Microstructure and magnetism of Co_2FeAl Heusler alloy prepared by arc and induction melting compared with planar flow casting

Andrii Titov[1,2]

[1] VSB-Technical University of Ostrava, CZ
[2] CEITEC Institute of Physics of Materials Brno, CZ

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   - X-Ray Diffraction
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   - Vibrating Sample Magnetometer
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Motivation

Ongoing interest in investigation of Heusler alloys around the world

- various compositions
- various applications:
  - spintronics • shape memory alloys
  - magneto-optical applications
- attractive magnetic properties:
  - magneto-optical characteristics • high T_C
  - high saturation magnetization • magnetic moment

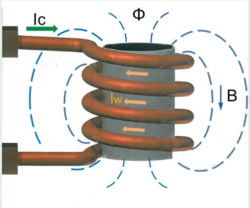
The aims of the study:

1. Preparation of full Heusler alloy Co_2FeAl by three different procedures: arc melting, induction melting and planar flow casting;
2. Comparing the effects of these procedures on microstructure and magnetic properties.

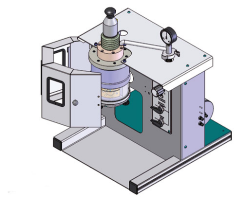
Sample preparation

sample preparation → high-purity Co, Fe, Al

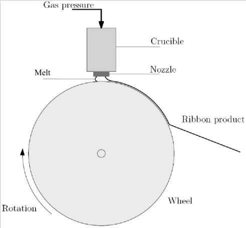
Induction Melting



Arc Melting



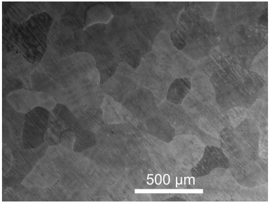
Planar Flow Casting



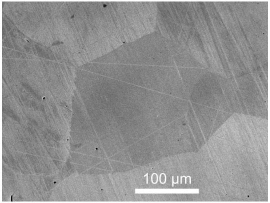
button-type ingots
⇓
spark erosion cutting
⇓
discs 500 μm thick

⇓
ribbons (**amorphous**, nanocrystalline, crystalline)
⇓
20 μm thick, 2 mm wide ribbons

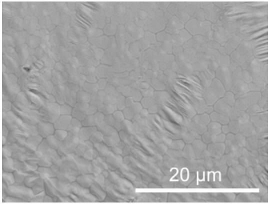
arc melted sample (DAM)

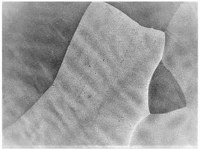


ind. melted sample (DIM)



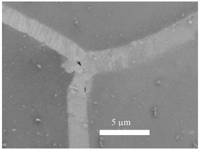
ribbon sample (R)





Co_2FeAl
DAM sample

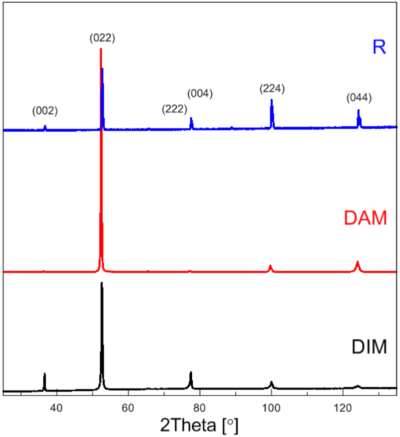
Co (at.%)	~48
Fe (at.%)	~23
Al (at.%)	~29



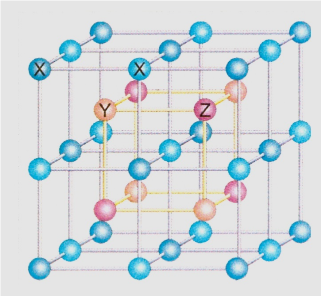
Co_2FeSi
DAM sample

Co (at.%)	47.82⇒~57
Fe (at.%)	24.83⇒~8
Si (at.%)	27.38⇒~35

Comp.	Co [at.%]	Fe [at.%]	Al [at.%]
DAM	48.84±0.59	24.06±1.70	27.10±2.11
DIM	49.29±0.21	25.53±0.10	25.18±0.31
R	40.70±2.62	22.21±1.48	37.09±4.02



