

Aspects of Si/Fe_xCo_y multilayers used for neutron optics

Anke Teichert
Hahn-Meitner-Institute Berlin

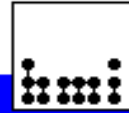
Content



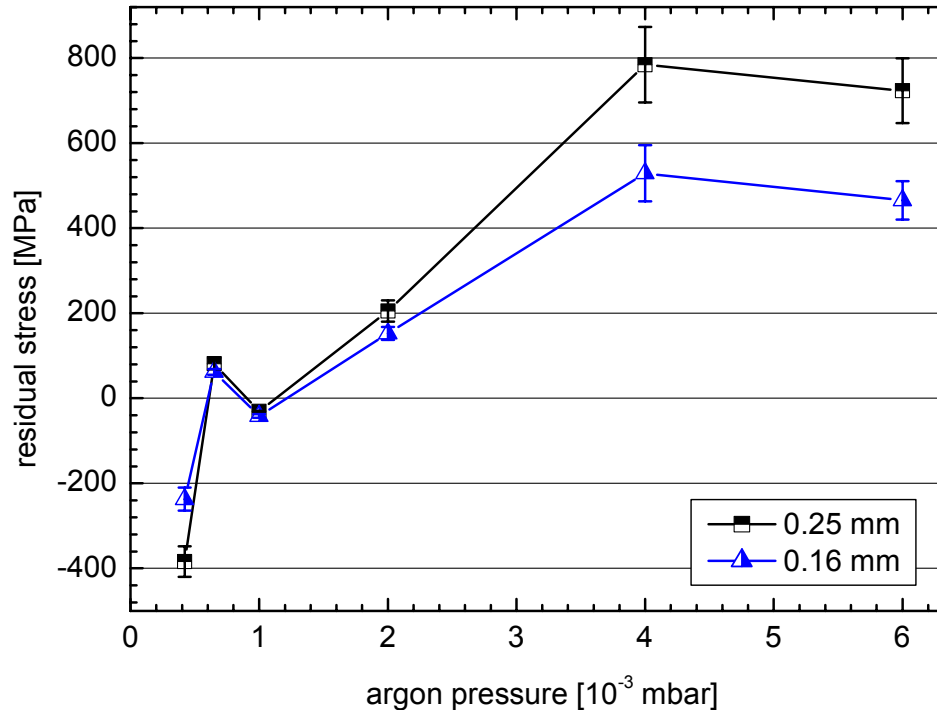
Hahn-Meitner-Institut
Berlin

- properties of monochromators with 10 bilayers depending on argon pressure
- comparison of properties of the $\text{Si-Fe}_{90}\text{Co}_{10}$ and Si-Fe multilayers
- conclusion

Stress in monochromator systems with 10 bilayers and 10 nm bilayer thickness



Hahn-Meitner-Institut
Berlin

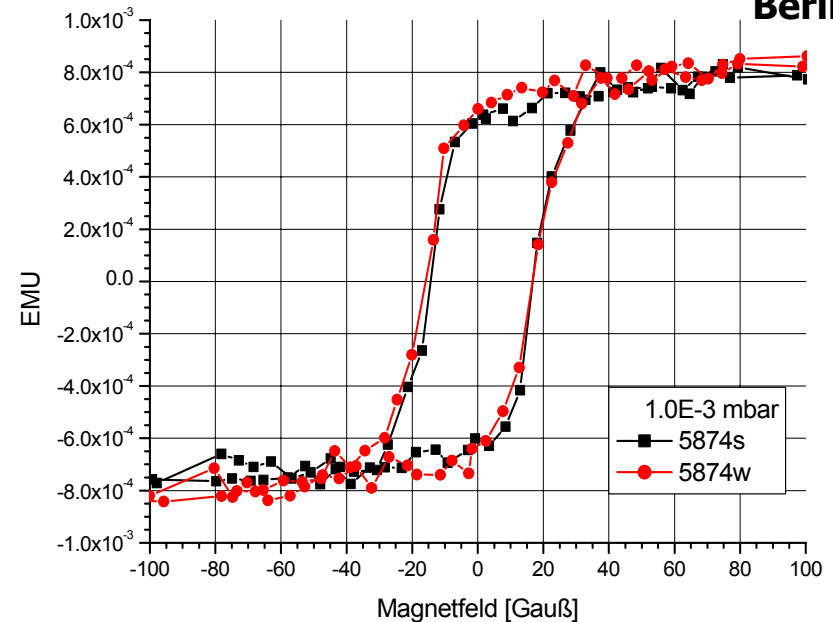
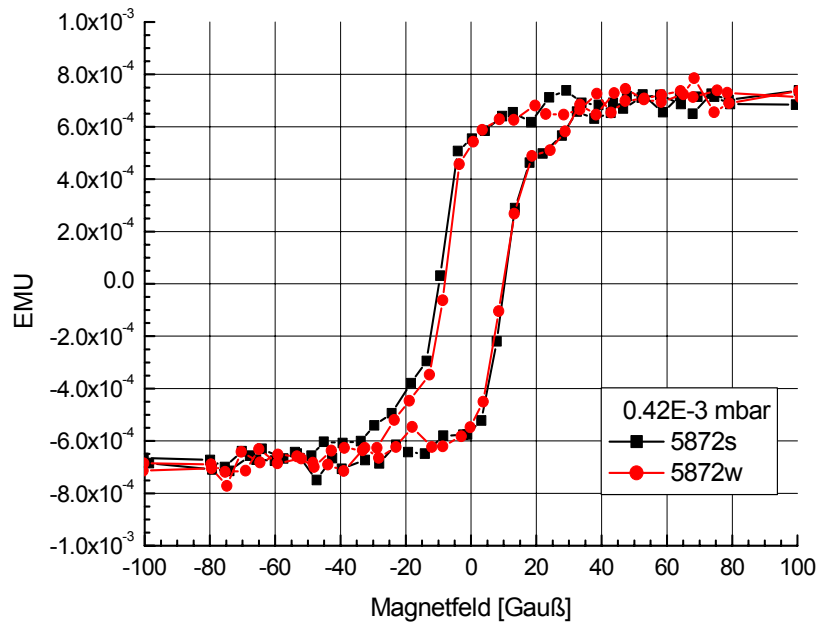


