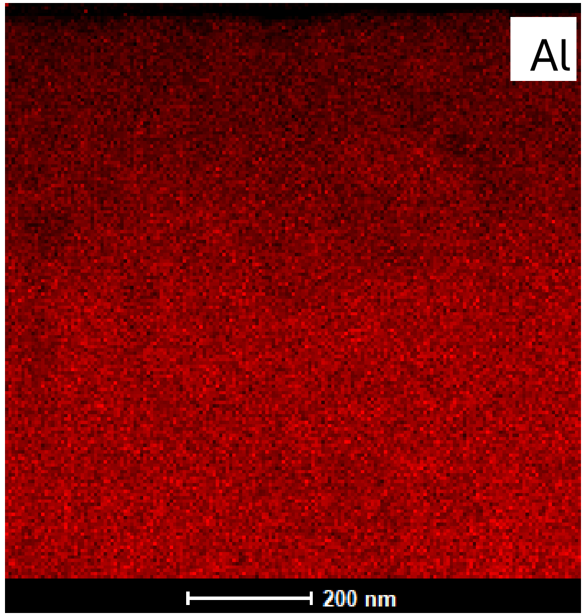
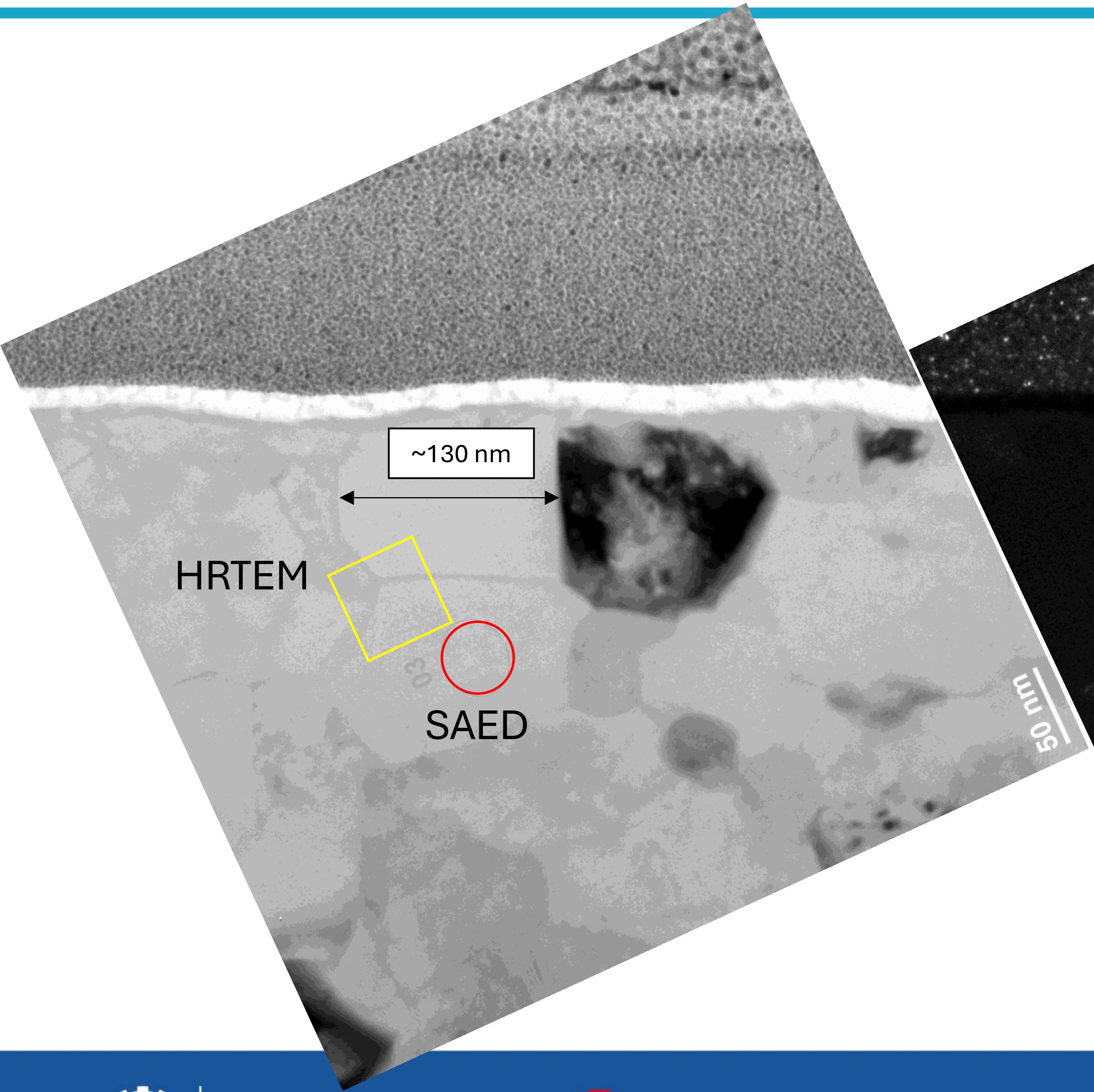
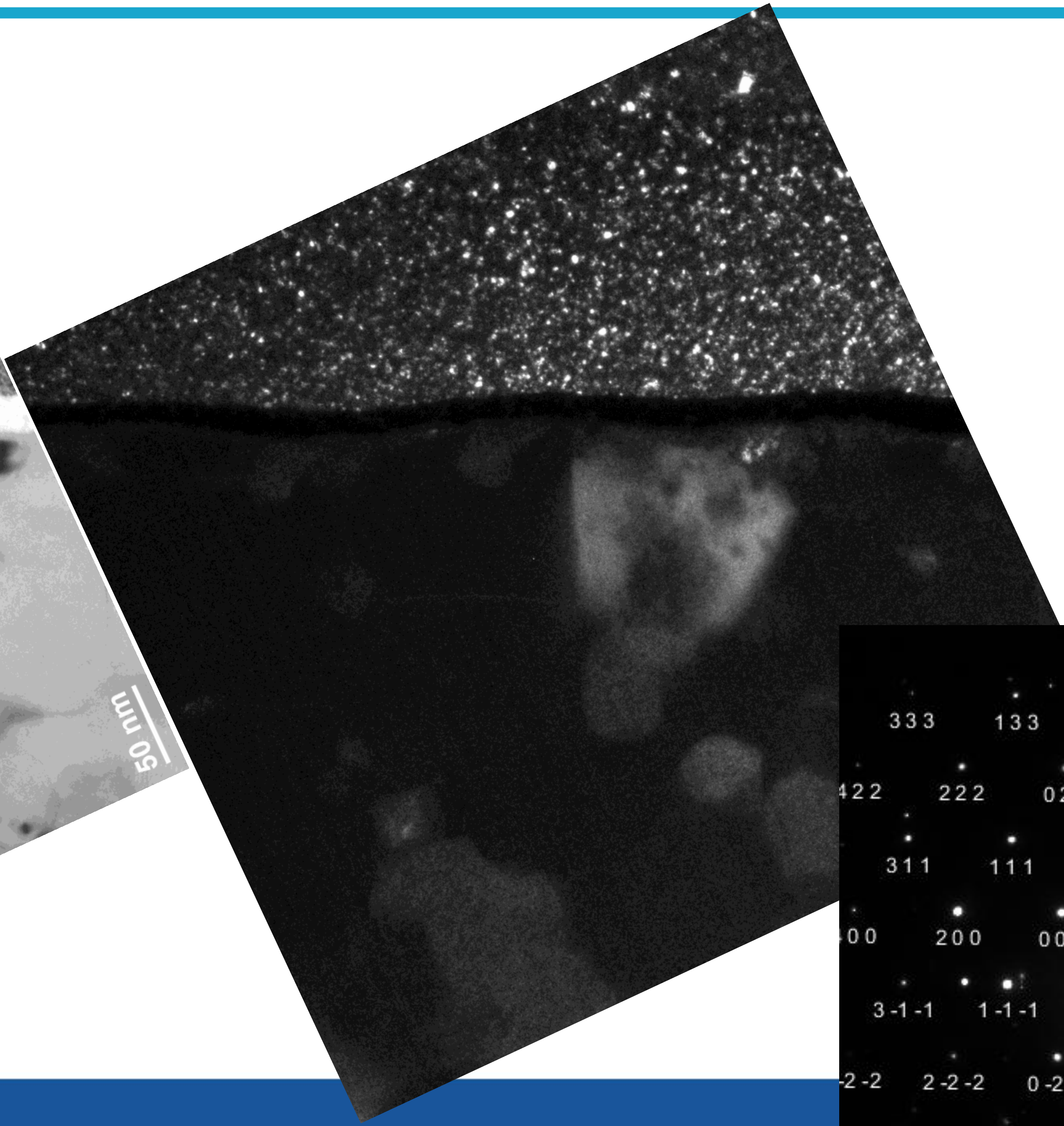


