Co_2FeX (X = Si,Al) Heusler alloys prepared by Planar Flow Casting and Arc Melting: microstructure and magnetism

Andrii Titov[1,2], O.Životský[1], Y. Jirásková[2], J. Buršík[2], A. Hendrych[1], D. Janičkovič[3]

[1] Department of Physics, VSB – Technical University of Ostrava
[2] Institute of Physics of Materials, AS CR Brno
[3] Institute of Physics, AS Slovakia, Bratislava

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Motivation

1. Prepare full Heusler alloys of common formula X_2YZ (X=Co; Y=Fe; Z=Al,Si) by arc melting and planer flow casting.
2. Contribute to so far poor information concerning the relationships among different production conditions of selected Heusler alloys and subsequent structural/compositional physical properties.

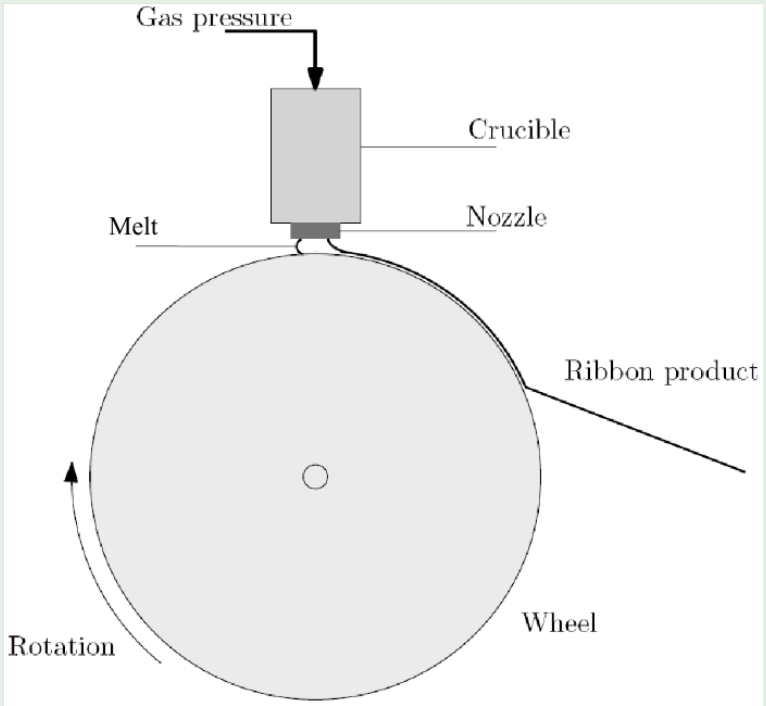
Ongoing interest in investigation of Heusler alloys around the world

- various compositions
- interesting structure
- attractive magnetic properties:
  - high T_C, magnetic moment, magnetooptical characteristics
  - high saturation magnetization

Sample preparation

sample preparation $\rightarrow$ high-purity Co, Fe, Si, Al

Planar Flow Casting



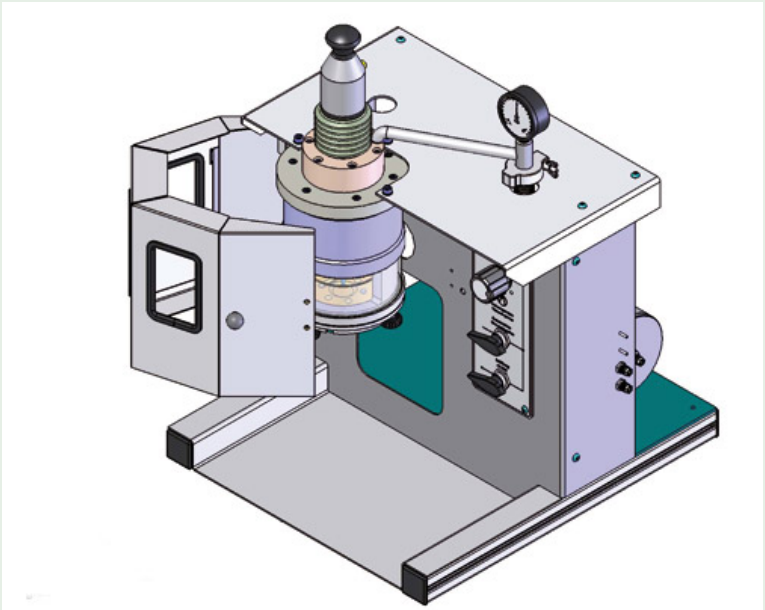
$\Downarrow$

ribbons (**amorphous**, nanocrystalline, crystalline)