- The monochromators with the system (10 [5 nm Si+ 5 nm Fe]+ 5 nm Si) were prepared at a bias voltage of 32 V. The sputter power were 0.26 kW and 0.28 A.
- The stress is zero at 1.0×10^{-3} mbar and becomes more tensile with higher argon pressure.

Magnetic properties of monochromators with 10 bilayers



Hahn-Meitner-Institut
Berlin

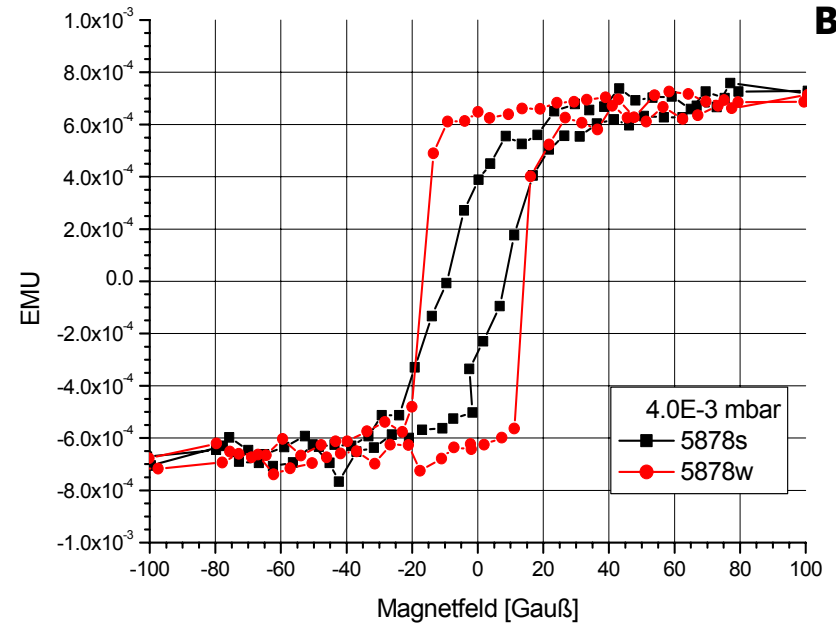
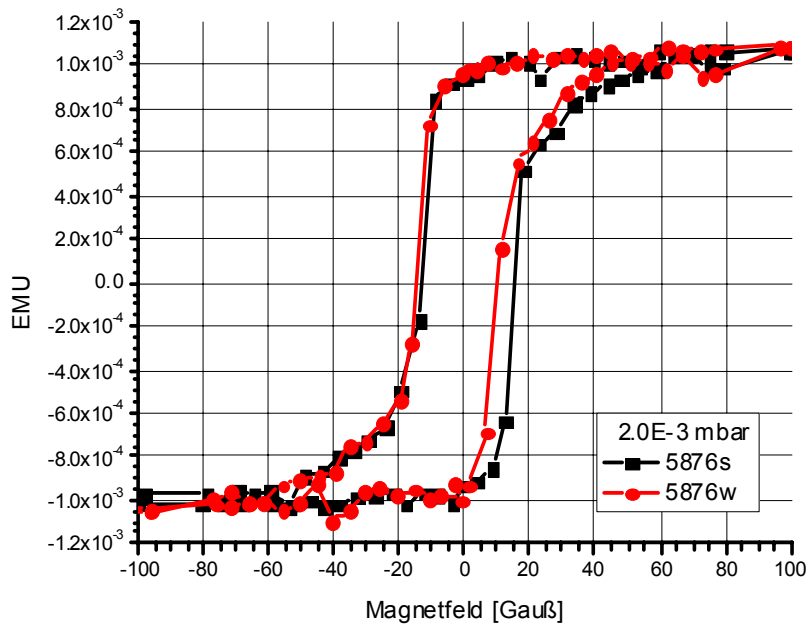


