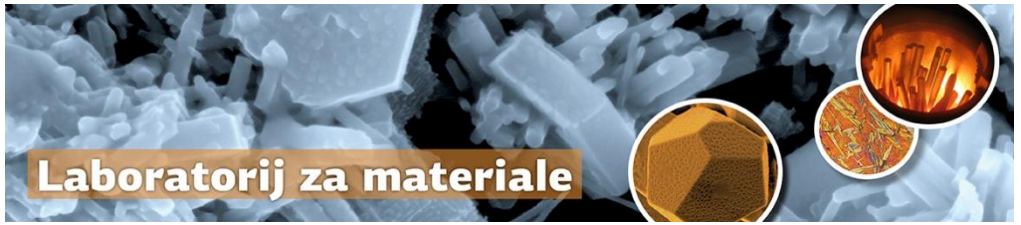
Fakulteta za strojništvo



Inženirski materiali

Uvod

Franc Zupanič

Univerza v Mariboru

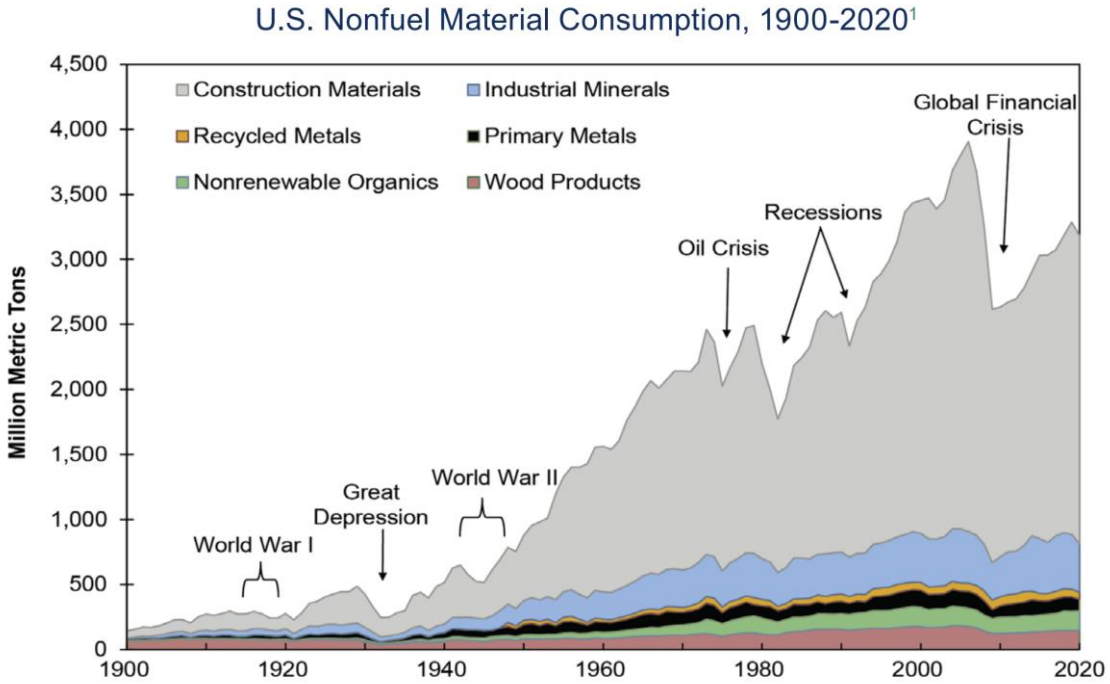
Maribor, 16. 1. 2024

Vrste inženirskih materialov

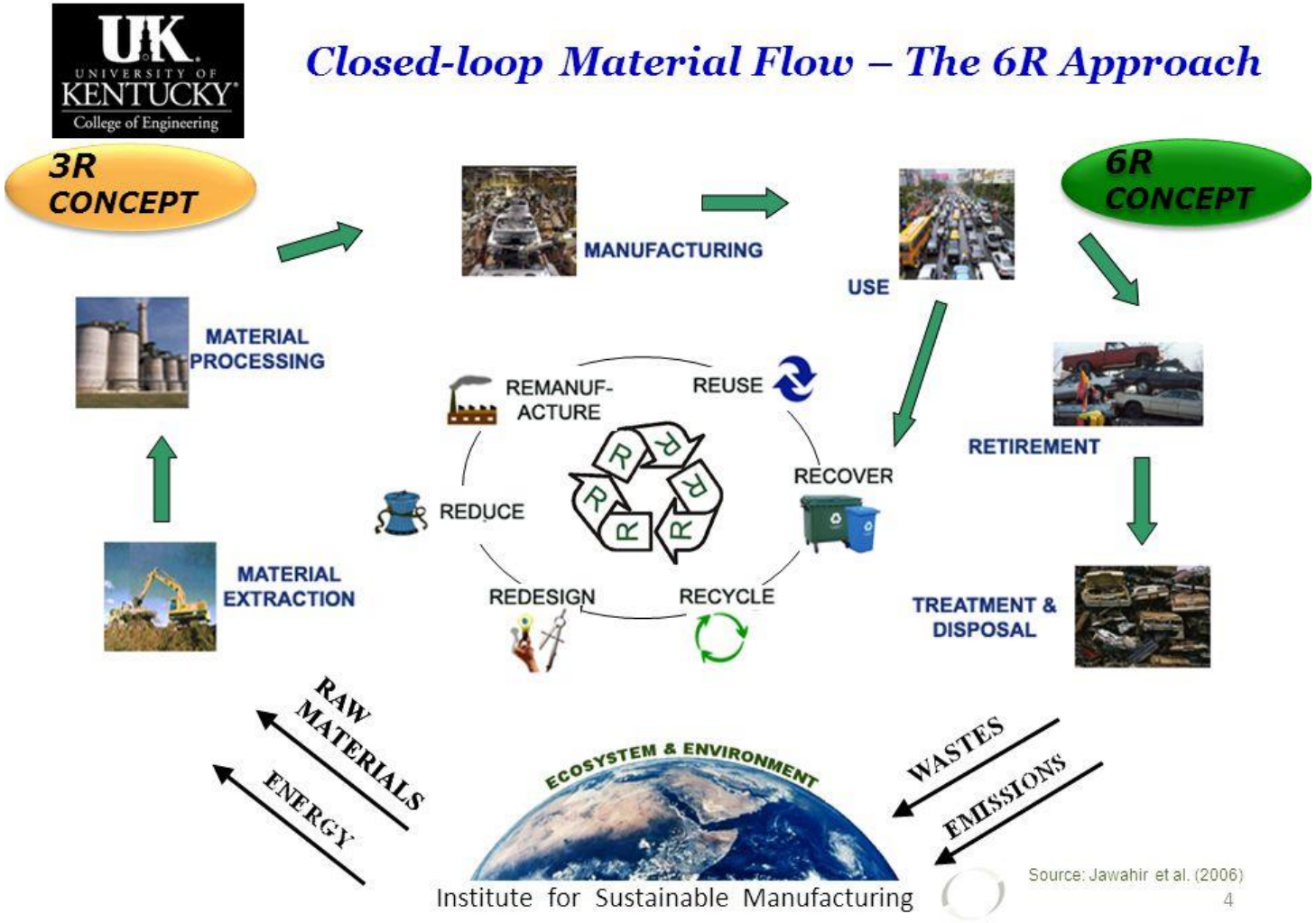
- Tradicionalni inženirski materiali
  - Kovine
  - Keramika
  - Polimeri
  - Kompoziti
- Trajnostni materiali
- Biomateriali
- Pametni materiali
- Nanomateriali