$\Downarrow$

20 μm thick, 2 mm wide ribbons

Arc Melting



$\Downarrow$

button-type ingot

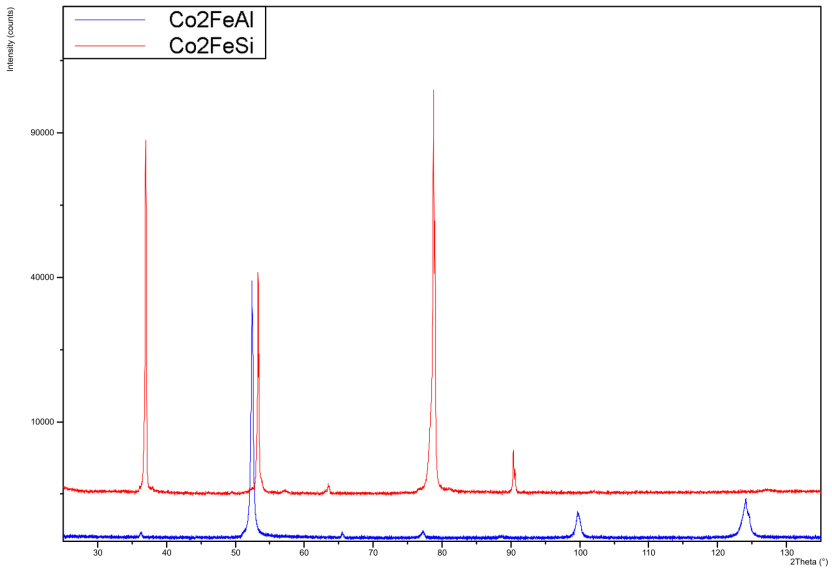
$\Downarrow$

spark erosion cutting

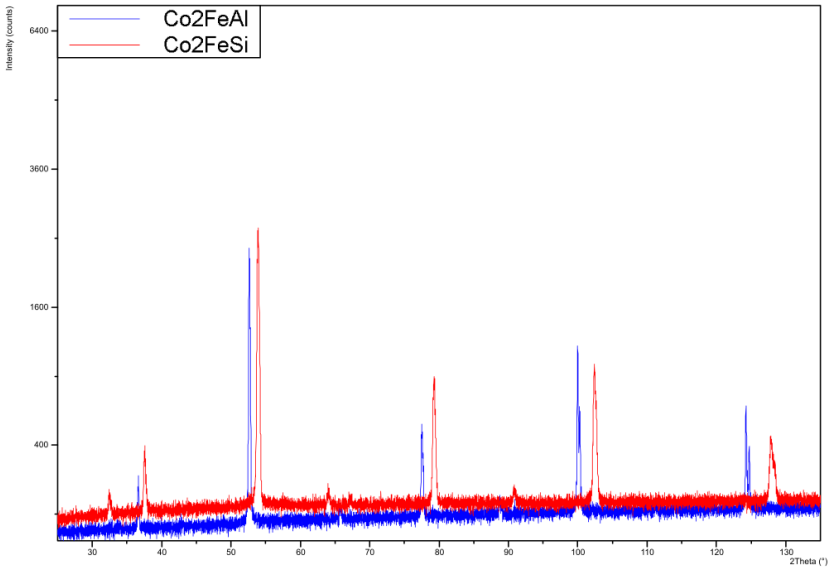
$\Downarrow$