pressure		M_s	remanence	coercivity		M_s	remanence	coercivity
0.42	S	1.09E-03	57.4 %	14.5 gauss	W	7.96E-04	66.5 %	8.1 gauss
0.65	S	8.96E-04	75.1 %	15.4 gauss	W	8.75E-04	75.1 %	14.9 gauss
1.00	S	8.30E-04	75.0 %	14.7 gauss	W	8.72E-04	75.5 %	15.9 gauss

Magnetic properties of monochromator with 10 bilayers

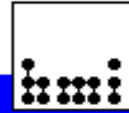


Hahn-Meitner-Institut
Berlin

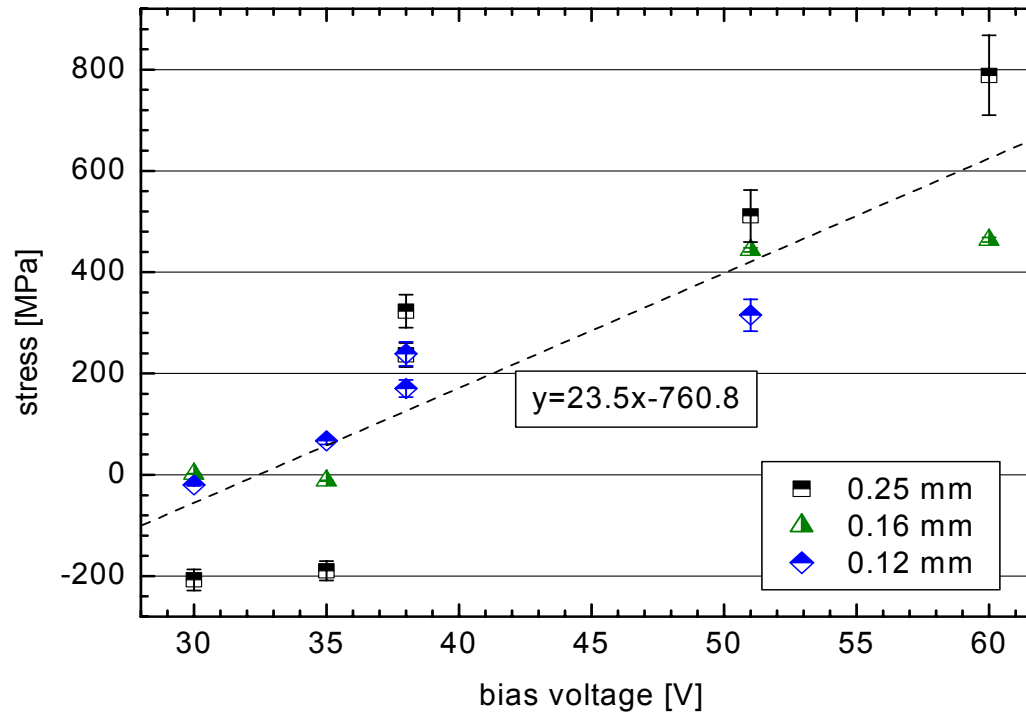


pressure		M_s	remanence	coercivity		M_s	remanence	coercivity
2.00	S	1.17E-03	84.2 %	13.1 gauss	w	1.14E-03	85.4 %	14.7 gauss
4.00	S	7.73E-04	37.8 %	9.7 gauss	w	7.56E-04	85.6 %	16.8 gauss
6.00	S	5.06E-04	25.3 %	13.4 gauss	w	5.61E-04	83.8 %	12.2 gauss

