WWU MÜNSTER

On the Appearance of a High-Entropy Effect: Tracer Diffusion and Microstructure Analysis of $(CoCrFeMn)_{100-x}Ni_x$ ($20 \leq x \leq 100$)

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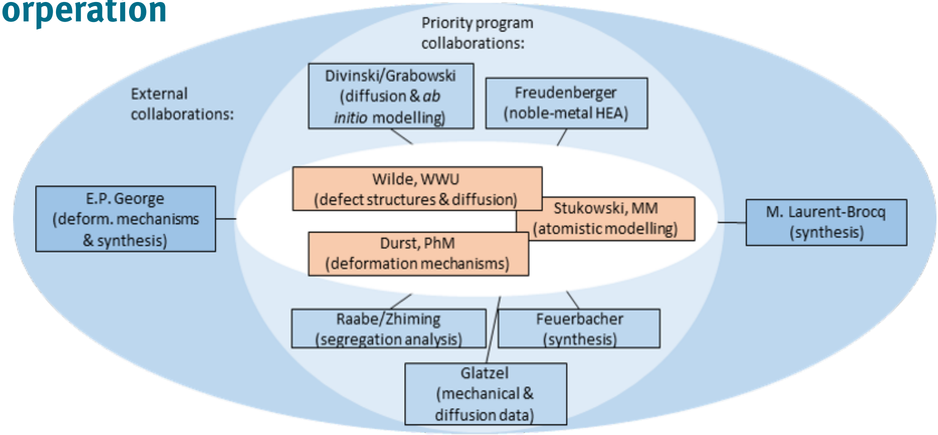
Coorperation



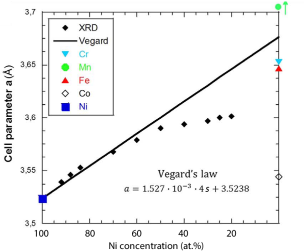
Schematic of Collaboration between different institutes.

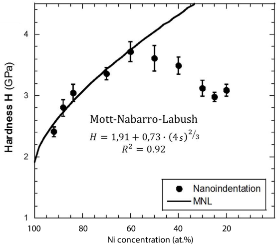
Appearance of the HEA effect

- lattice parameter follows Vegard's law from $20\text{ at.\%} \leq x \leq 60\text{ at.\%}$; Vegard's law:

$$a_{Vegard}(x) = a_{Ni} \cdot \frac{x}{100} + \frac{100 - x}{4 \cdot 100} \cdot (a_{Cr} + a_{Co} + a_{Fe} + a_{Mn}) \tag{1}$$

- hardness follows Mott-Nabarro- Labush law from $20\text{ at.\%} \leq x \leq 60\text{ at.\%}$



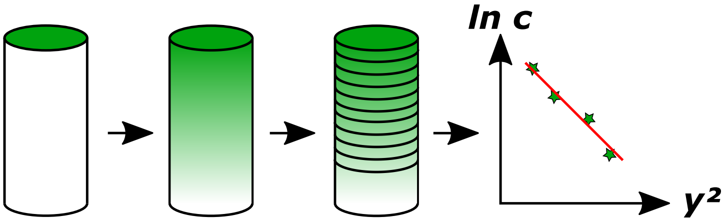


Lattice parameter and hardness behaviour of $(CoCrFeMn)_{100-x}Ni_x$[1].

$x = 100 - 4s$, $s = \frac{100-x}{4}$ s concentration of solutes.

[1] Laurent-Brocq et al., "From diluted solid solutions to high entropy alloys: On the evolution of properties with composition of multi-components alloys", 2017

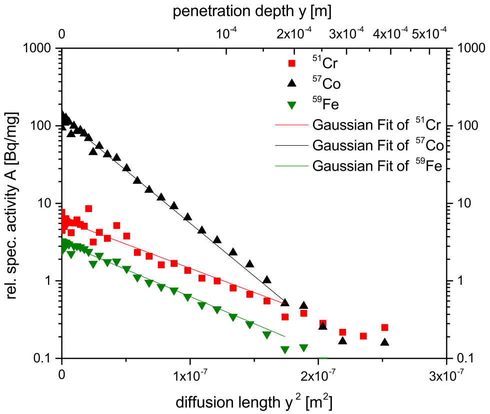
Radiotracer method



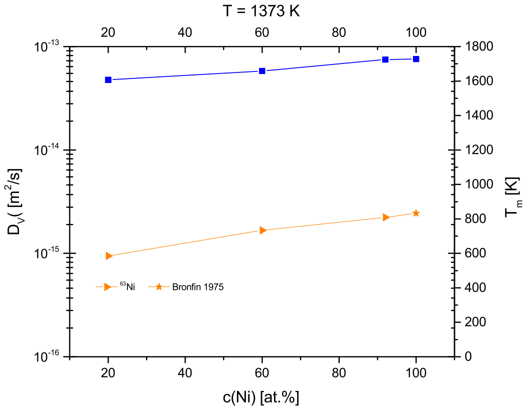
concentration/activity profile for volume diffusion