disc 20 mm diameter, 500 μm thick

Microstructure
XRD



disc samples

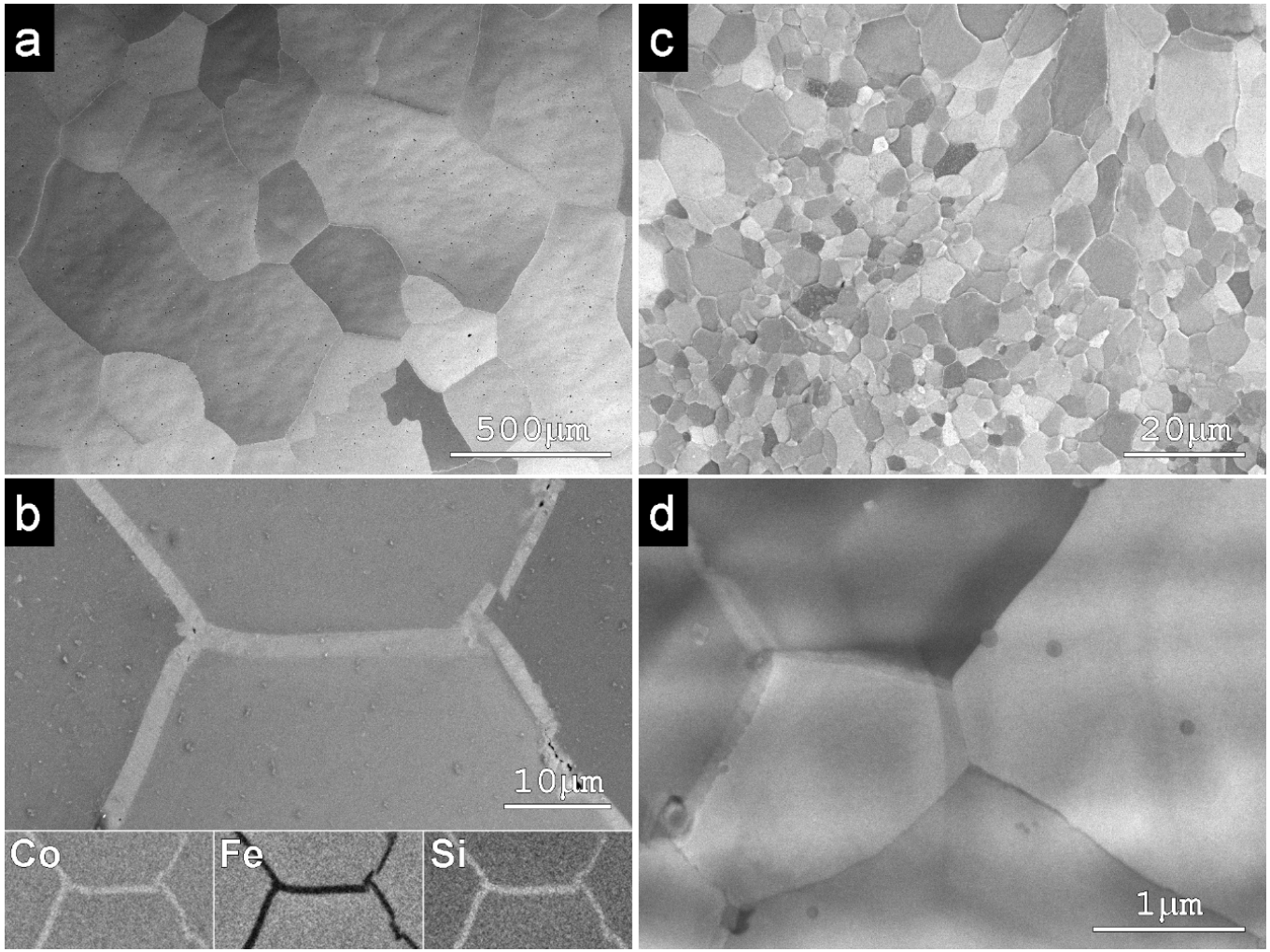


ribbon samples

	a [nm]
Co_2FeSi disc	0.564
Co_2FeSi ribbon	0.565
Co_2FeAl disc	0.573
Co_2FeAl ribbon	0.572