Stress in Si-Fe₉₀Co₁₀ supermirrors with 50 layers

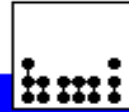


Hahn-Meitner-Institut
Berlin

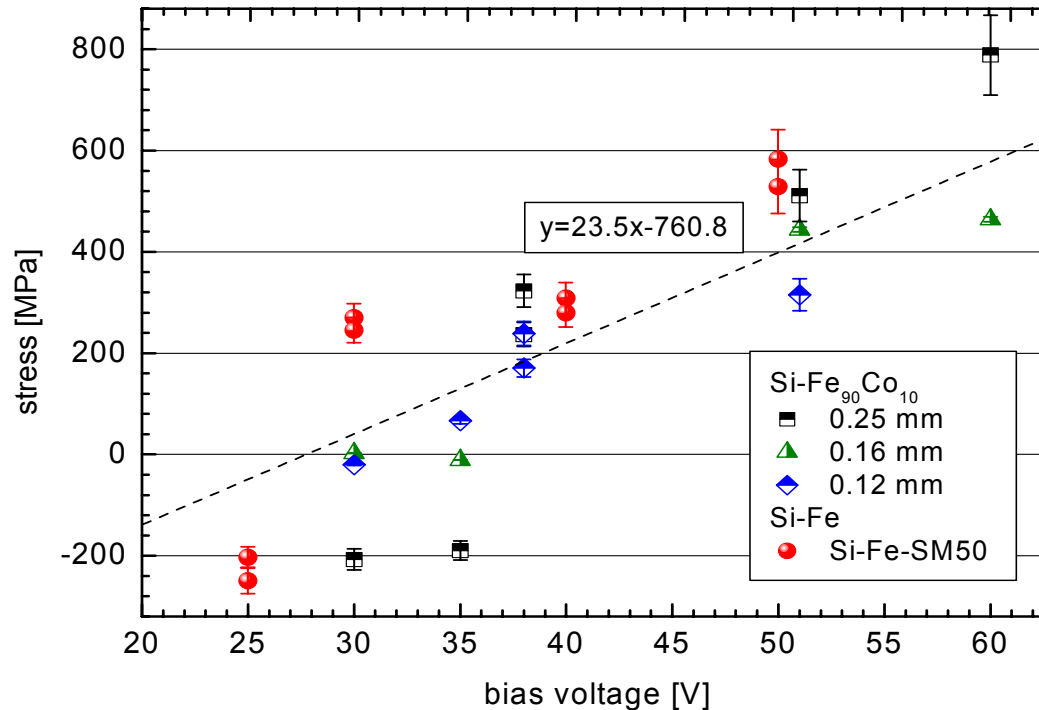


- The sputter parameter of the supermirrors were $p_{Ar} = 1.50 \times 10^{-3}$ mbar; $P = 0.25$ kW; $I = 0.30$ A.
- The stress is zero at a bias voltage of 34 V.
- It becomes more tensile with increasing bias voltage.

Stress in Si-Fe supermirrors with 50 layers



Hahn-Meitner-Institut
Berlin



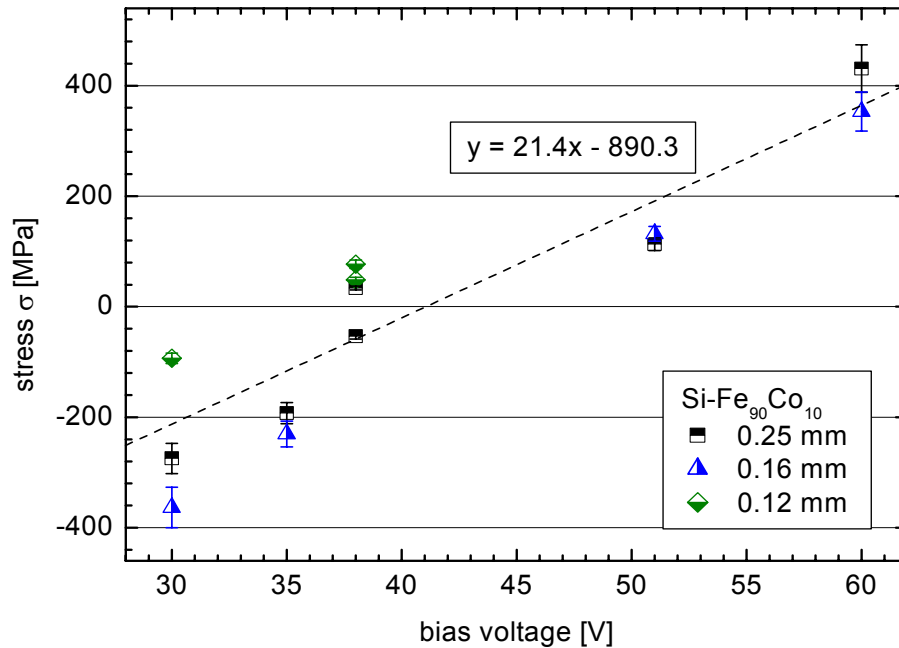
- The sputter parameter of the Si-Fe supermirrors (red) were $p_{Ar} = 1.50 \times 10^{-3}$ mbar, $P = 0.25$ kW and $I = 0.30$ A.
- The stress values in the Si-Fe supermirrors are very closed to the values in the Si-Fe₉₀Co₁₀ supermirrors.