Svetovna proizvodnja materialov

- Kovine
  - jeklo, 1,8 Gt
  - aluminij, > 80 Mt
- Polimeri
  - plastika (duromeri in plastomeri), 360 Mt
  - guma, sintetična 30 Mt, kavčuk 15 Mt
- Keramika
  - cement, 4,1 Gt
  - SiC, 8,8 Mt
  - steklo, 209 Mt
- Kompoziti
  - ogljikova vlakna, 0,3 Mt
  - aramidna vlakna, 0,105 Mt



Življenjski cikel materialov



Koncept 6R

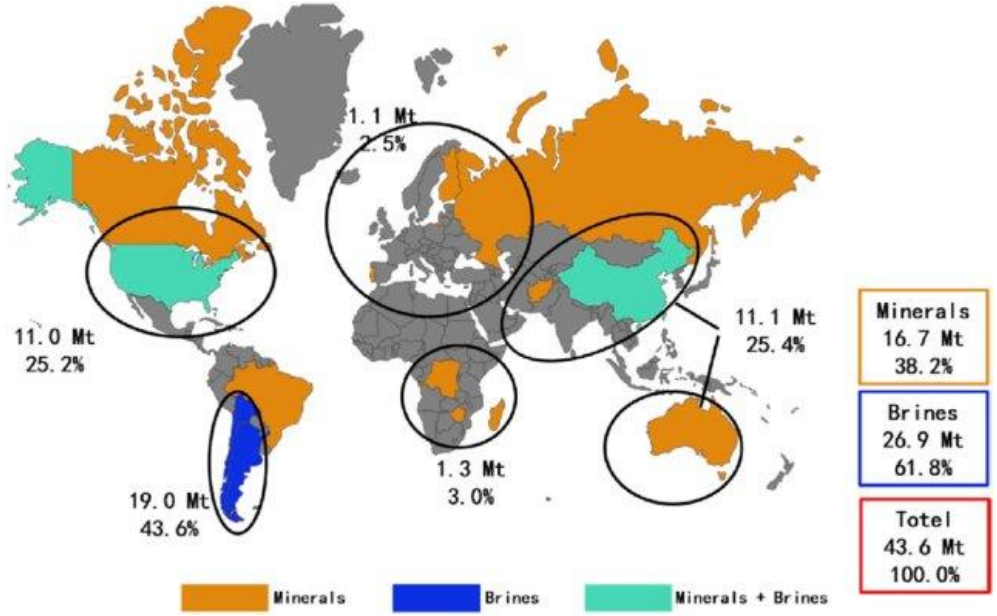
Reduce – zmanjšaj
Reuse – ponovno uporabi
Redesign – rekonstruiraj
Remanufacture – ponovno izdelaj
Recycle – recikliraj
Recover - obnovi

Strateške surovine

- kovine redkih zemelj
- kobalt
- skandij
- litij

- raziskava morskega dna na Arktiki

https://www.researchgate.net/publication/340030643_Introduction_of_manganese_based_lithium-ion_Sieve-A_review/figures?lo=1



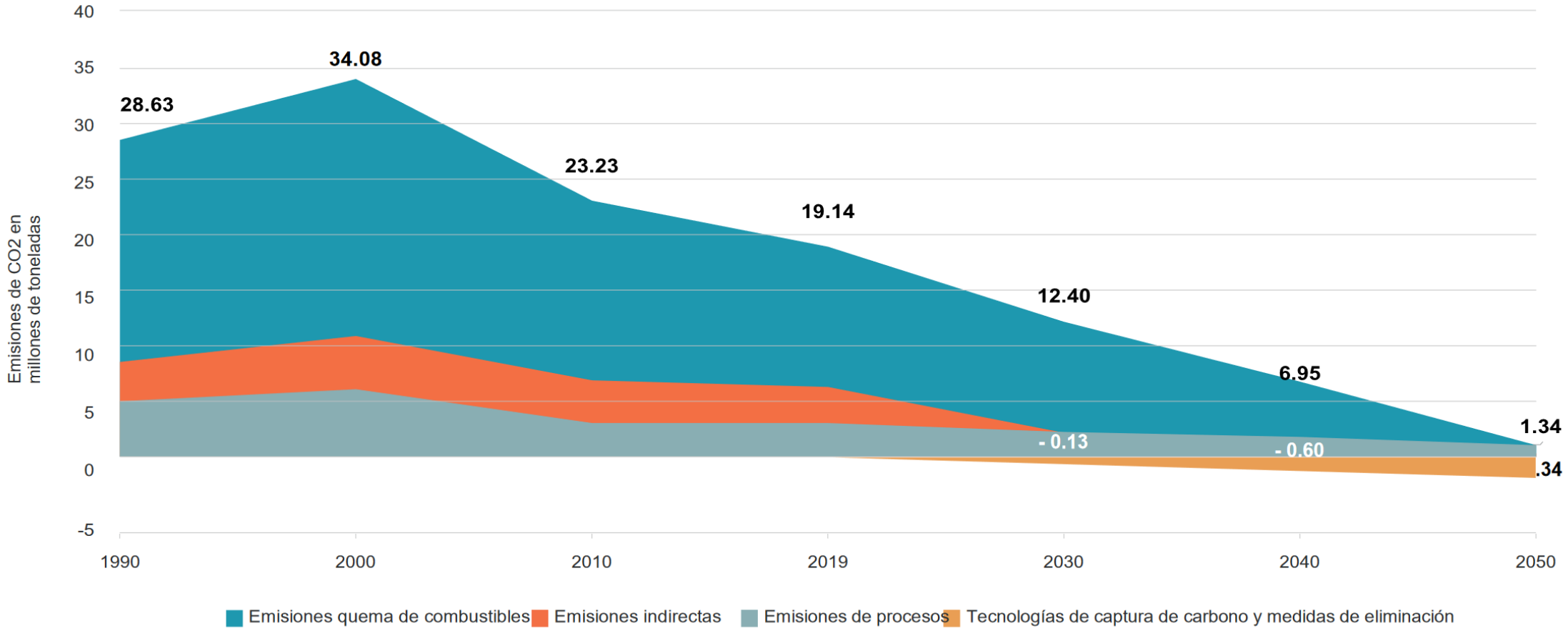
https://www.researchgate.net/publication/340030643_Introduction_of_manganese_based_lithium-ion_Sieve-A_review/figures?lo=1