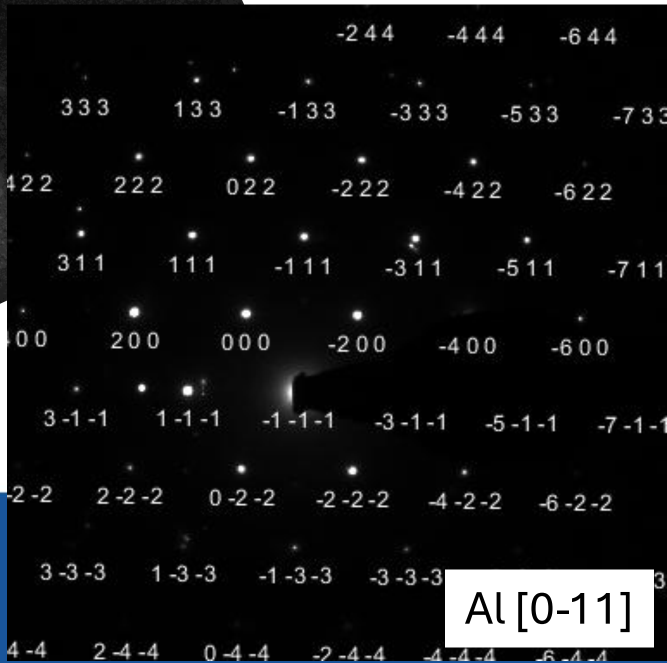




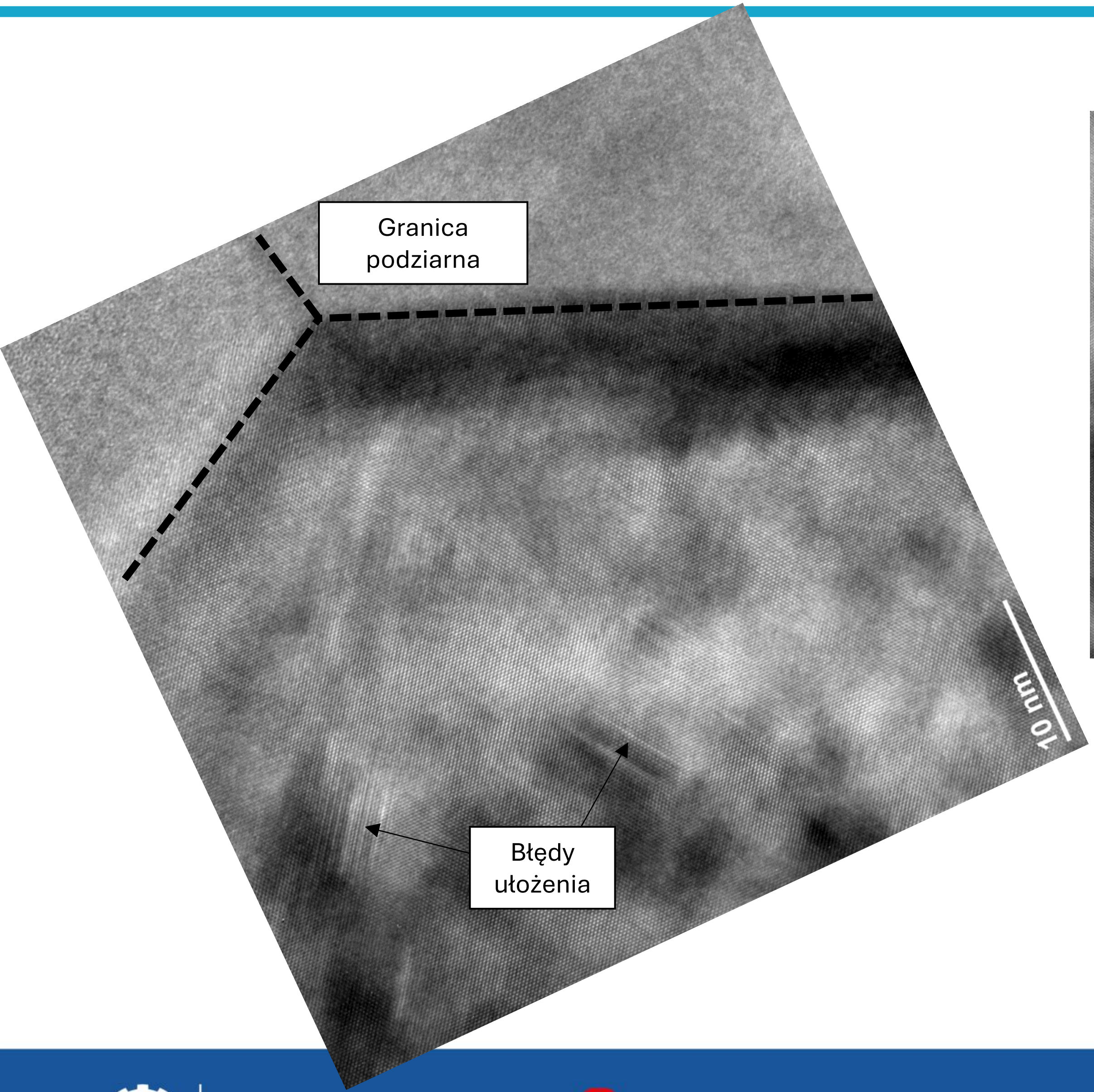
Mikrostruktura stopu AlSi10Mg po procesie śrutowania