Stress in Si-Fe₉₀Co₁₀ and Si-Fe monochromators with 25 bilayers

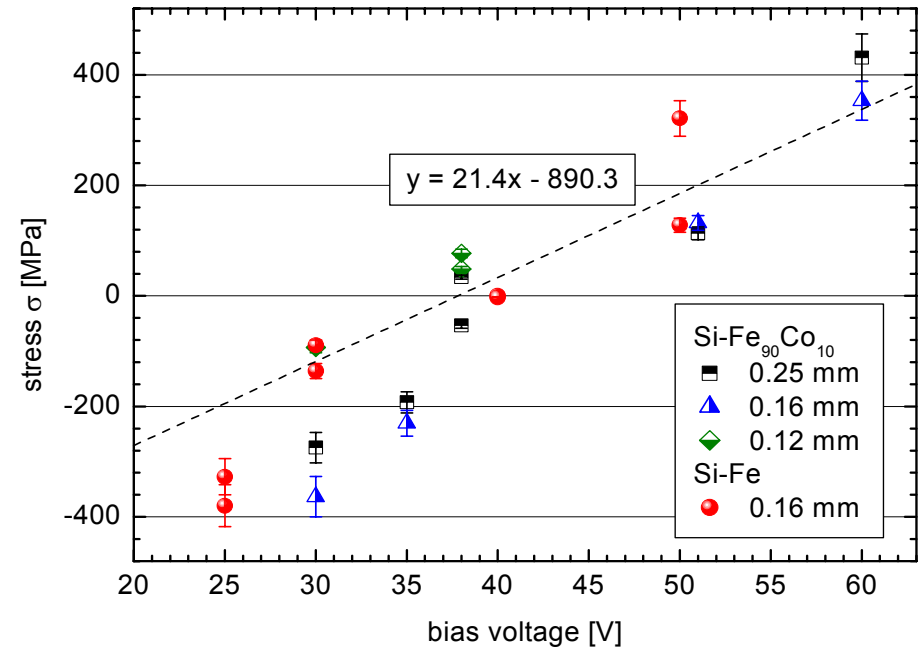


Hahn-Meitner-Institut
Berlin

Si-FeCo monochromator



Si-Fe monochromator



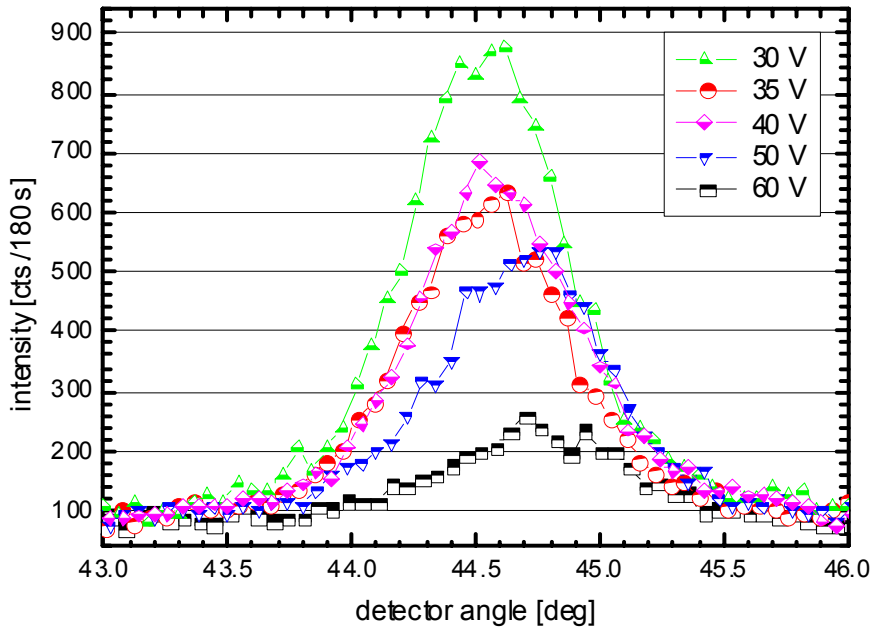
- The sputter parameter of the monochromators with the system (25 [15 nm Si+15 nm Fe_xCo_y]+15 nm Si) were $p_{Ar} = 1.50 \times 10^{-3}$ mbar, $P = 0.25$ kW and $I = 0.30$ A.
- The stress values in the Si-Fe supermirrors (red) are very close to the values in the Si-Fe₉₀Co₁₀ supermirrors.