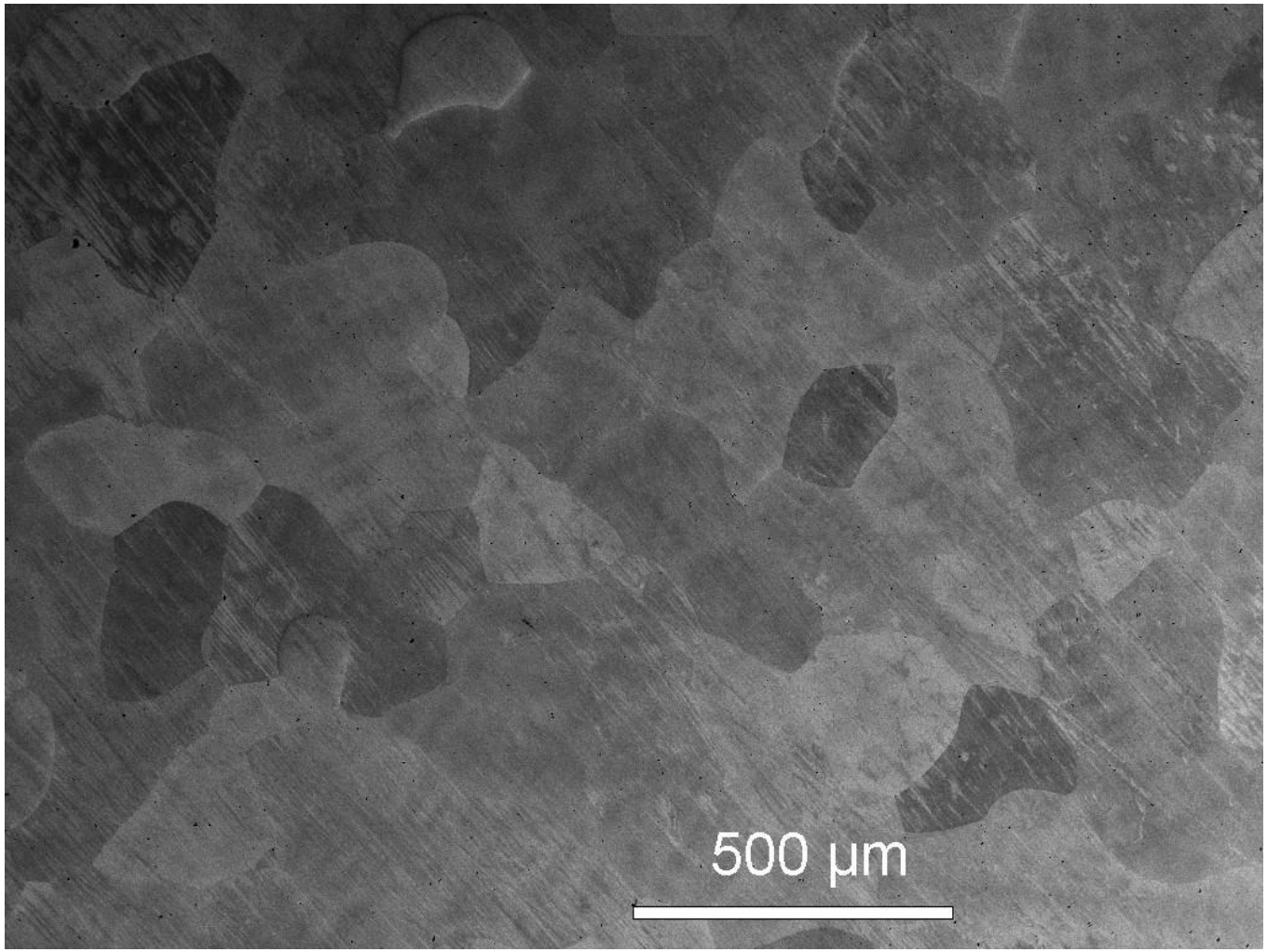
by ICSD database: 622893 for Co_2FeSi and 57607 for Co_2FeAl

Microstructure
SEM+EDX Co_2FeSi



		Co (at.%)	Fe (at.%)	Si (at.%)
D		47.82±0.02	24.83±0.09	27.38±0.11
R	A	48.10±0.19	25.00±0.17	26.90±0.36
	W	46.00±0.17	23.87±0.29	30.19±0.43