Sproščanje CO_2 pri izdelavi

- $CaCO_3 \rightarrow CaO + CO_2$
- $2FeO + C \rightarrow 2Fe + CO_2$
- $2Al_2O_3 + 3C \rightarrow 2Al + 3CO_2$

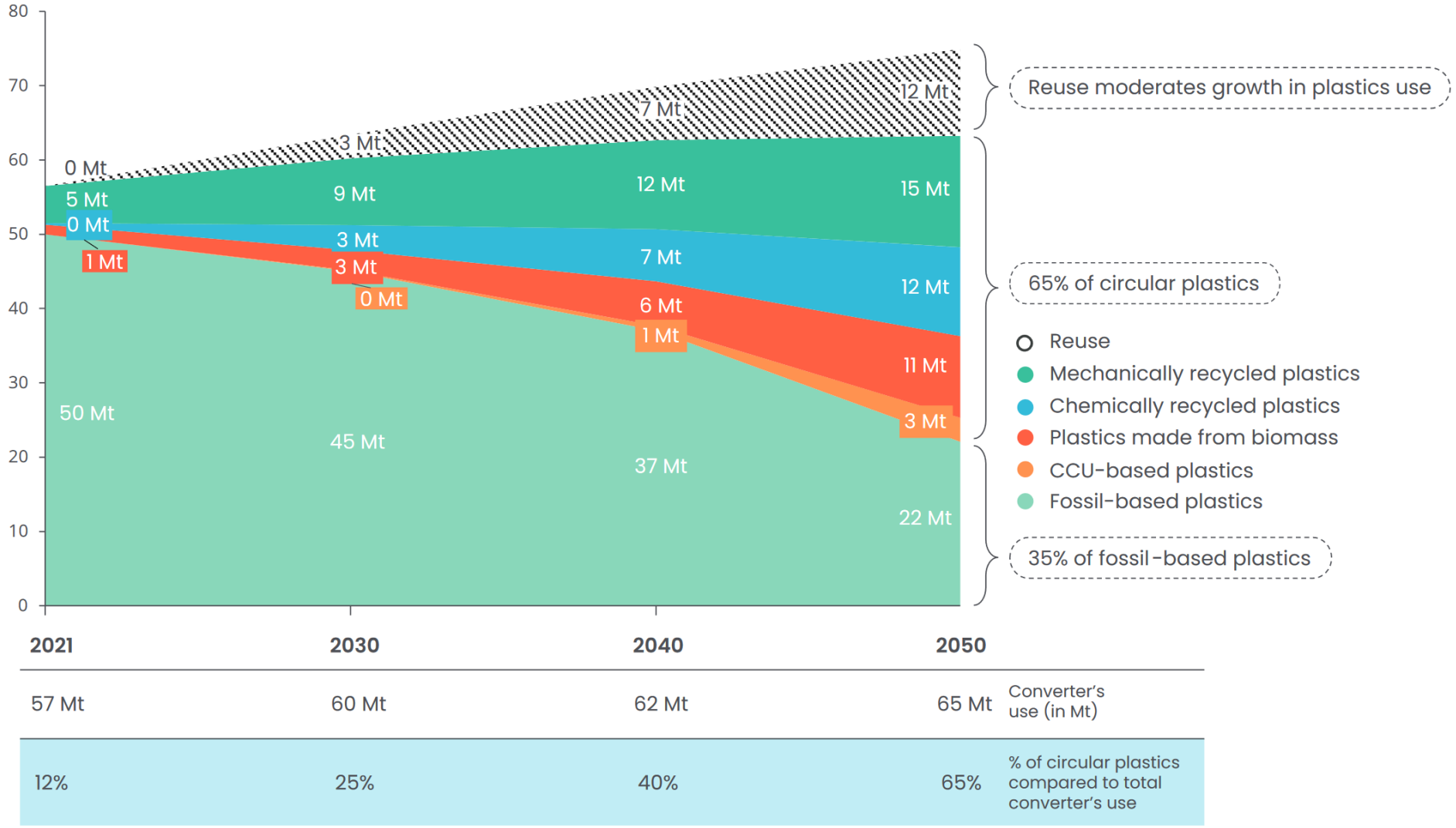
- Razvoj brezogljičnih postopkov
- Imobilizacija nastalega CO_2
- Energija iz nefosilnih (zelenih) virov

Keramika – brezogljična proizvodnja



https://www.ceramicroadmap2050.eu/chapters/continuing-our-path-towards-climate-neutrality/#

Izdelava polimerov iz nefosilnih virov



2021	2030	2040	2050	
57 Mt	60 Mt	62 Mt	65 Mt	Converter's use (in Mt)
12%	25%	40%	65%	% of circular plastics compared to total converter's use

https://plasticseurope.org/wp-content/uploads/2023/10/PlasticsEurope_Summary_24.10.pdf