Crystallinity of Fe₉₀Co₁₀ and Fe layers in the monochromator systems with 25 bilayers



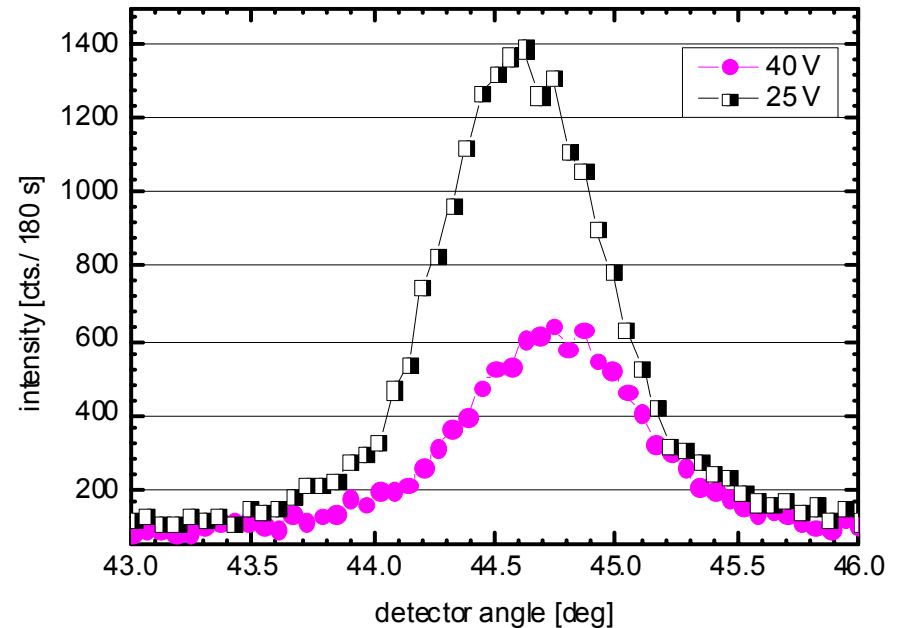
Hahn-Meitner-Institut
Berlin

Si-FeCo monochromator



Bias	intensity	2θ	FWHM	grain size
30 V	763 cts.	44.54	0.77	112.1 Å
35 V	502 cts.	44.54	0.79	109.0 Å
40 V	550 cts.	44.58	0.81	106.6 Å
50 V	431 cts.	44.69	0.82	105.0 Å
60 V	148 cts.	44.74	0.92	93.8 Å