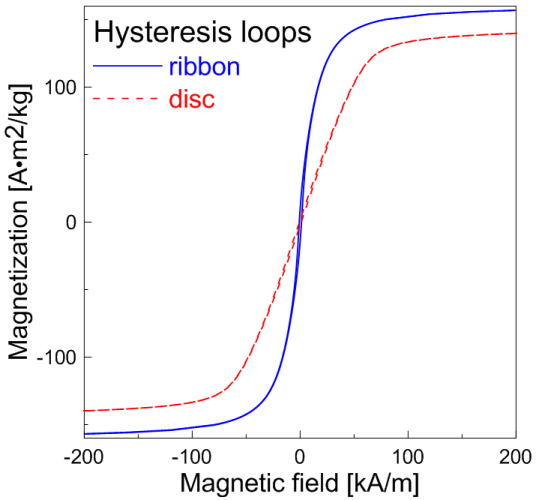
Microstructure
SEM+EDX Co_2FeAl

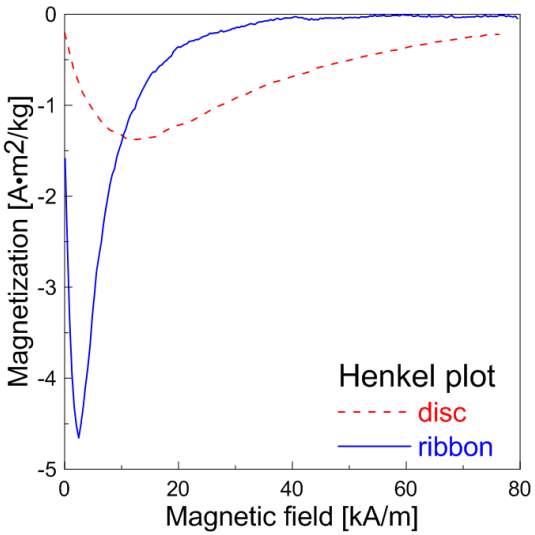


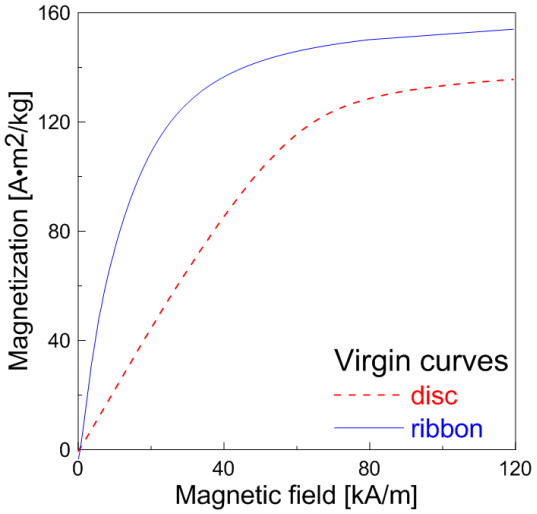
	Co (at.%)	Fe (at.%)	Al (at.%)
D	48.51±0.29	9.94±2.21	27.55±2.37

Bulk magnetization

Co_2FeSi by Vibrating Sample Magnetometer





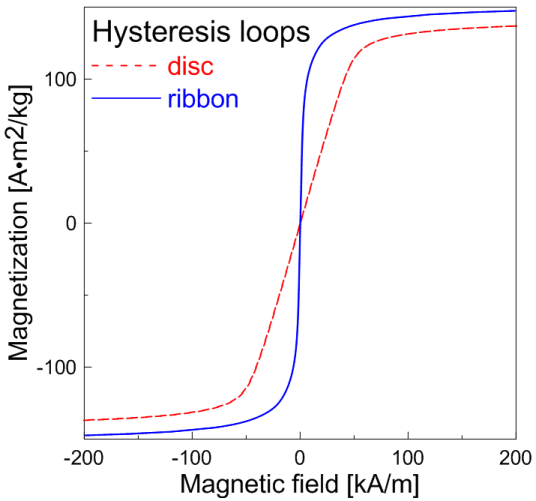


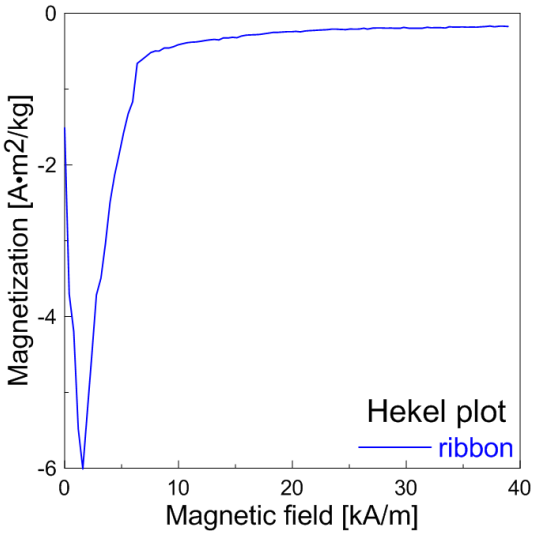
	ribbon	disc
M_s (Am^2/kg)	160.51	145.02
M_r (Am^2/kg)	12.05	2.02
H_c (kA/m)	1.03	1.03
ΔH (kA/m)	2.48	11.63
ΔM (Am^2/kg)	-4.66	-1.38