$L2_1$ structure

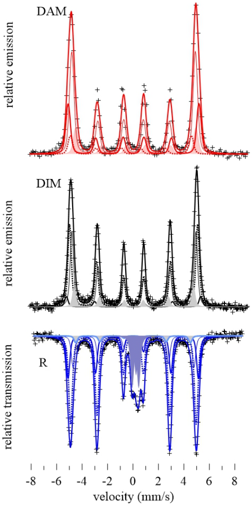


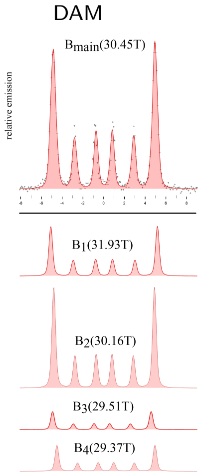
X≡Co at (000) and $(\frac{1}{2}\frac{1}{2}\frac{1}{2})$
Y≡Fe at $(\frac{1}{4}\frac{1}{4}\frac{1}{4})$
Z≡Al at $(\frac{3}{4}\frac{3}{4}\frac{3}{4})$

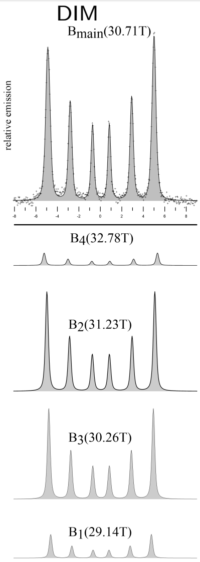
	microstrain [%]	crystalite size [nm]	lattice parameter [A]
R	0.265	43.1	5.706
DIM	0.203	60.8	5.733
DAM	0.232	51.0	5.734