Zeleni viri energije

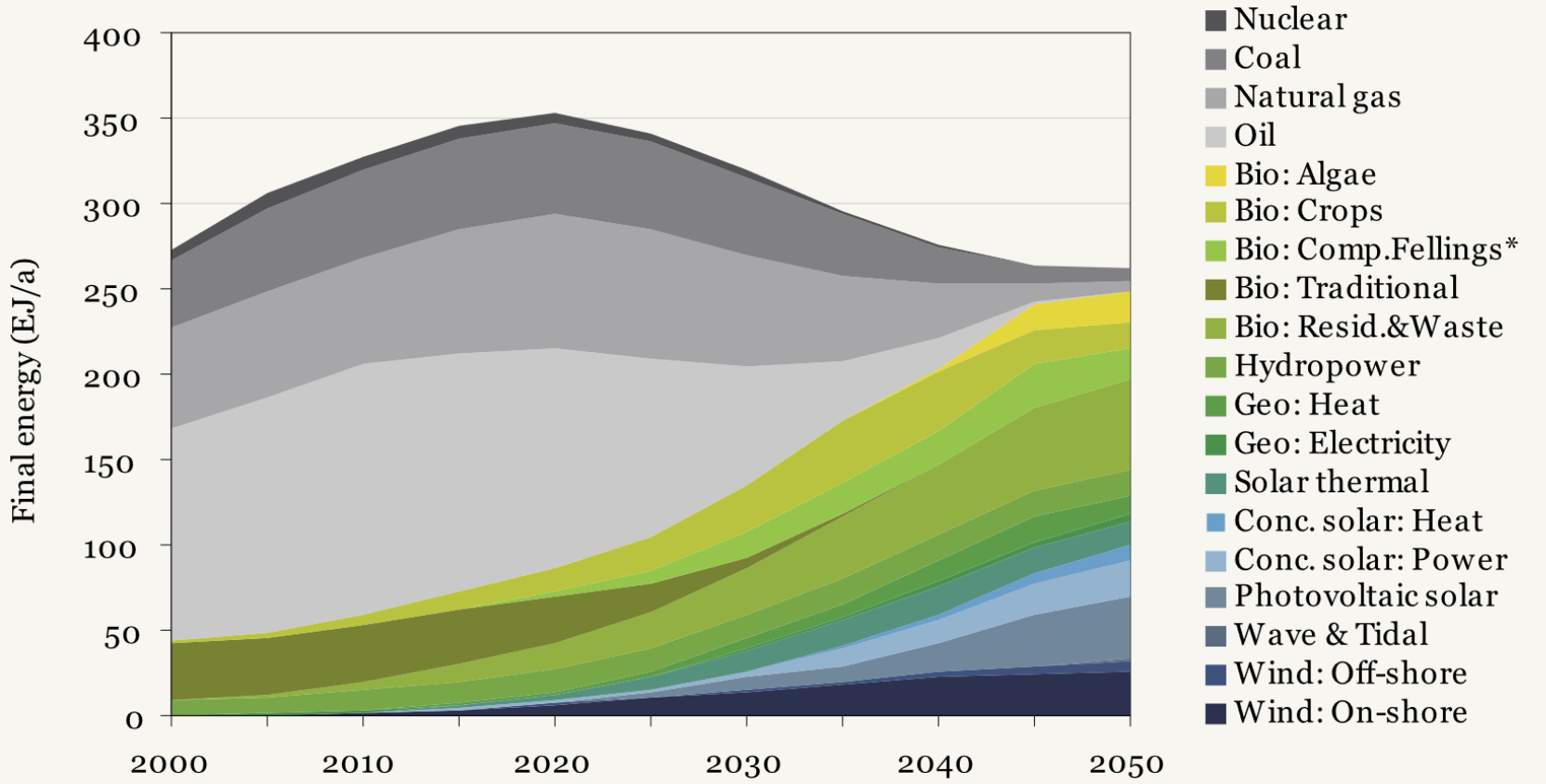
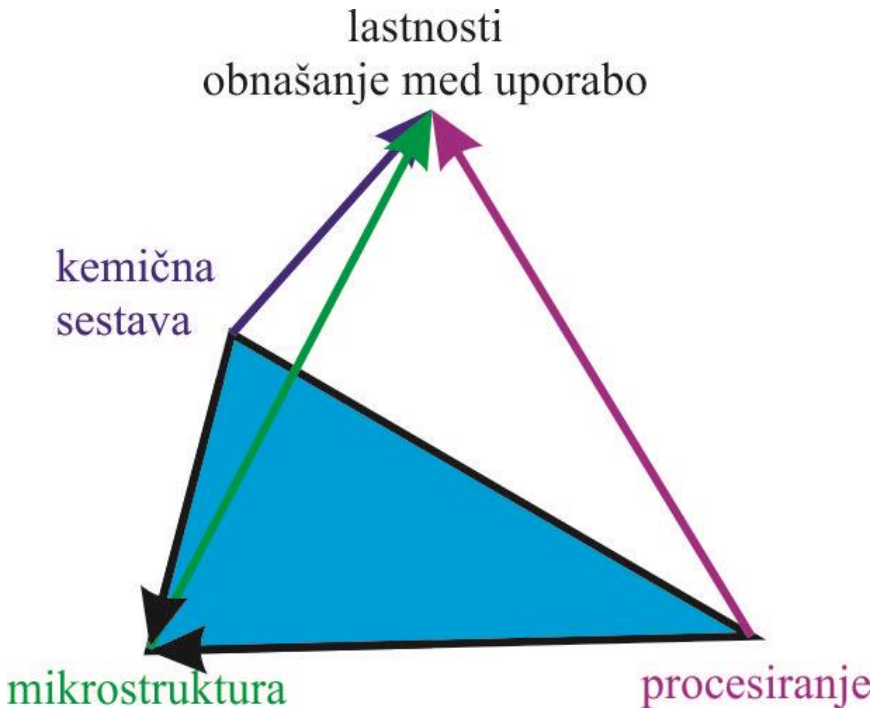