Si-Fe monochromator

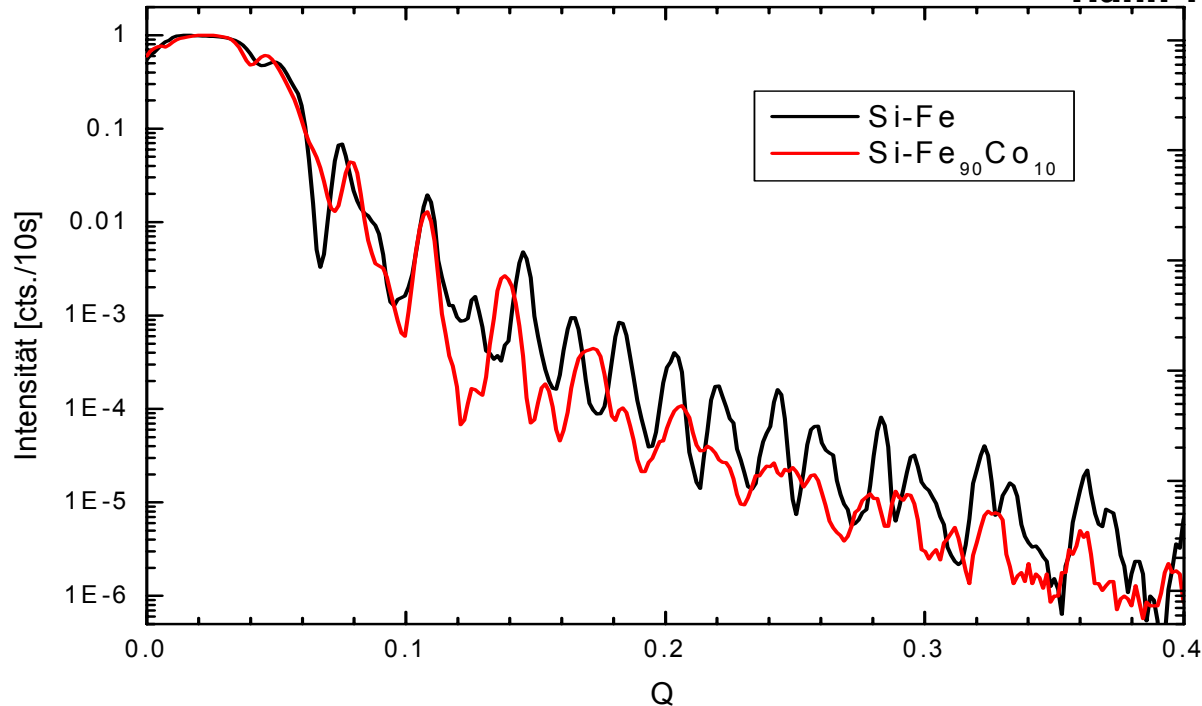


Bias	Intensity	2θ	FWHM	grain size
25 V	1416 cts.	44.60	0.73	118.1 Å
40 V	600 cts.	44.73	0.79	108.4 Å

Interface layers and roughness of multilayer systems with 25 bilayers



Hahn-Meitner-Institut
Berlin

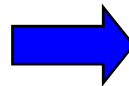
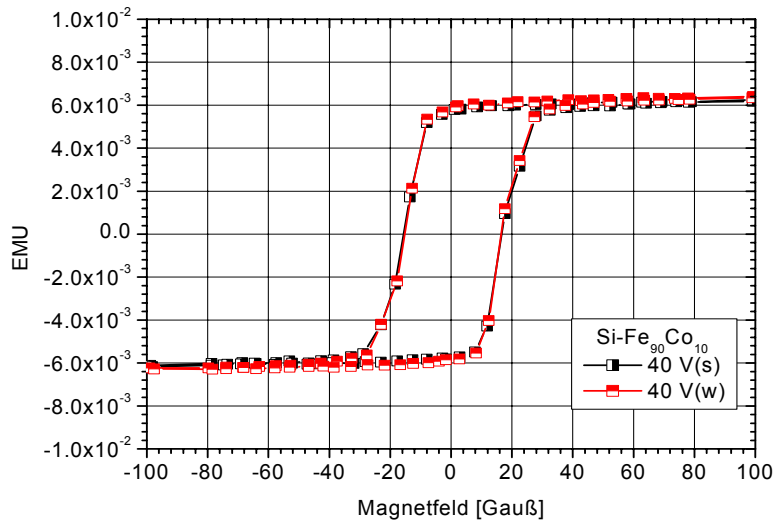


		d	SLD(re)	SLD(im)	σ_R
Si-Fe	ZWS auf Si	9.7 Å	4.245E-05	6.79E-06	7.6 Å
	ZWS auf Fe	10.2 Å	4.945E-05	2.35E-06	7.9 Å
Si-Fe ₉₀ Co ₁₀	ZWS auf Si	13.9 Å	4.054E-05	6.79E-06	9.8 Å
	ZWS auf FeCo	15.5 Å	4.671E-05	2.359E-06	10.1 Å

Magnetic properties of monochromators

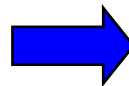
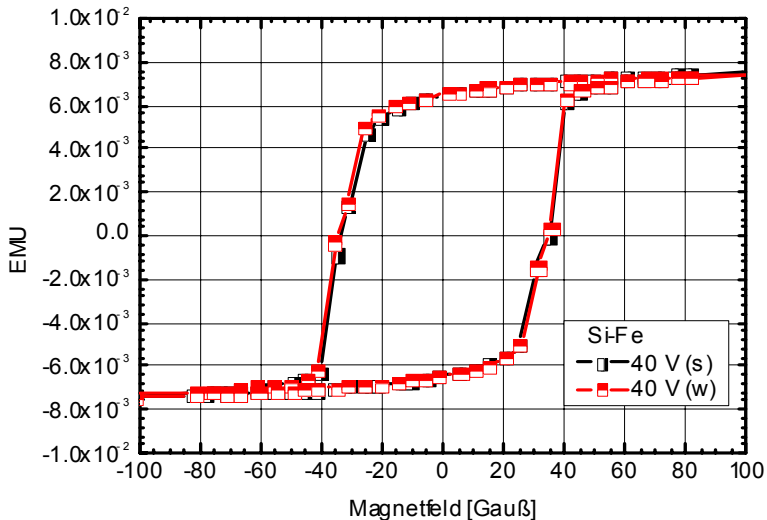