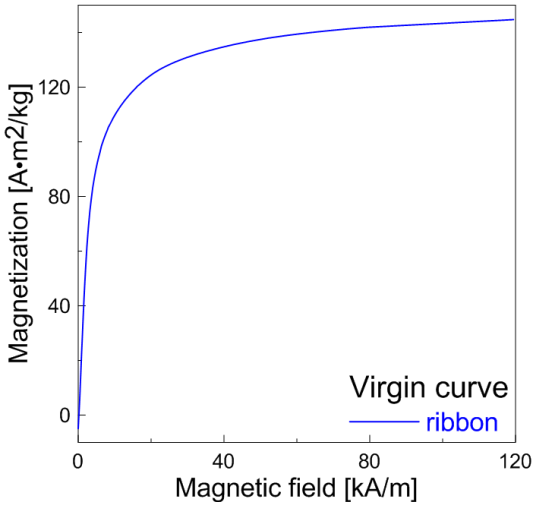
$$\Delta M(H) = M_{VIR}(H) - \frac{M_{UP}(H) + M_{DOWN}(H)}{2}$$

Bulk magnetization

Co_2FeAl by Vibrating Sample Magnetometer



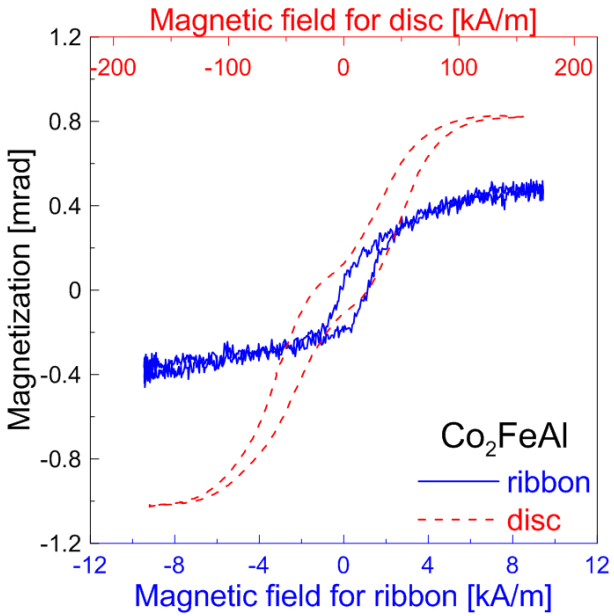


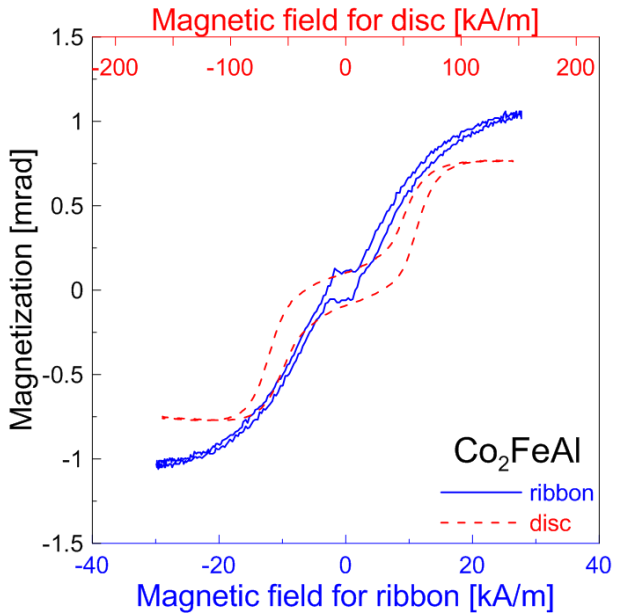


	ribbon	disc
M_s (Am^2/kg)	151.17	141.51
M_r (Am^2/kg)	4.509	0.26
H_c (kA/m)	0.145	0.102
ΔH (kA/m)	1.59	—
ΔM (Am^2/kg)	6.01	—