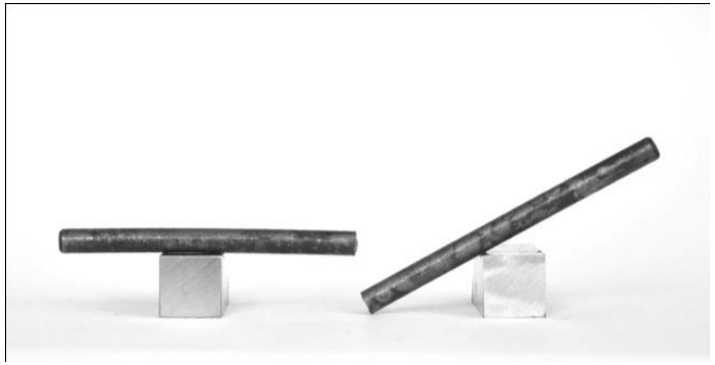
Figure 4: World Energy Supply by Source.
The Ecofys Energy Scenario, December 2010

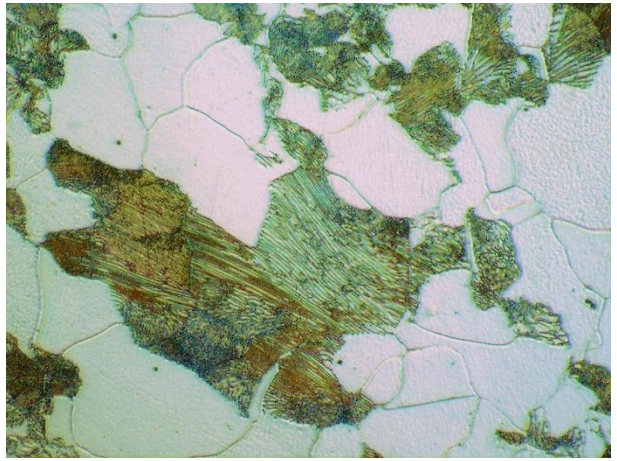
Pomembni koraki pri pridobivanju energije

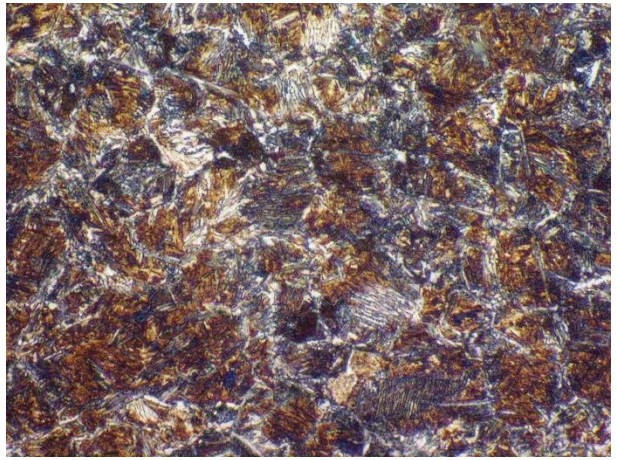
- fuzija
- jedrske samopolnilne baterije
- sobna superprevodnost
- litijeve ionske baterije
- alternativne baterije
- magnetni materiali
- vodikove gorivne celice
- pridobivanje vodika

Kaj je veda o materialih



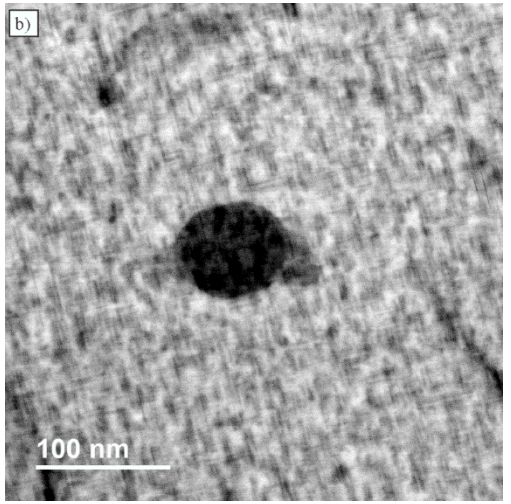


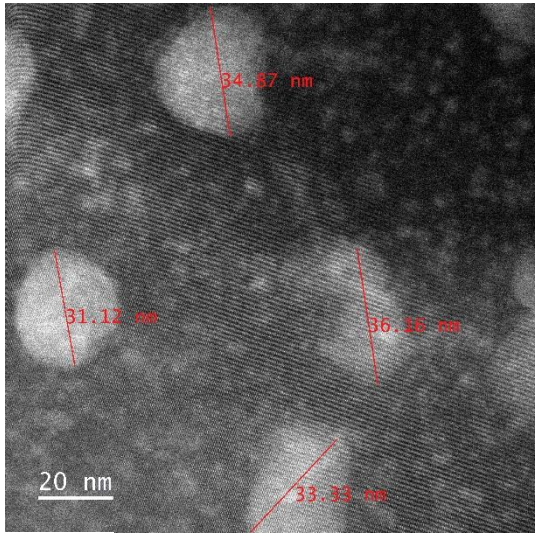




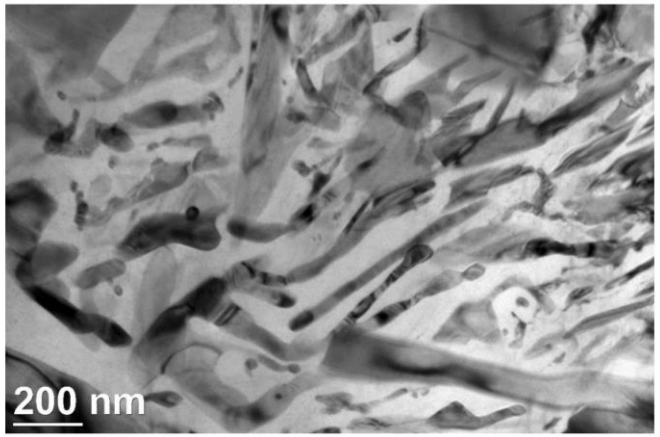
Katedra za materiale in preoblikovanje

- Visokotrdnostne aluminijeve zlitine Al-Mg-Si (serija 6xxx)