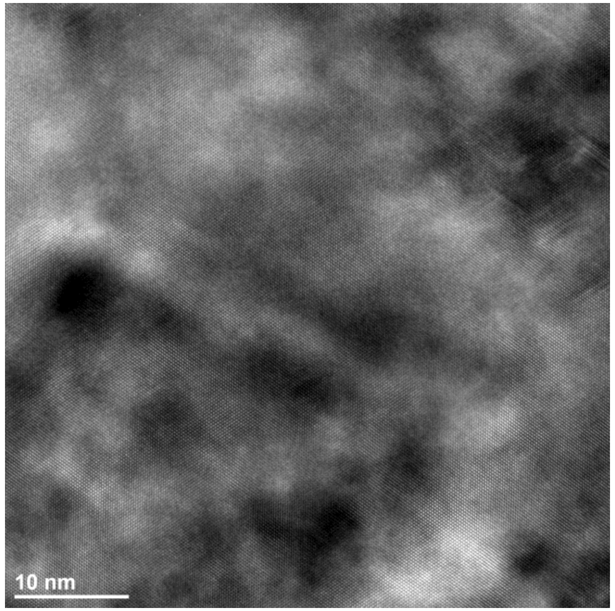


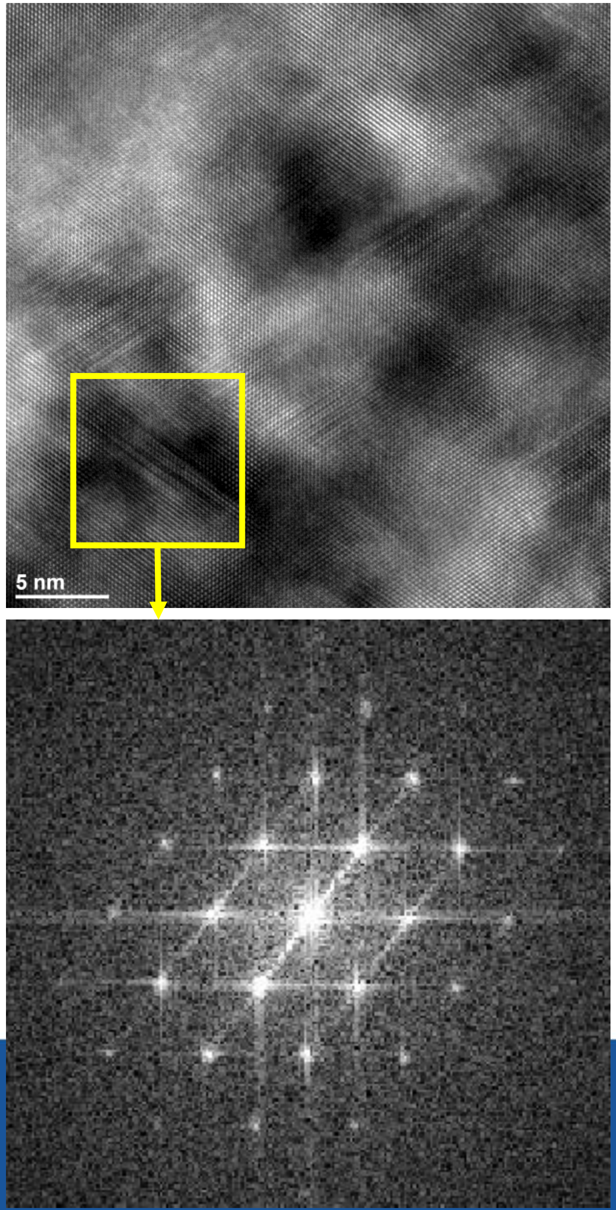




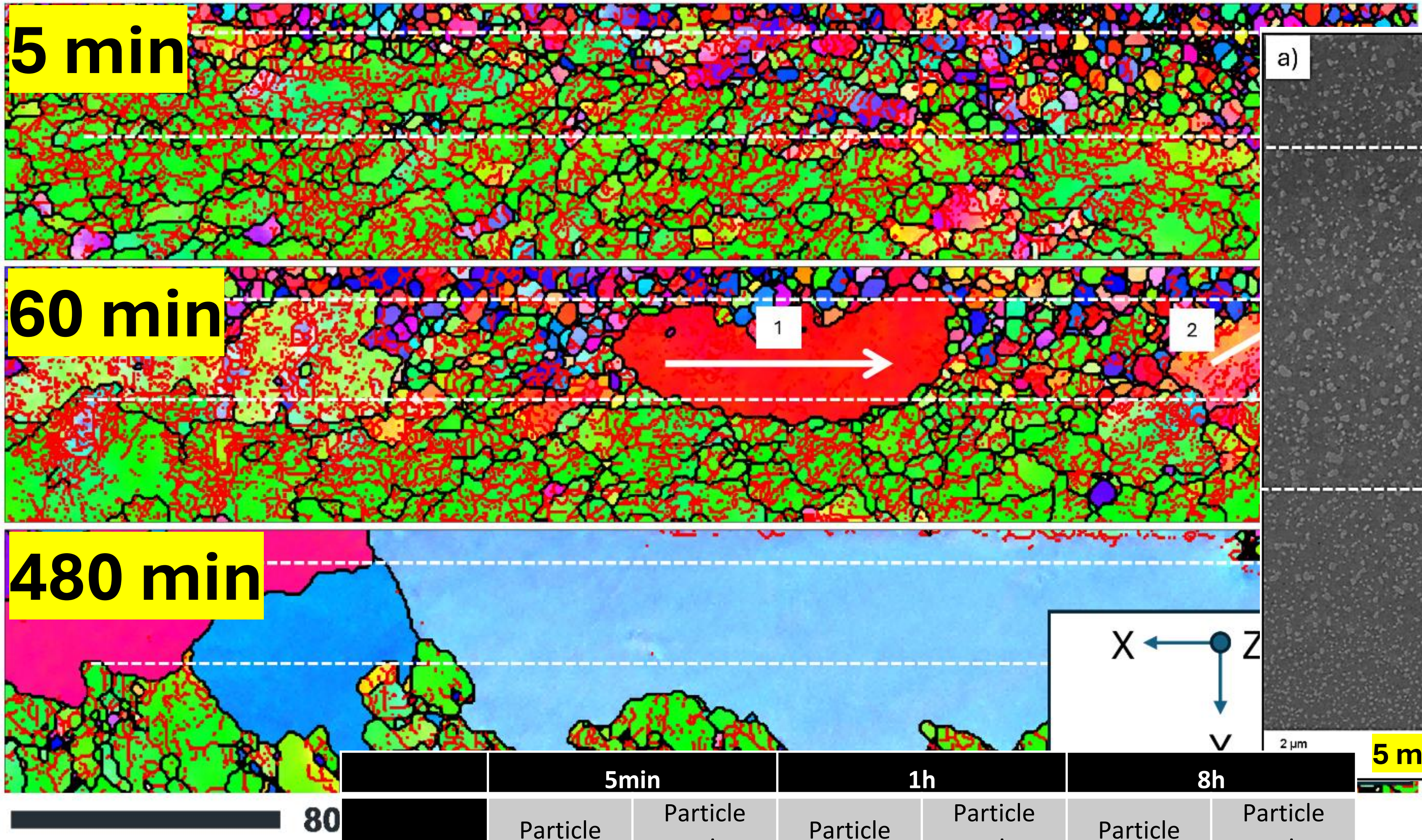
Mikrostruktura stopu AlSi10Mg po procesie śrutowania