$$c = \frac{M}{\sqrt{2\pi Dt}} exp\left(-\frac{y^2}{4Dt}\right) \qquad (2)$$

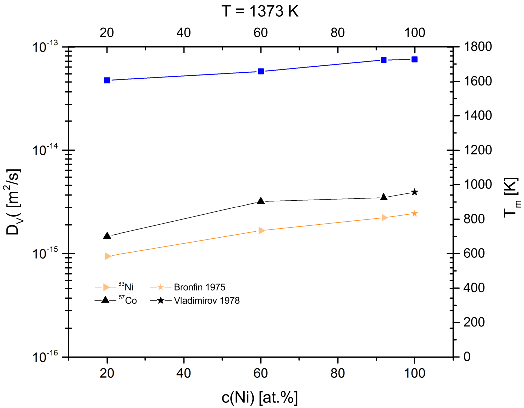
Radiotracer profiles



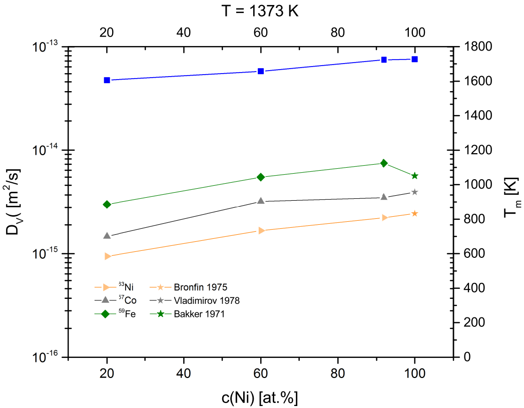
^{63}Ni diffusion



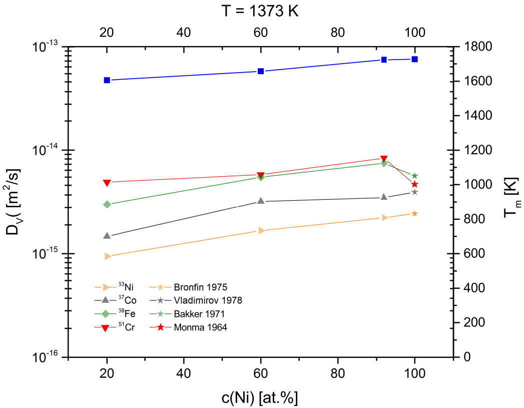
^{57}Co diffusion



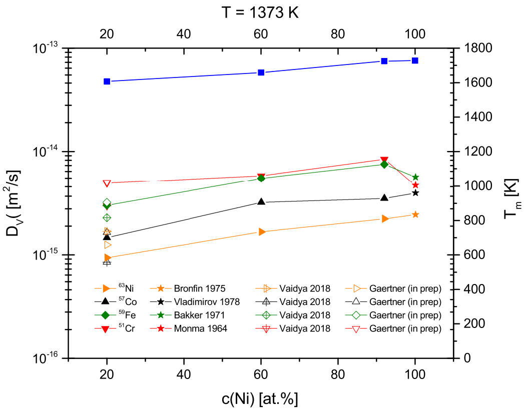
^{59}Fe diffusion



^{51}Cr diffusion



From pure nickel to Cantor alloy



Bronfin, Bulatov, and Drugova, "Self-diffusion of Ni in the intermetallic compound Ni 3 Al and pure Ni", 1975

Vladimirov et al., "Volume diffusion of cobalt and tungsten in nickel", 1978

Bakker, Backus, and Waals, "A Curvature in the Arrhenius Plot for the Diffusion of Iron in Single Crystals of Nickel in the Temperature Range from 1200 to 1400 ° C", 1971

Monma, Suto, and Oikawa, "Diffusion of Ni63 and Cr51 in nickelchromium alloys", 1964

Vaidya et al., "Bulk tracer diffusion in CoCrFeNi and CoCrFeMnNi high entropy alloys", 2018

Gaertner et. al., in prep (project Divinski)

Conclusion

i ^{63}Ni and ^{57}Co diffusion is slowest, ^{59}Fe and ^{51}Cr are faster and ^{54}Mn is fastest diffusor

ii no special features in diffusion at $x = 60$ at.%, solute enhancement effects at $x \rightarrow 100$ at.% (reminder: kinks in hardness and lattice parameter at $x = 60$ at.%)

Outlook

- clarify ^{54}Mn diffusion
- *remarkable increase at low solute concentrations*: further diffusion experiements with $Co_1Cr_1Fe_1Mn_1Ni_{96}$ and $Co_3Cr_3Fe_3Mn_3Ni_{88}$
- *Arrhenius behaviour*: radiotracer measurements at different temperaturs
- *time dependency*: effects of grain boundary diffusion in HEA

Acknowledgment

Thank you for your kind attention.

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