Hahn-Meitner-Institut
Berlin



Si-Fe₉₀Co₁₀ monochromator

	M_s	remanence	coercivity
40 V (s)	7.675E-3	88.8%	24.7 Gauß
40 V (w)	7.377E-3	85.9%	24.6 Gauß



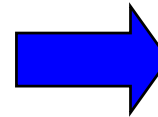
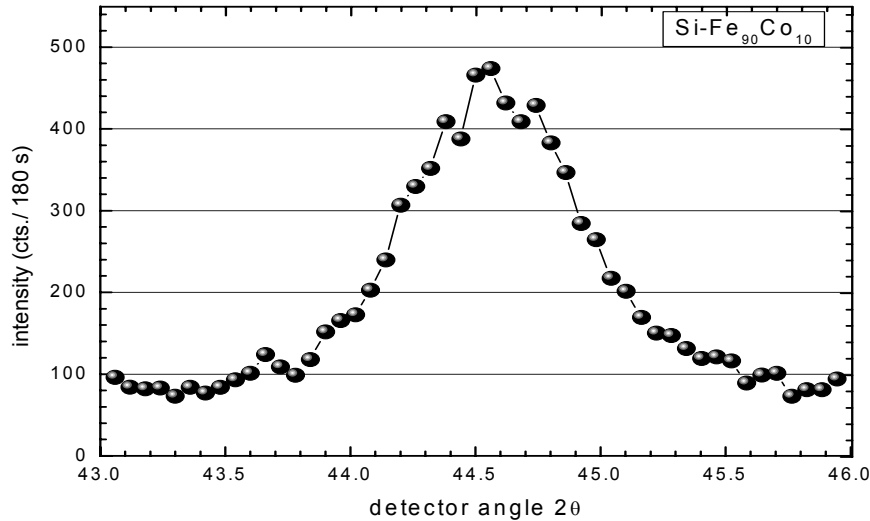
Si-Fe monochromator

	M_s	remanence	coercivity
40 V (s)	7.861E-3	82.5%	33.6 Gauß
40 V (w)	7.831E-3	83.1%	34.8 Gauß

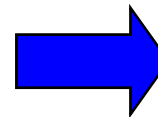
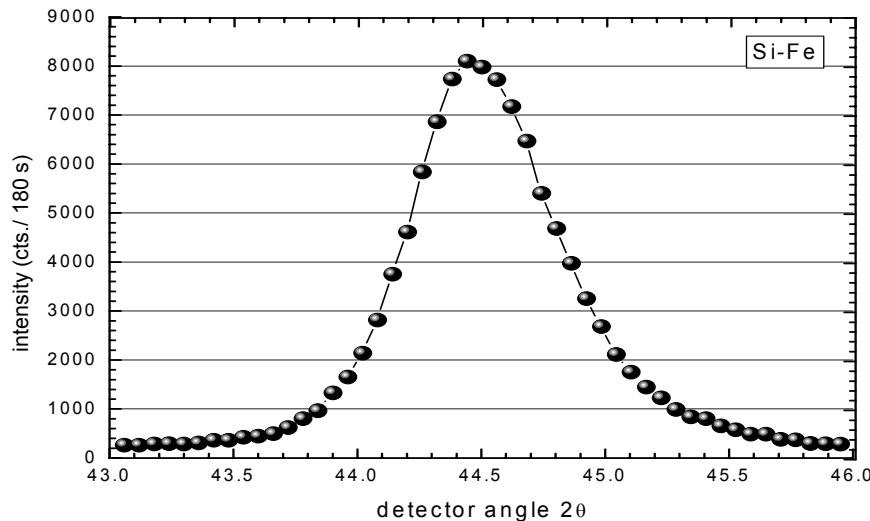
XRD measurements of Si-Fe_xCo_y supermirrors



Hahn-Meitner-Institut
Berlin



Si-Fe₉₀Co₁₀
2θ 44.57 deg
FWHM 0.83 deg
Intensity 423 counts



Si-Fe
2θ 44.50 deg
FWHM 0.68 deg
Intensity 8300 counts



- Stress values in the Si-Fe are very closed to the values in the Si-Fe₉₀Co₁₀ multilayers
- Si-Fe multilayers ⇒ thinner interface layer thickness and lower roughness
 - ⇒ higher crystallinity for the Si-Fe supermirrors
 - ⇒ higher coercivity
- Magnetic anisotropy at argon pressures higher than 4×10^{-3} mbar