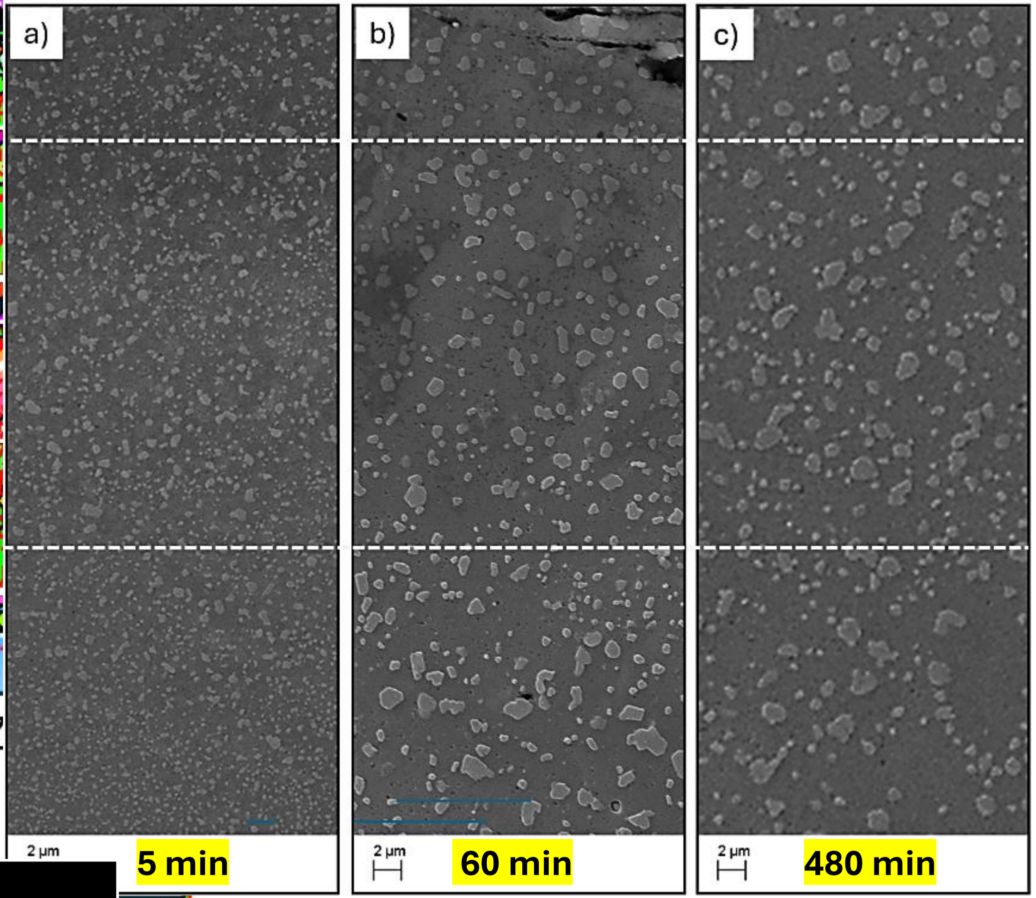






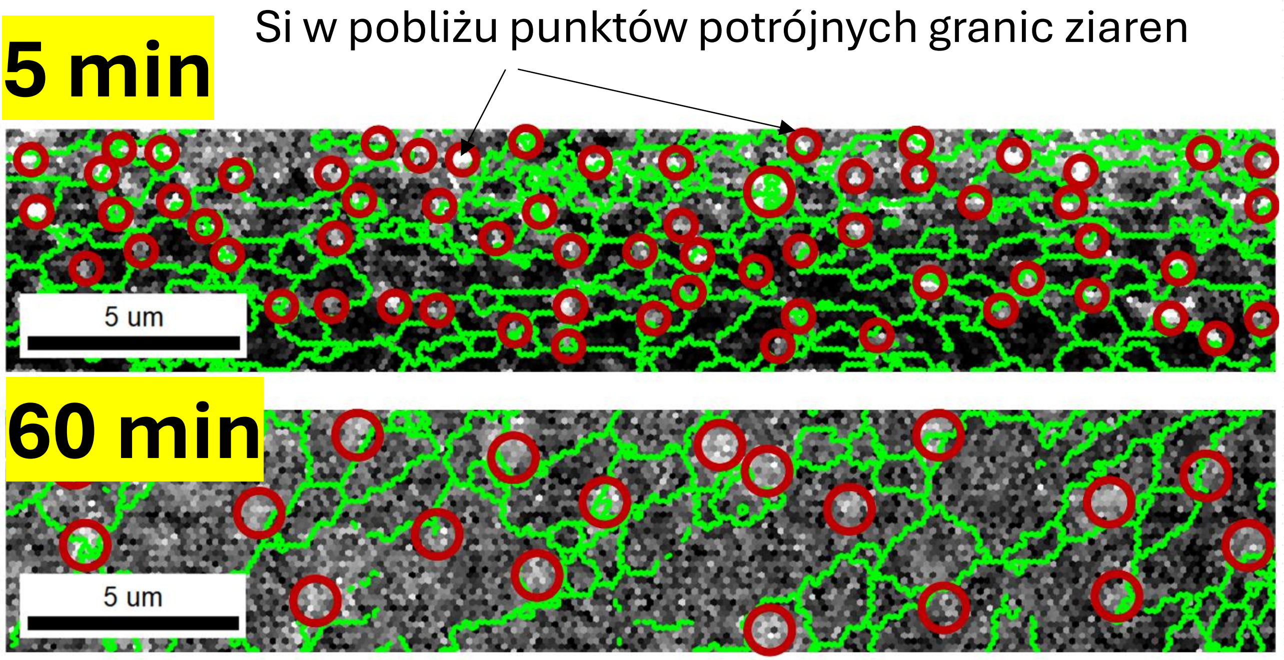
Stabilność termiczna mikrostruktury

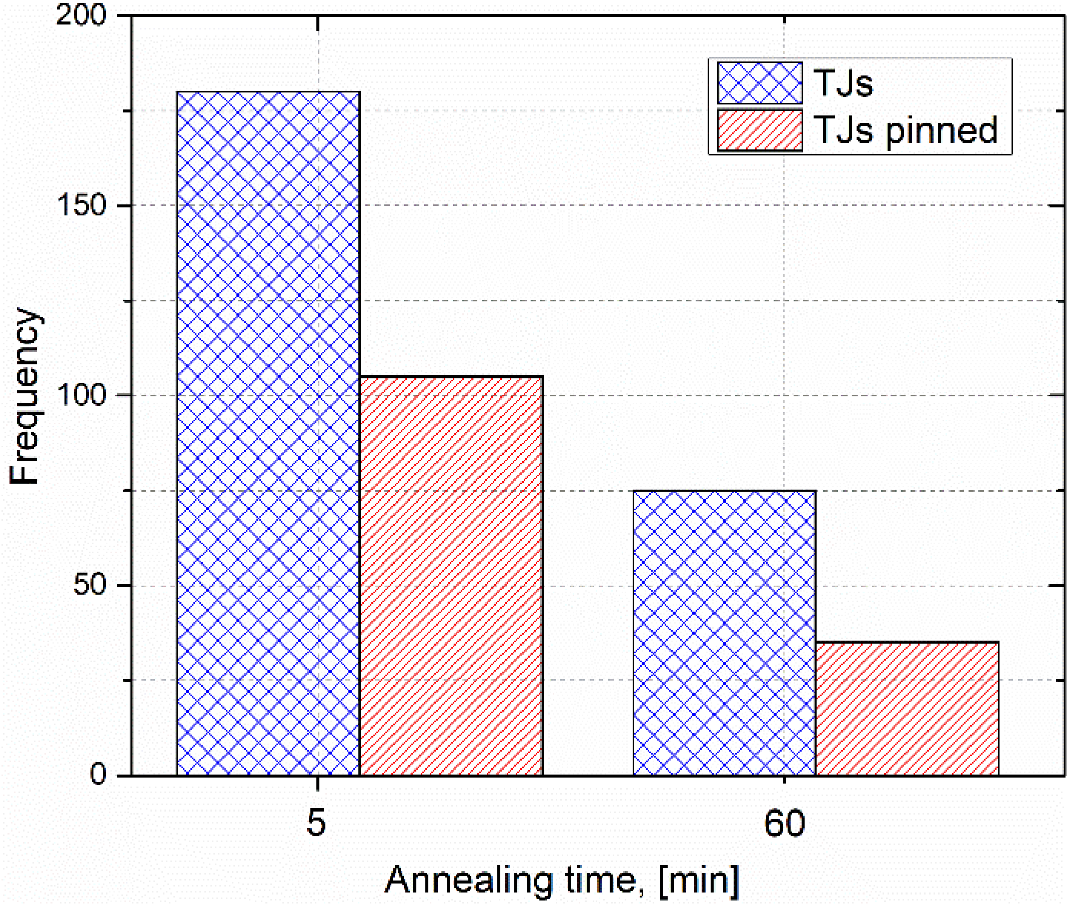




	5min		1h		8h	
	Particle size, µm	Particle spacing, µm	Particle size, µm	Particle spacing, µm	Particle size, µm	Particle spacing, µm
Topmost layer	0.31	0.37	0.47	1.32	0.54	1.79
Transition layer	0.28	0.39	0.49	1.85	0.55	1.98
Matrix	0.24	0.28	0.43	1.64	0.57	1.86

Stabilność termiczna mikrostruktury





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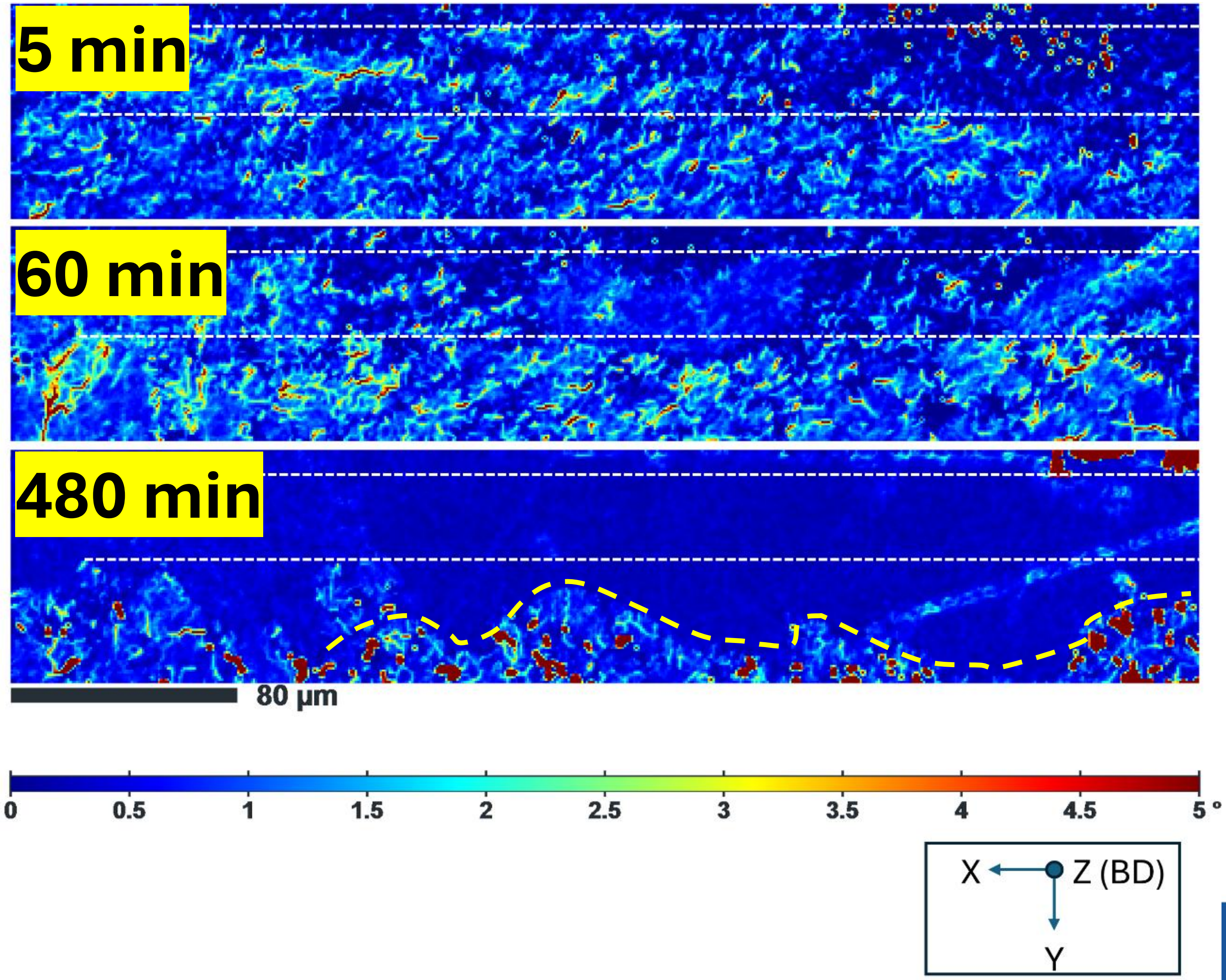
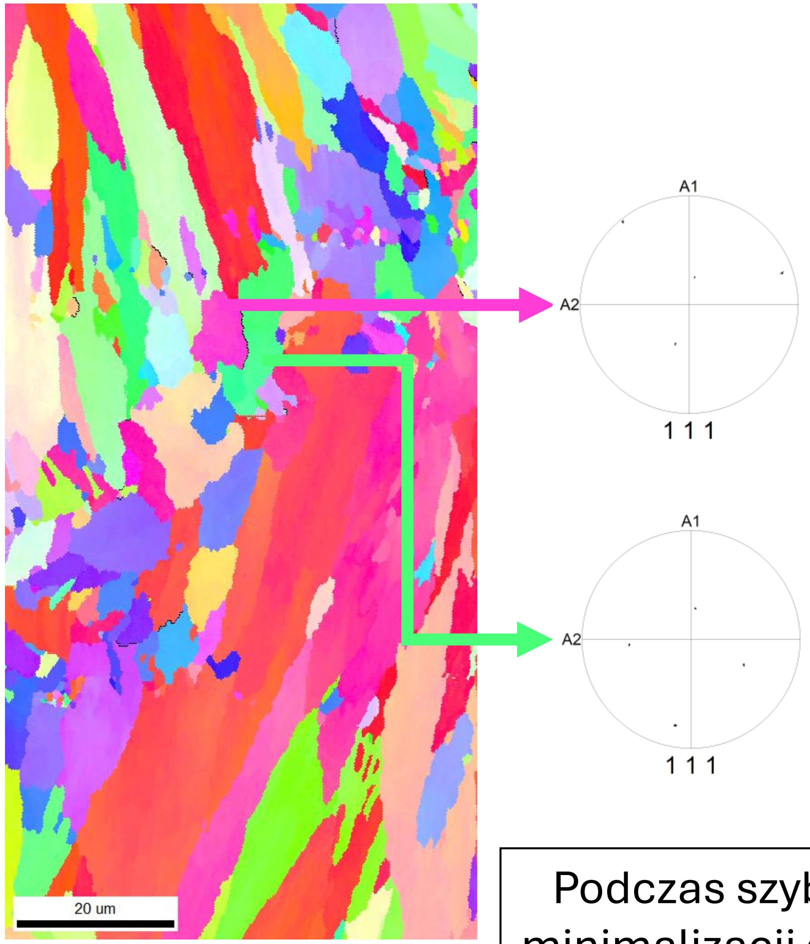
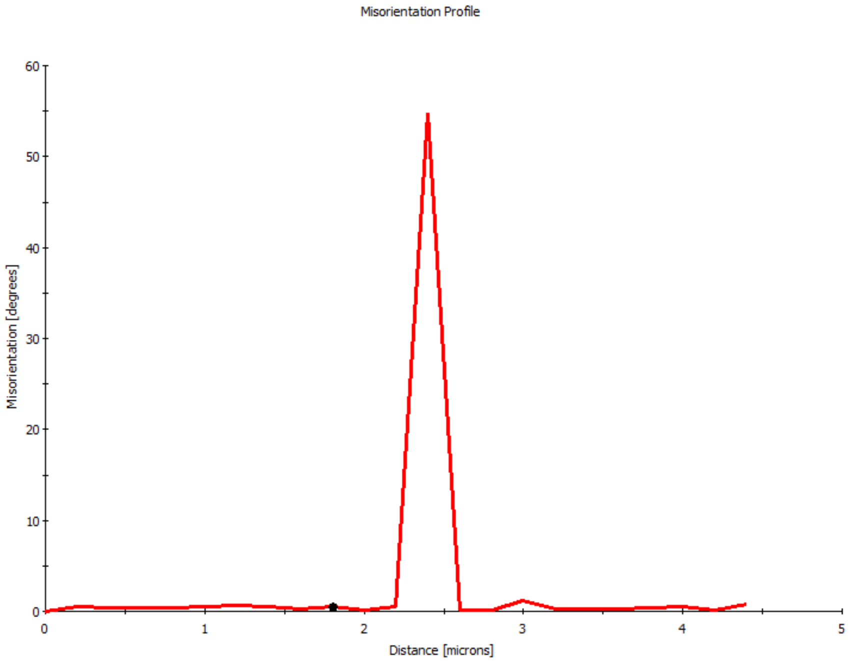