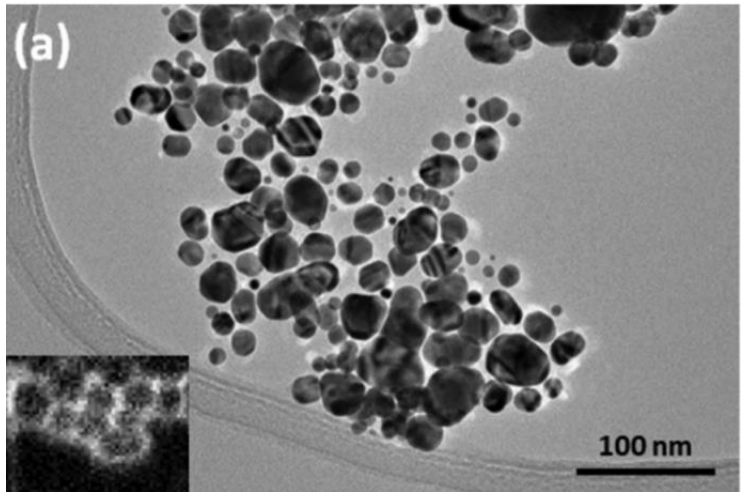




- Toplotnoobstojne aluminijeve zlitine s kvazikristalnimi in kristalnimi nanoizločki



- Superbainitna jekla

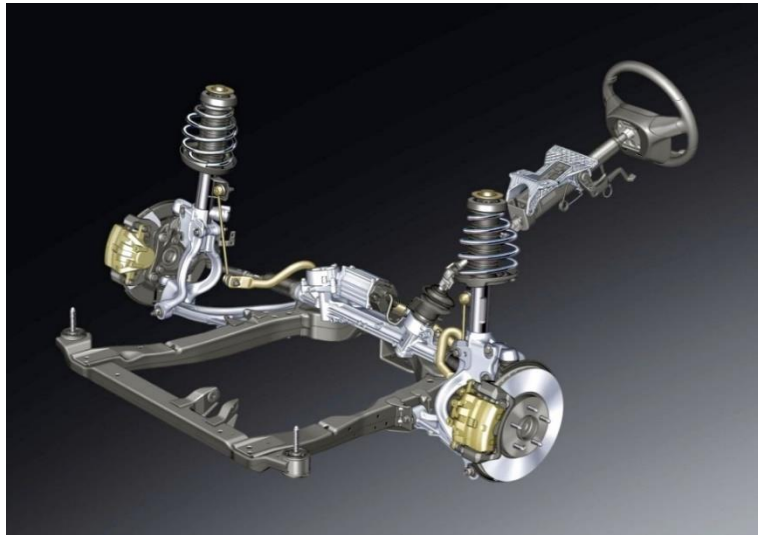


- Zlati nanodelci

Materiali: Od atoma do uporabe

- Kemična sestava
  - dosedaj v veliki meri intuitivna
  - uporaba programov za simulacijo
  - uporaba kvantnih računalnikov
  - umetna inteligenca
- Fizikalno modeliranje procesov

Visokotrdnostna Al-zlitina iz sistema Al-Mg-Si



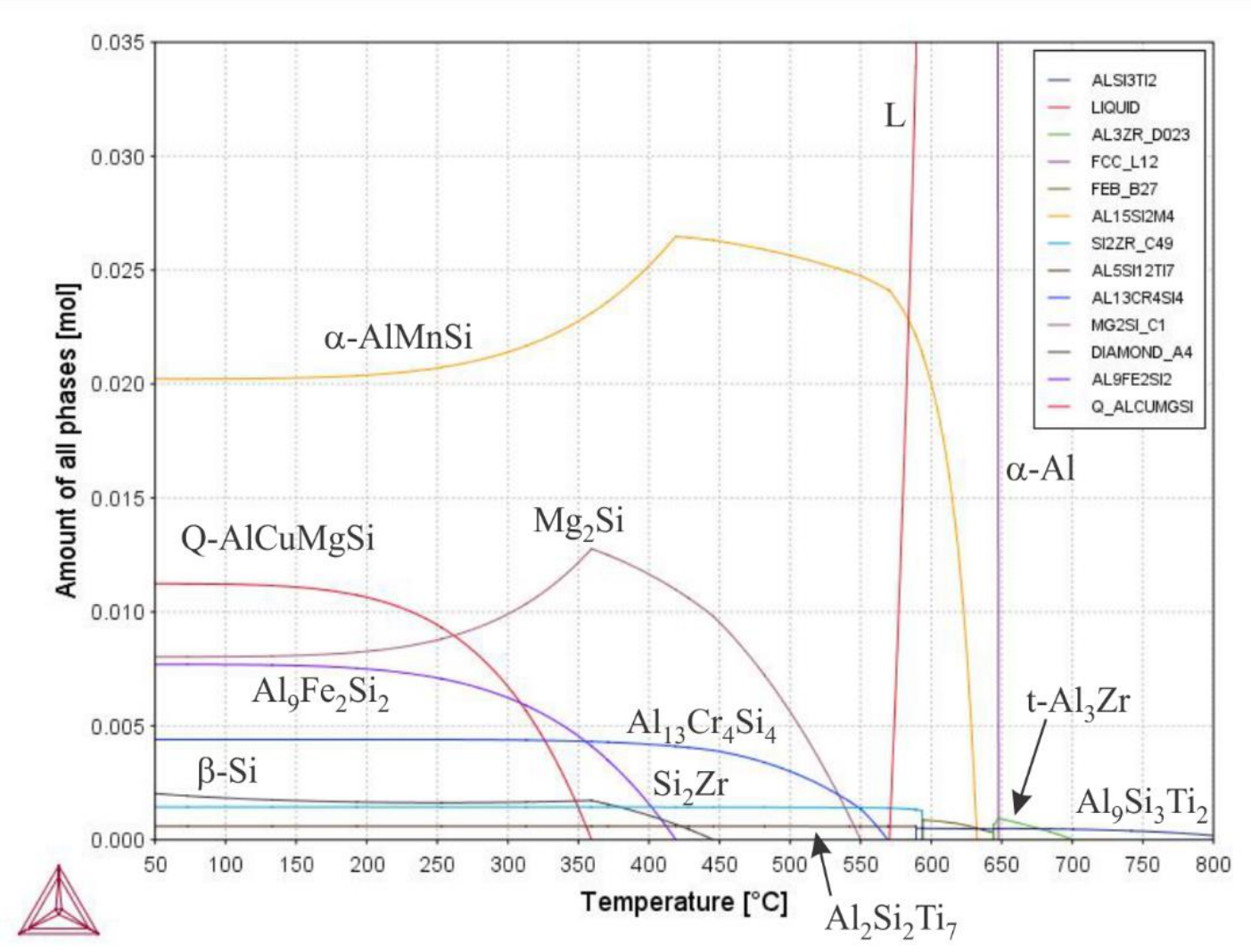
Element	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Zr
Examined alloy	1.58	0.18	0.55	0.71	1.01	0.19	0.17	0.04	0.17
AA 6082	0.7-1.3	0.5	0.1	0.4-1.0	0.6-1.6	0.25	0.2	0.1	-
AA 6086	1.3-1.7	0.14-0.25	0.75	0.7-0.8	0.85-1.1	0.15-0.25	0.2	0.1	0.15-0.25