$$\Delta M(H) = M_{VIR}(H) - \frac{M_{UP}(H) + M_{DOWN}(H)}{2}$$

Surface magnetization
Magneto Optical Kerr Effect



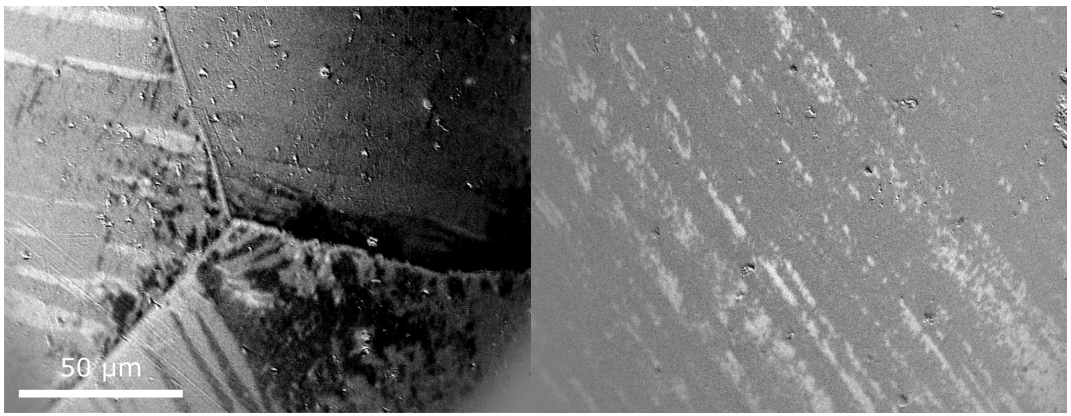


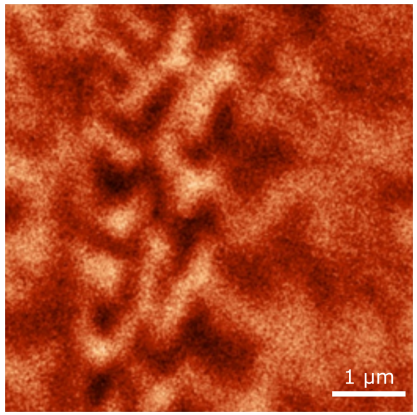
	Co_2FeSi		Co_2FeAl	
	ribbon	disc	ribbon	disc
M_s (mrad)	0.49	0.89	1.06	0.77
M_r (mrad)	0.12	0.13	0.086	0.097
H_c (kA/m)	0.59	3.36	2.32	32.1

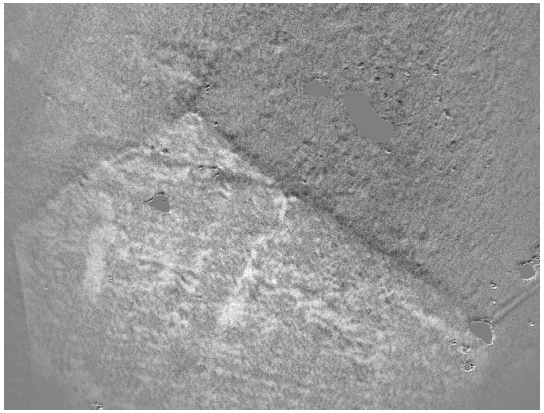
Surface magnetization

Magneto Optical Kerr Microscopy and Magnetic Force Microscopy, only disc surface

Co_2FeSi







Co_2FeAl

Conclusion

- Full ternary Heusler alloys were successfully prepared by both techniques.
- from view point of microstructure
  - disc and ribbon differ in grain size
  - Co and Si enrichment at grain boundaries
- from viewpoint of magnetic properties
  - ribbons looks slightly softer then discs
  - higher dipole interactions originating in lower magnetic fields of ribbons
- ribbon brittleness has caused the surface polishing impossible and the manipulation with the sample was difficult

Thanks for attention

Acknowledgment

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