INŻYNIERIA GRANIC MIĘDZYKRYSTALICZNYCH (IGM) W STOPIE ALSI10MG / STABILNOŚĆ TERMICZNA MIKROSTRUKTURY PO PROCESIE KOBO

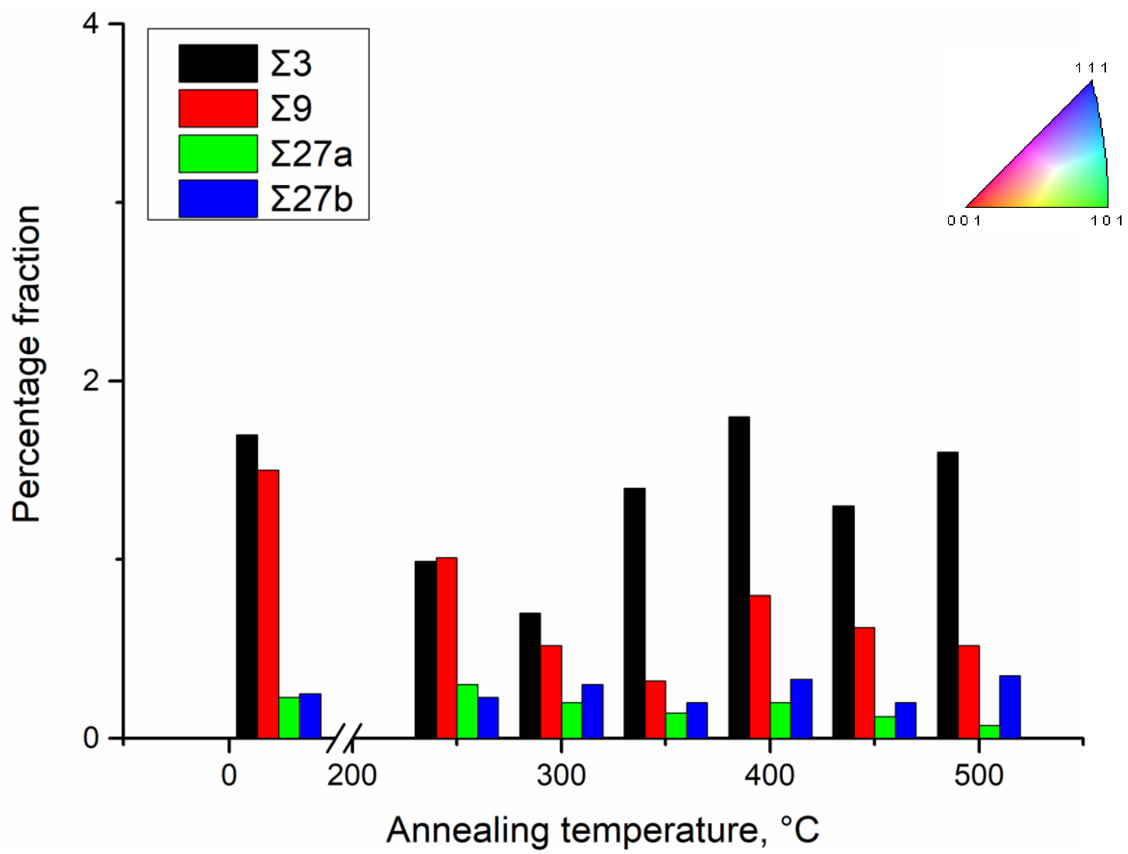
Granice specjalne – AlSi10Mg LPBF

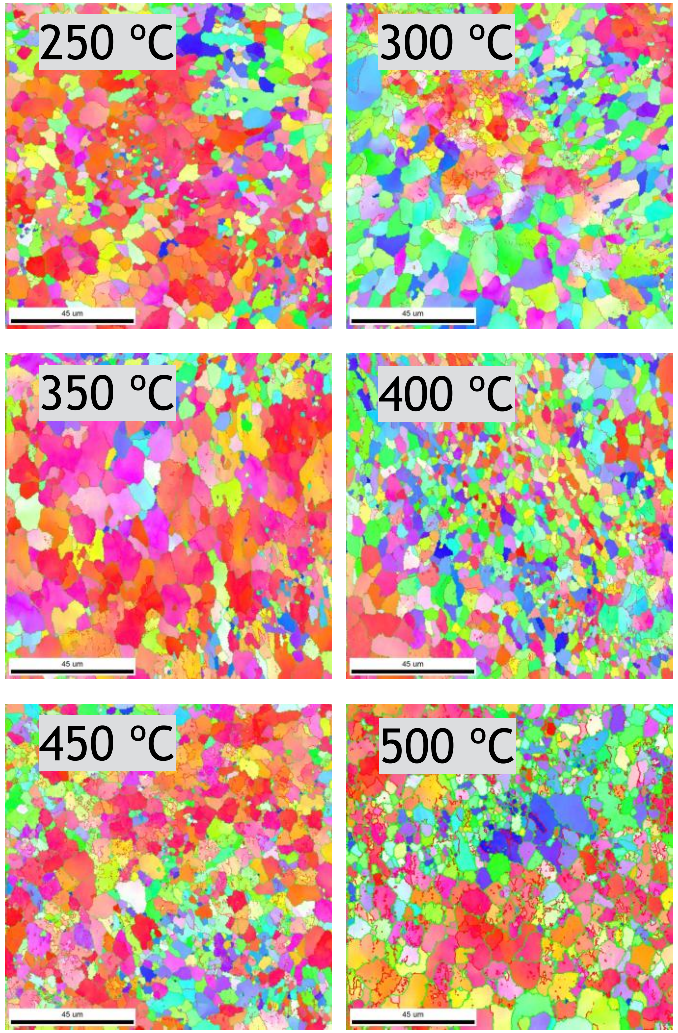




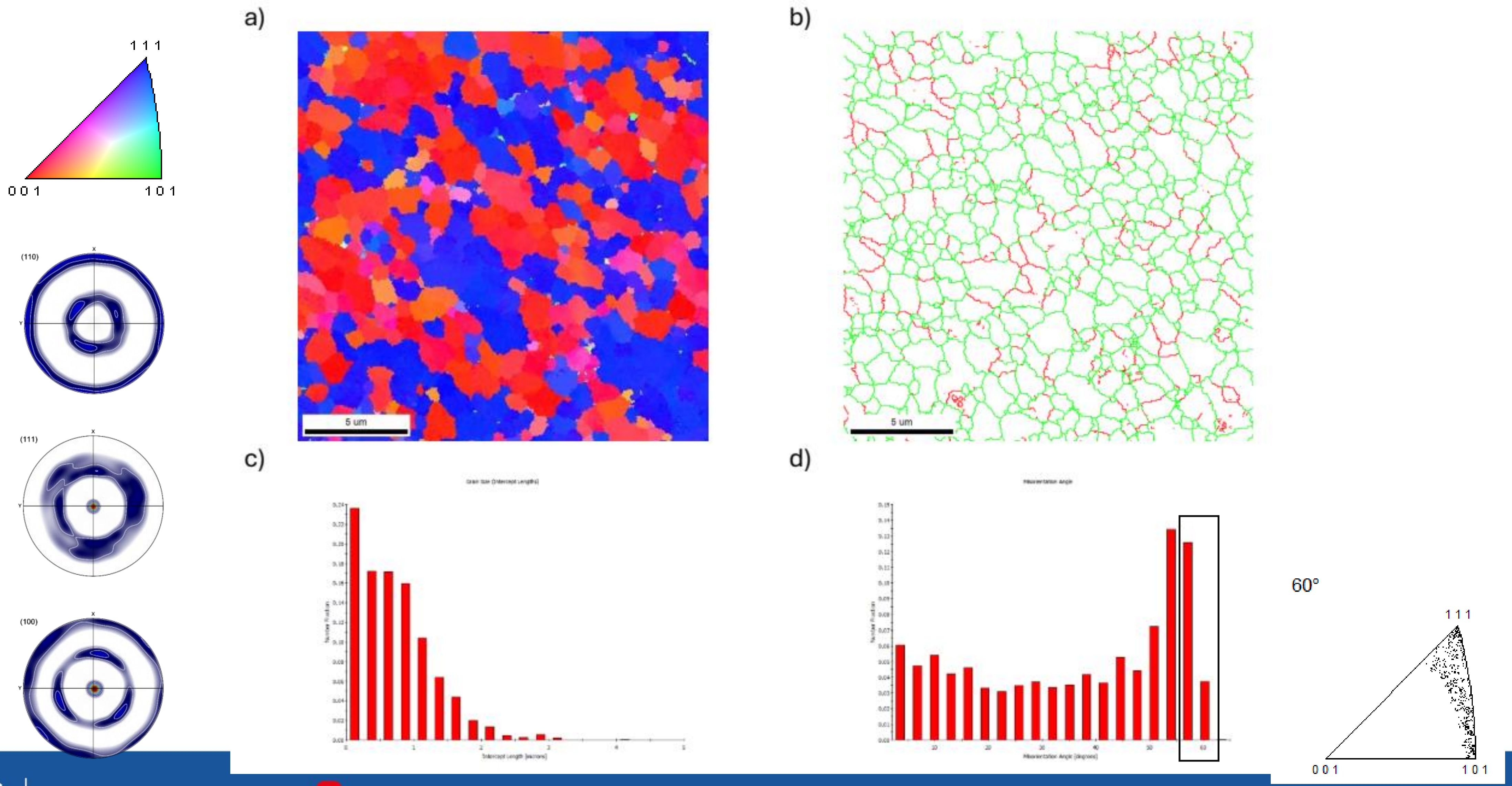
Podczas szybkiej krystalizacji i wzrostu ziaren, system dąży do minimalizacji energii. Powstawanie granic CSL jest energetycznie korzystne – mogą tworzyć się spontanicznie.