Cilj:

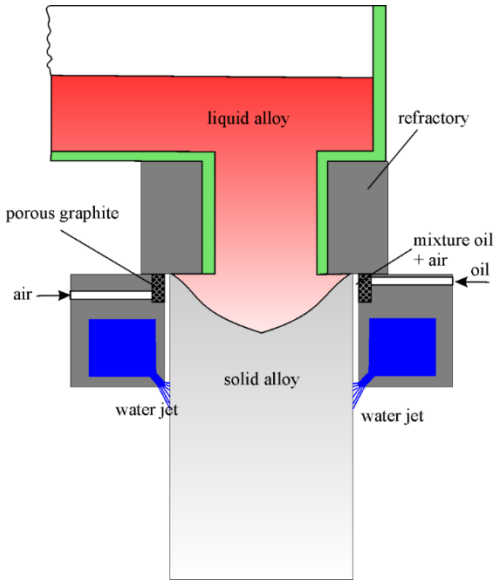
enakomerna porazdelitev disperzoidov, ki preprečijo rast kristalnih zrn,

enakomerna porazdelitev nanometrskih izločkov β''-Mg_2Si in Q'-AlCuMgSi, ki utrjujejo trdno raztopino bogato z aluminijem α-Al.

Napoved fazne sestave



Tehnologija izdelave



Litje in taljenje

↓

Zadrževanje taline

↓

Polkontinuirno litje
(HotTop-AirSlip, LFEC)