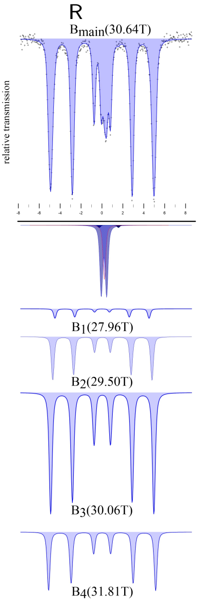
by ICSD database: 57607

Mössbauer spectrometry

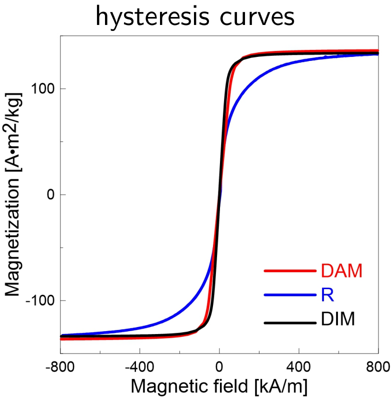


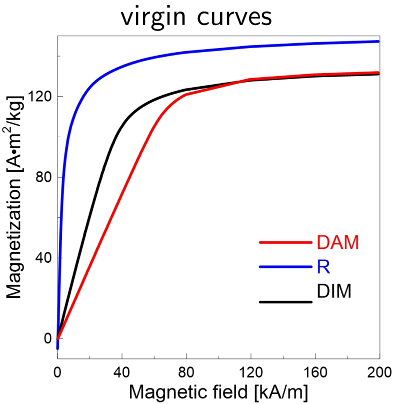




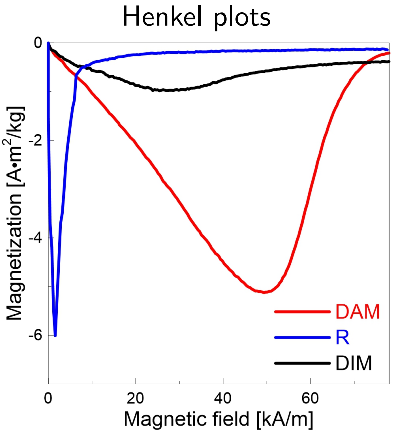


Bulk magnetization
Co_2FeAl by Vibrating Sample Magnetometer





	DAM	DIM	R
M_s (Am^2/kg)	137.57	138.26	132.82
M_r (Am^2/kg)	1.291	0.860	2.391
H_c (kA/m)	1.30	0.69	0.84

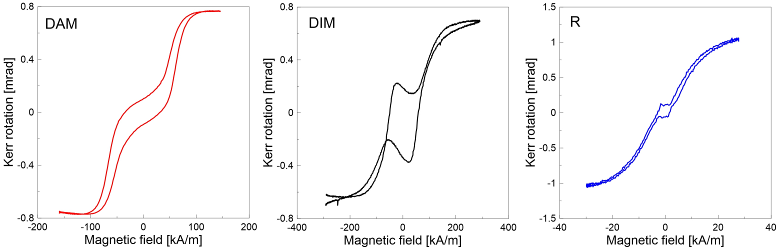


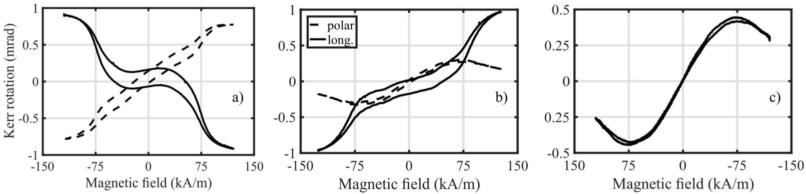
	DAM	DIM	R
ΔH (kA/m)	49.36	25.47	1.59
ΔM (Am^2/kg)	-5.13	-0.98	-6.01

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

O. Henkel, Phys. Stat. Sol. 7, 919 (1964)

Surface magnetization
Magneto-Optical Kerr Effect



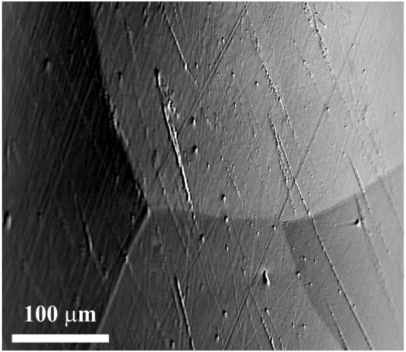


laser spot	300 μm
wave length	670 nm

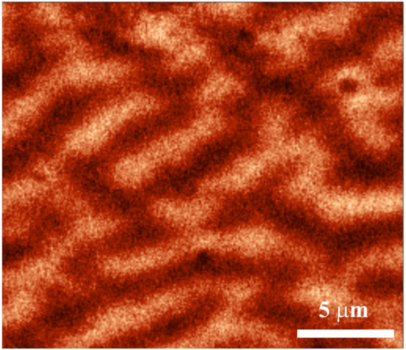
incident angle	50^o
penetration depth	$\approx$ 20 nm

Surface magnetization, DAM sample

Magneto-Optical Kerr Microscopy + Magnetic Force Microscopy



magnetic domains by
optical microscopy
longitudinal component



magnetic domains by
MFM
polar component

Conclusion

- Full ternary Heusler alloy were successfully prepared by all procedures.
- From viewpoint of microstructure:
  - discs and ribbon differ in grain size,
  - dendrite formation observed on the surface of grains (DAM).
- From viewpoint of magnetic properties:
  - ribbons seems to be slightly softer than discs,
  - higher dipole interactions originate at lower magnetic fields at ribbons,
  - similarity to Co_2FeSi Heusler alloy.

Huge roughness of ribbon samples and difficult manipulation of it complicated measurements.

Thanks for attention

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