Wykorzystanie naprężeń resztkowych do aktywacji IGM





Mikrostruktura stopu AlSi10Mg po procesie KOBO



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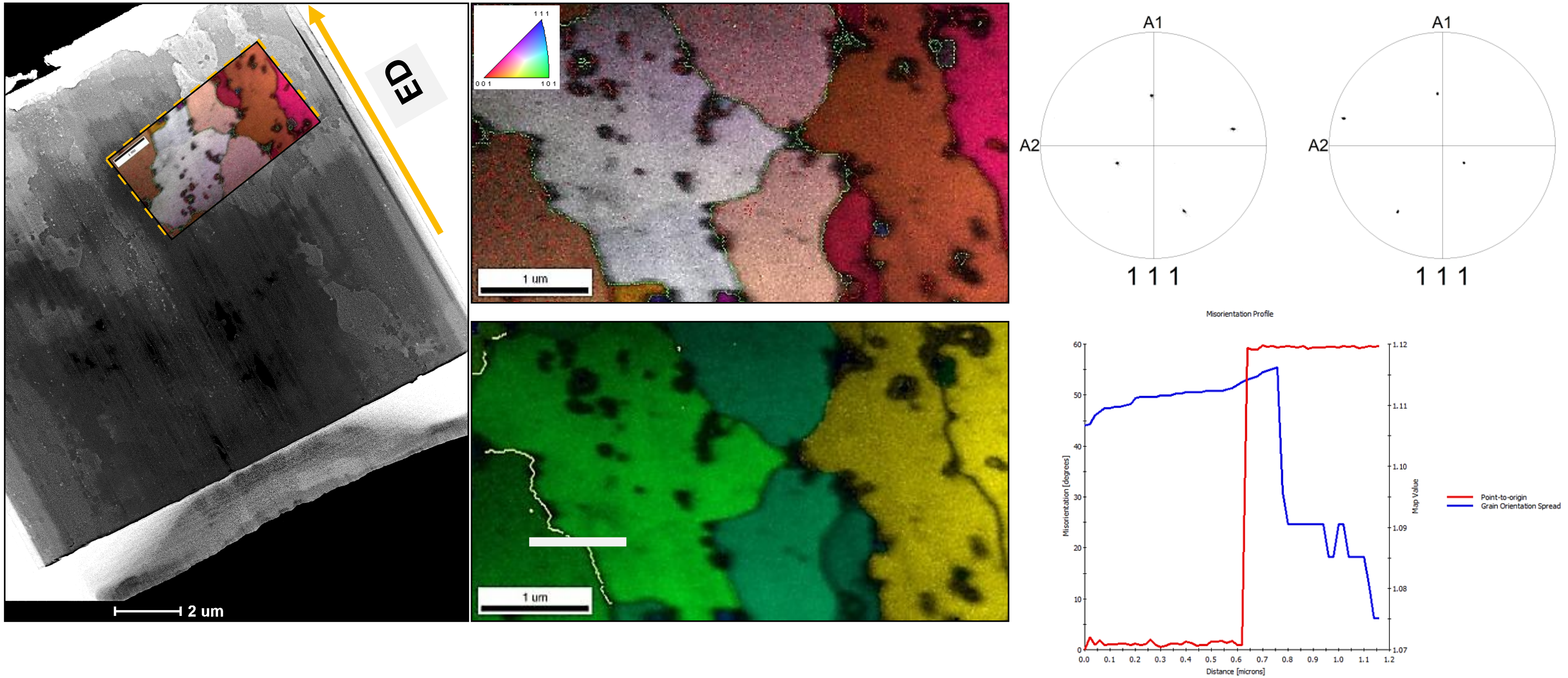
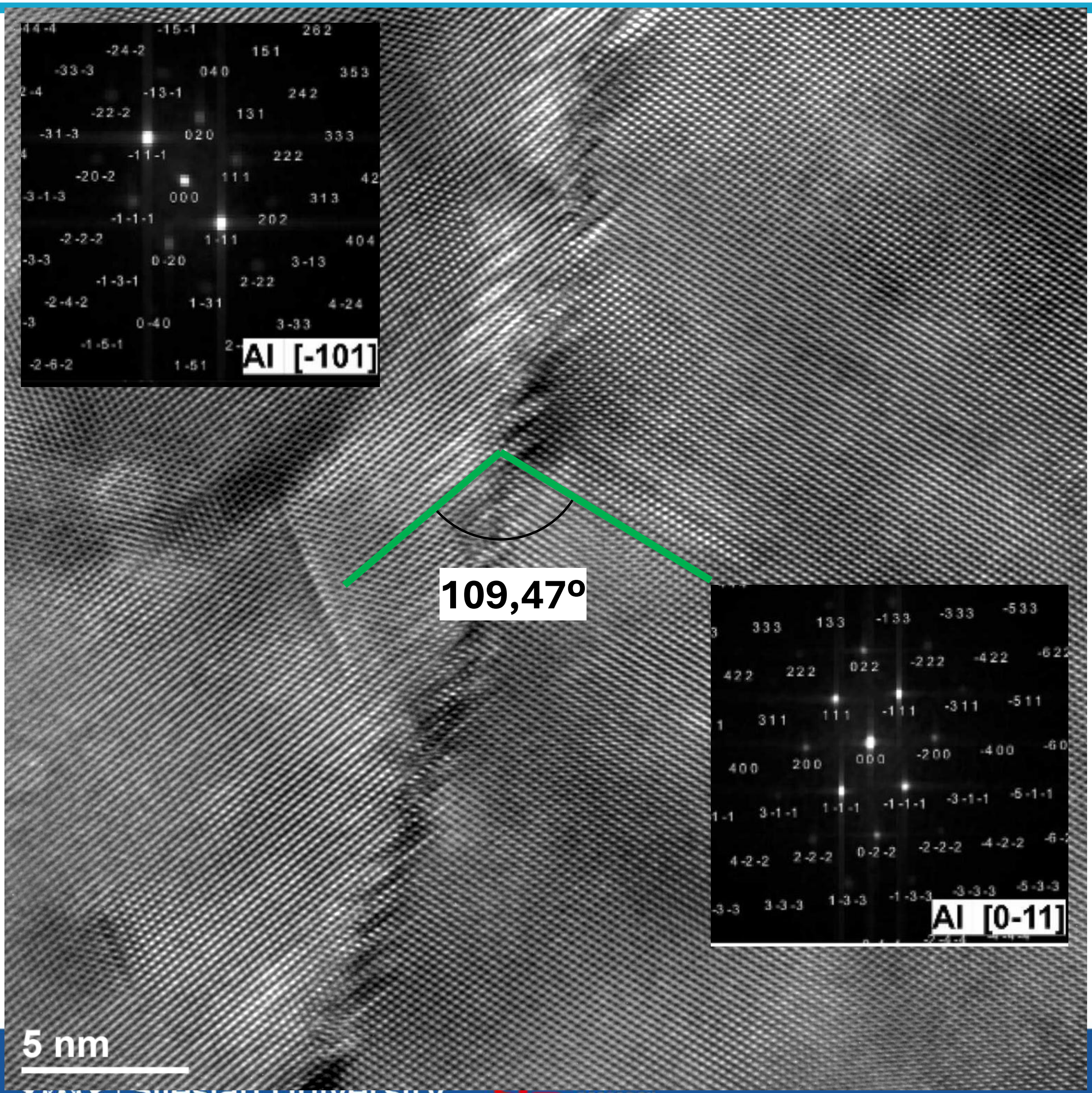
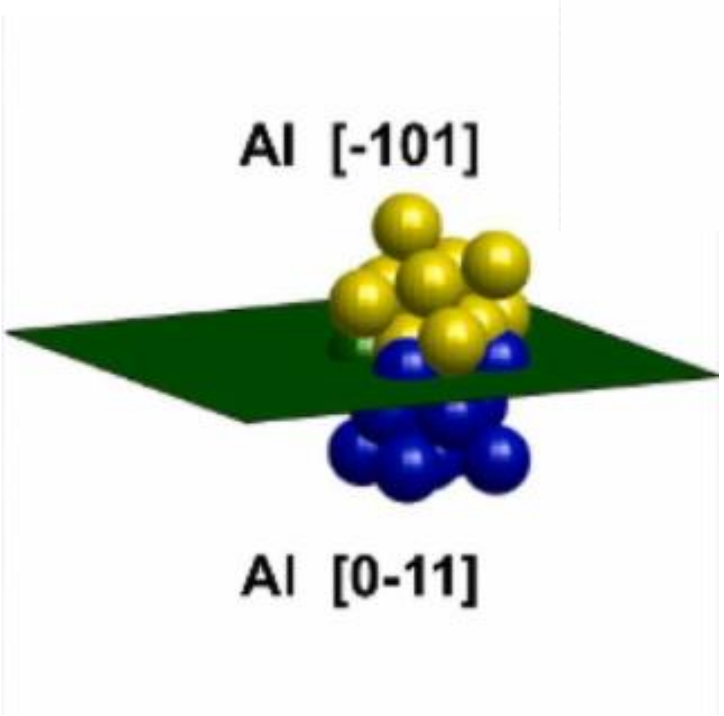
Mikrostruktura stopu AlSi10Mg po procesie KOBO