↓

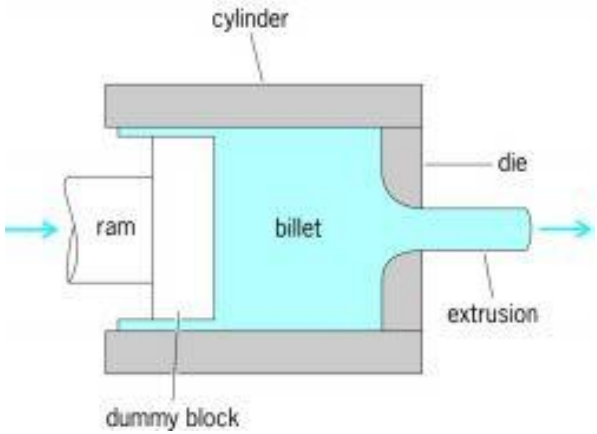
Homogenizacija

↓

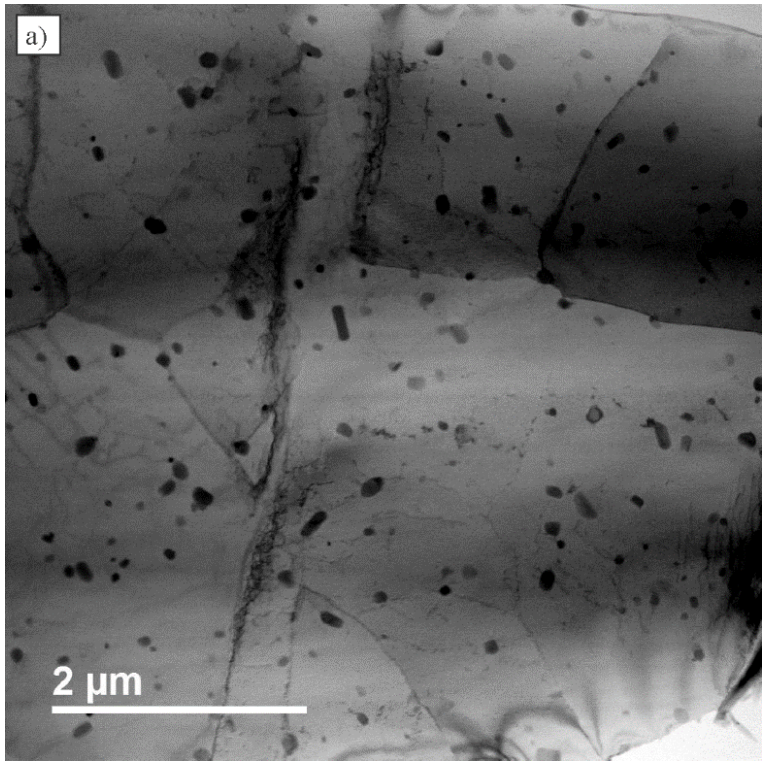
Ekstruzija

↓

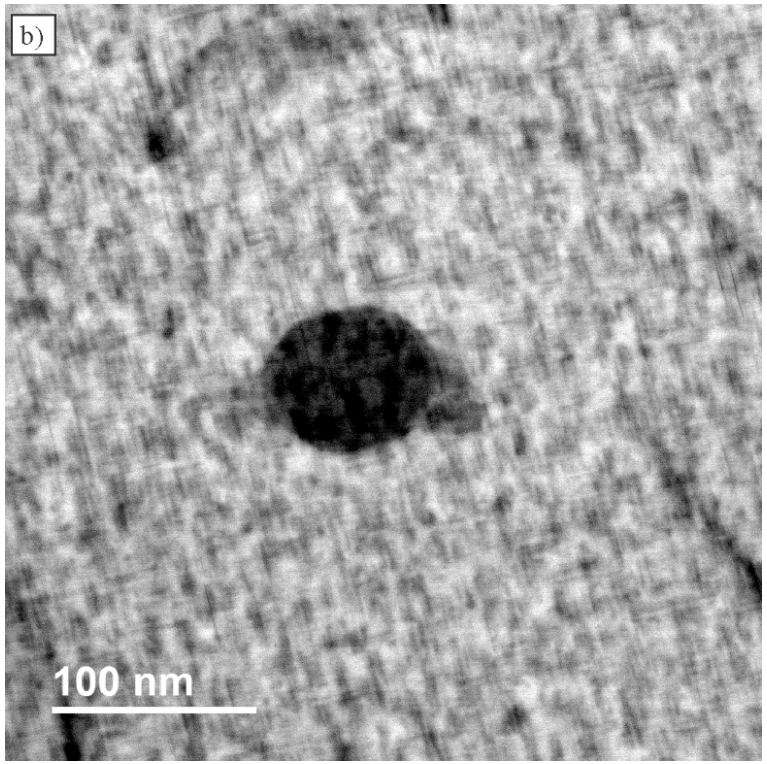
Topilno žarjenje in
umetno staranje



Mikrostruktura

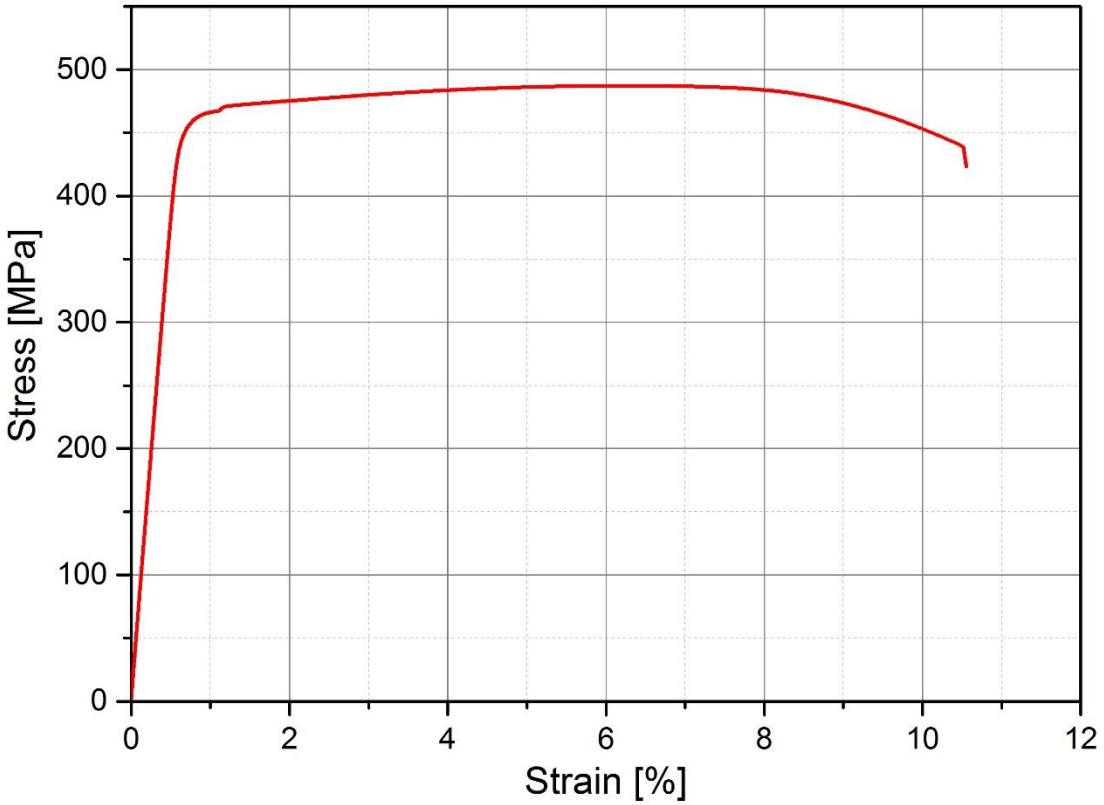


- Majhna kristalna zrna
- Disperzoidi α-AlMn(Fe,Cr)Si
- Majhna gostota dislokacij
- Izločki β‘-Mg_2Si in Q‘-AlMgCuSi

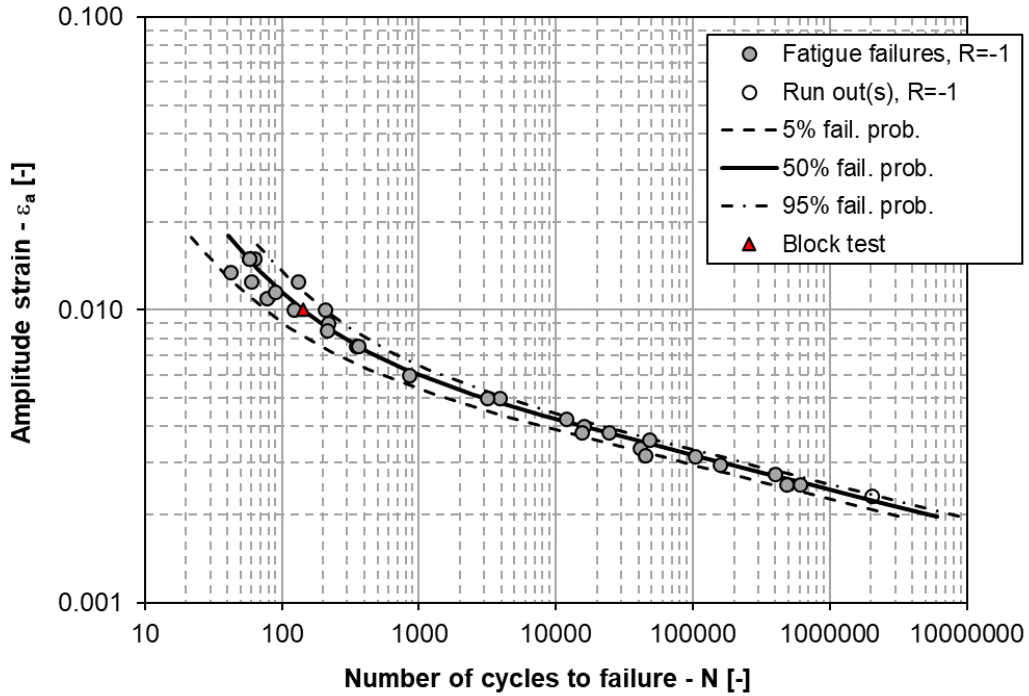


- Disperzoid a-AlMn(Fe,Cr)Si
- Velika gostota izločkov β‘‘-Mg_2Si in Q‘-AlMgCuSi

Lastnosti



Natezni diagram



Utrujanje