Wyniki analizy mikrostruktury stopu AlSi10Mg wykonanej techniką dyfrakcji linii Kikuchiego w trybie transmisyjnym

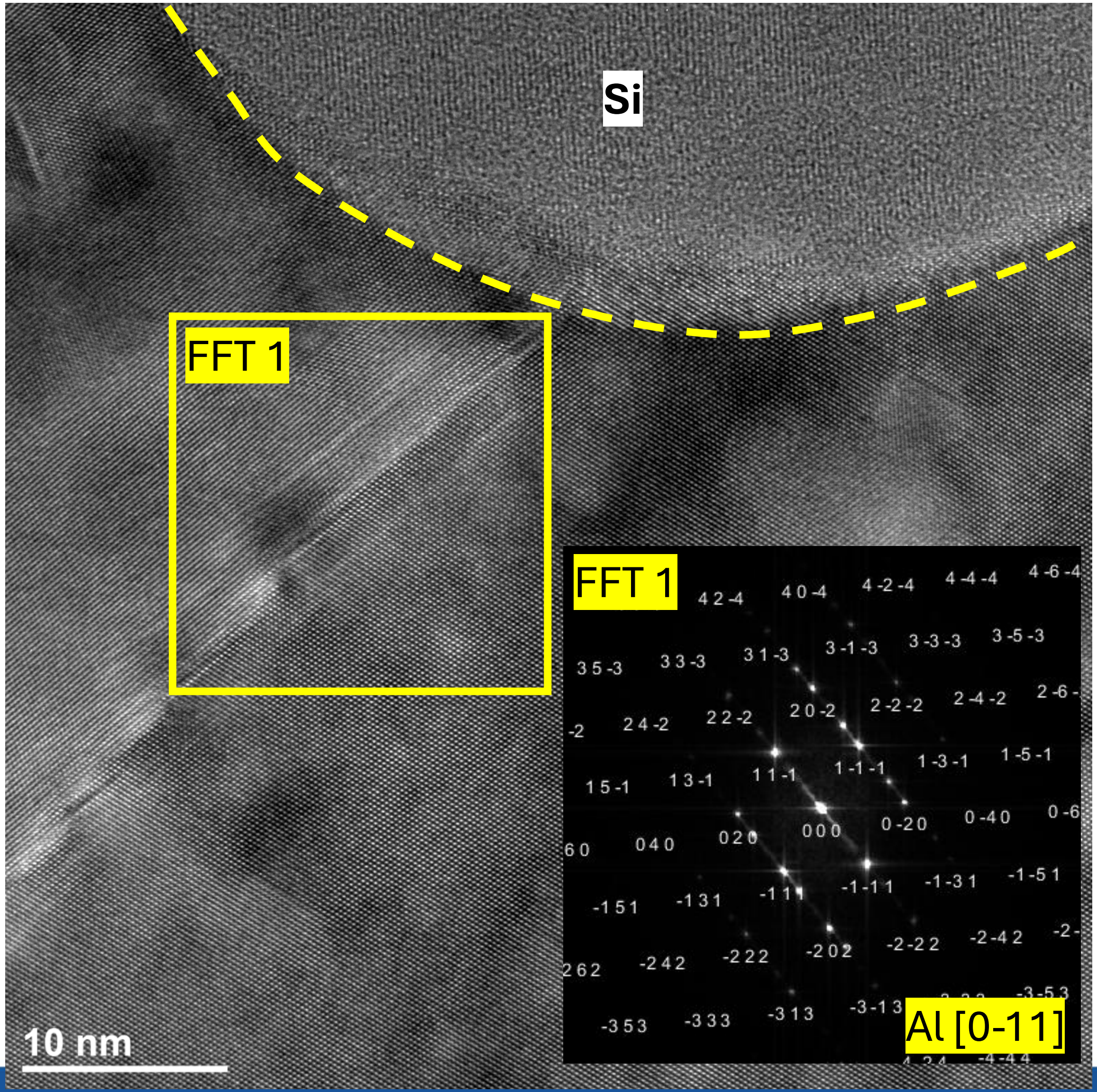
Mikrostruktura stopu AlSi10Mg po procesie KOBO

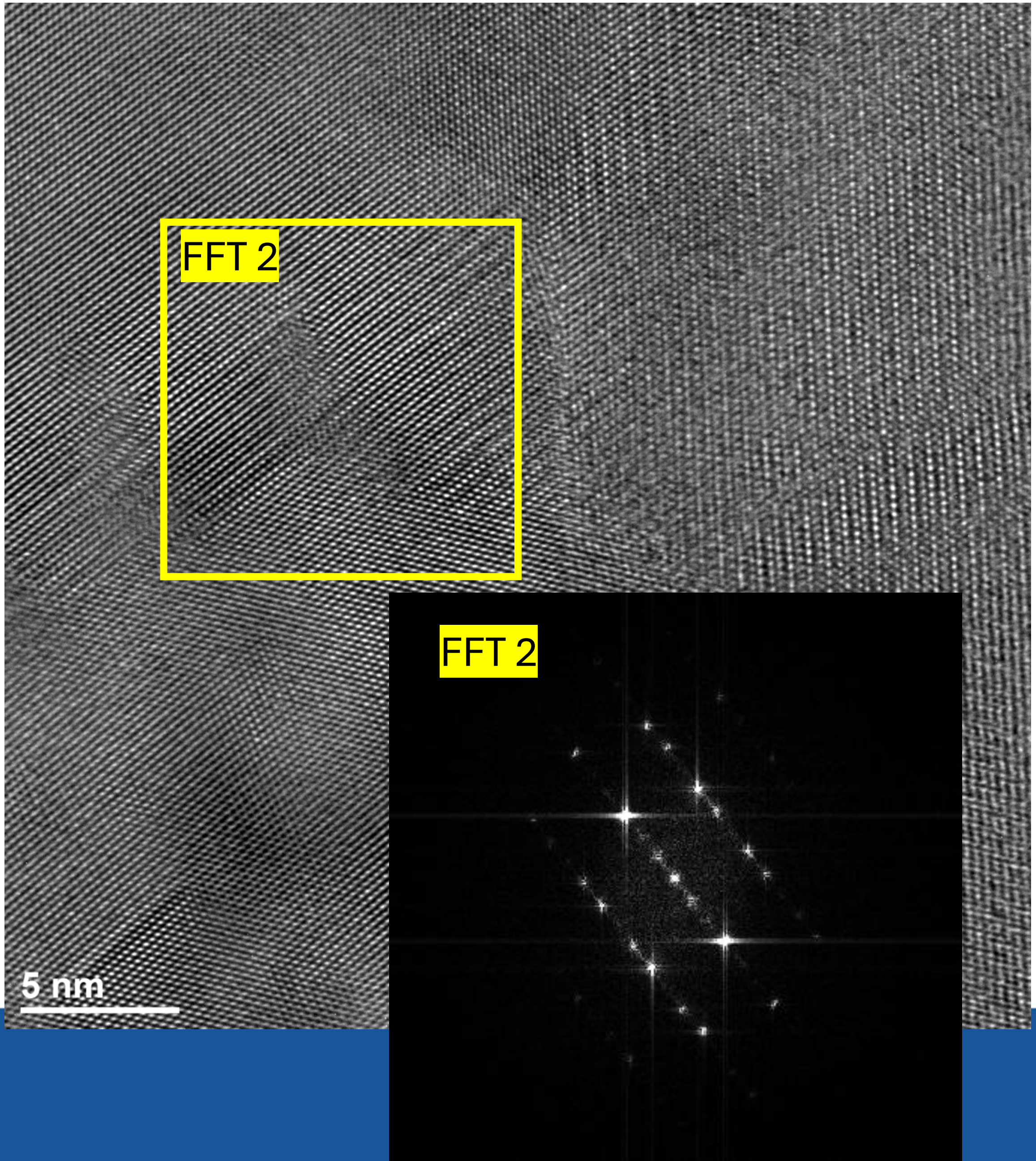




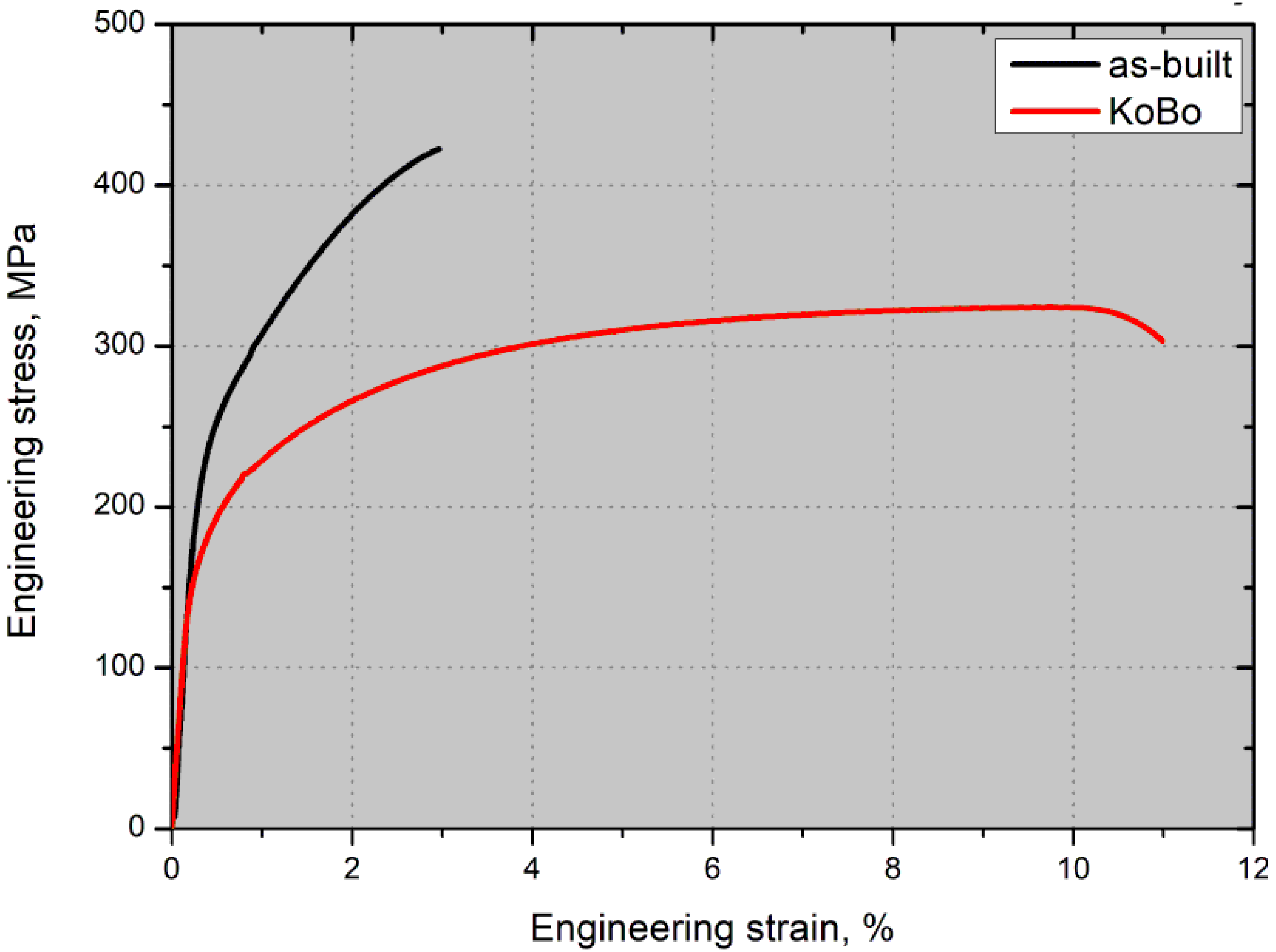
Model atomowy granicy

Mikrostruktura stopu AlSi10Mg po procesie KOBO

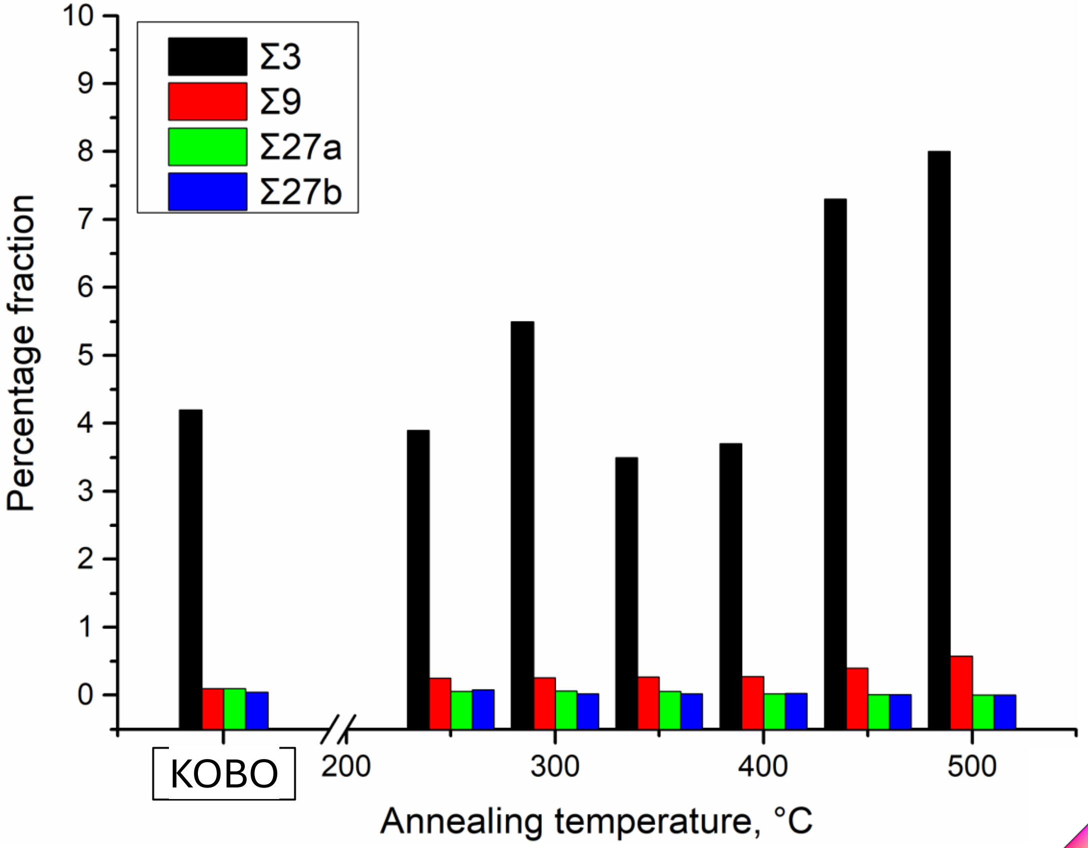


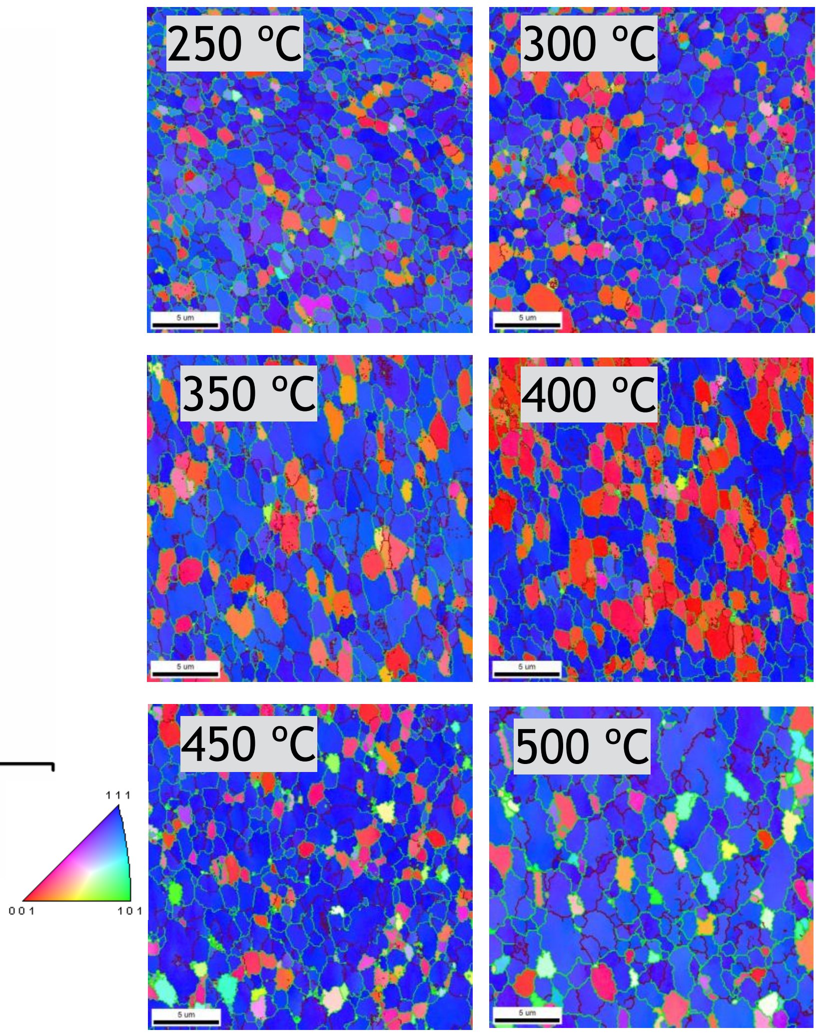


Porównanie własności mechanicznych



Stabilność termiczna mikrostruktury po procesie KOBO





Dziękuję za uwagę

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- SONATA 17 - 2021/43/D/ST8/01946
- OPUS 27 - 2024/53/B/ST8/03574