Search for structural relaxations upon spin reorientation in Ni-monolayers on W(110)

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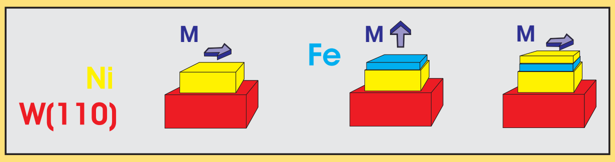
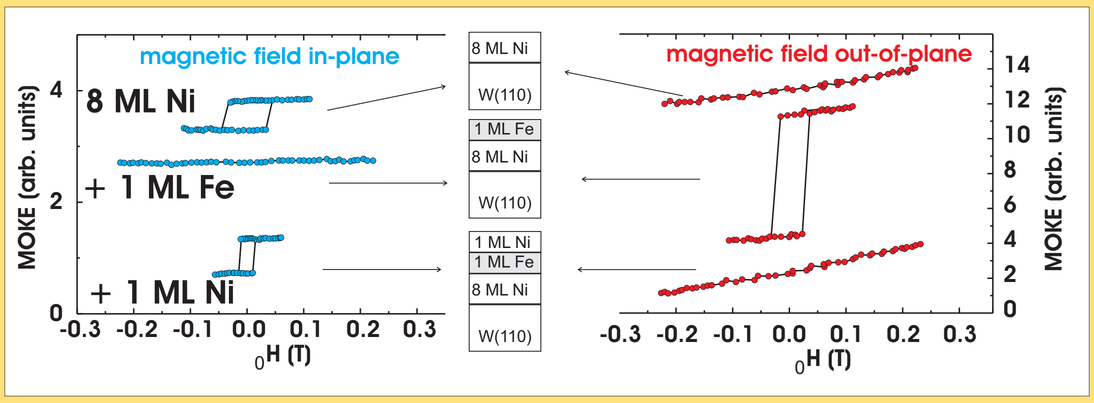
Unusual magnetic properties of Ni(111) layers:

adlayer induced SRT from in-plane to out-of-plane

spin-reorientation transition (SRT): change of the easy magnetization direction

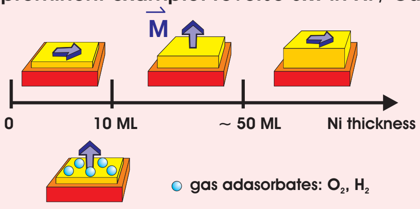




Why should we consider a correlation between SRT and structural change?

magnetoelasticity:
strain couples to the magnetic anisotropy
fcc vs. fct
deviation from cubic symmetry enhances magnetic anisotropy

prominent example: reverse SRT in Ni / Cu(001)



tetragonal distortion drives SRT
layer relaxation upon H-adsorption

stray field vs. strain:
most important anisotropy contributions

$\frac{1}{2} \grave{\imath}_0 M_s^2$ 11 μeV/atom

B_2 680 μeV/atom

K_V 0.4 μeV/atom

$_3 \quad \frac{D_{(111)}}{d_{(111)}} \quad \mu_0 M_s^2 / (2B_2) \quad 8 \quad 10^{3}$

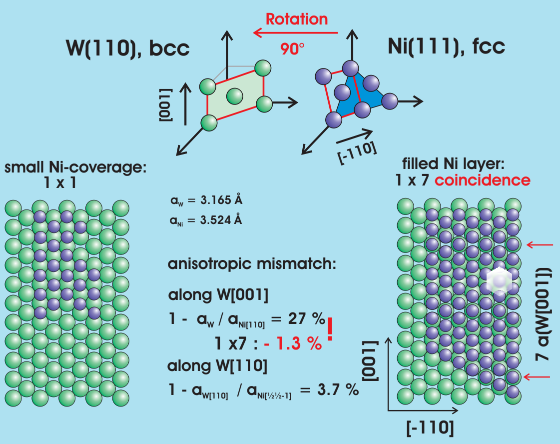
$d_{(111)}$ 0.015 A

small, but measurable relaxation is sufficient for SRT

Ni film growth on W(110) and structural analysis:

almost relaxed Ni(111) structure

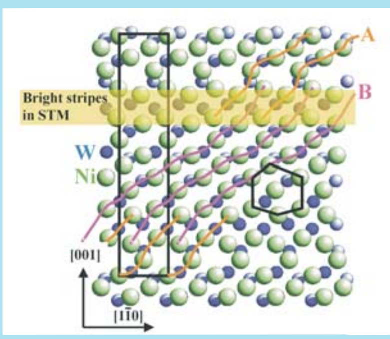
Nishiyama-Wassermann: fcc(111) on bcc(110)



a_W = 3.165 Å
a_{Ni} = 3.524 Å

anisotropic mismatch:
along W[001]
1 - a_W / $a_{Ni[110]}$ = 27 %
1 x7 : - 1.3 % !
along W[110]
1 - $a_{W[110]}$ / $a_{Ni[11\bar{2}]}$ = 3.7 %

modulated Ni 1 x 7 structure on W(110)
good template for subsequent growth of Ni(111)

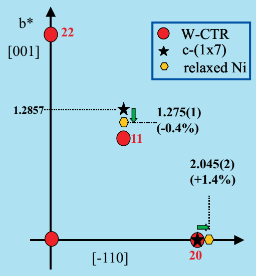


Ni:		W:	
x	0.7 Å	x	0.3 Å
y	0.4 Å	y	0.3 Å
z	0.3 Å	z	0.1 Å

significant modulation of Ni AND W
quasi-hexagonal arrangement of Ni
Ni site: "bridge" and NOT "on-top"

PRB 67 (2003) 155422

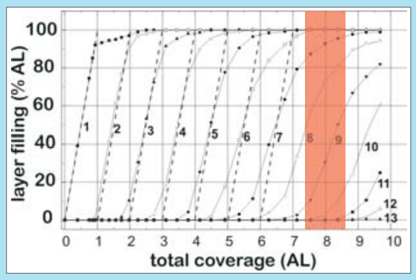
strain state
slightly distorted fcc-Ni(111)



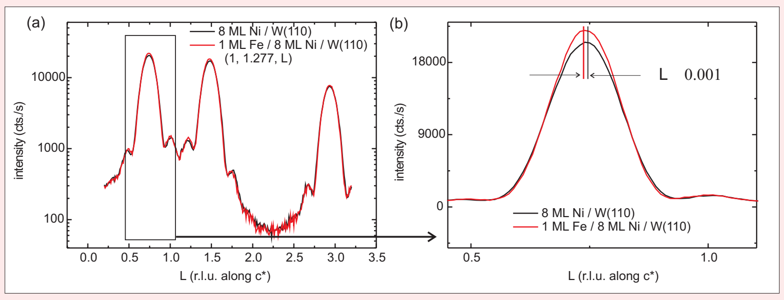
, as measured for 8 ML Ni / W(110)

1 0.004 along W[001]
2 0.014 along W[$\bar{1}$10]
3 0.007

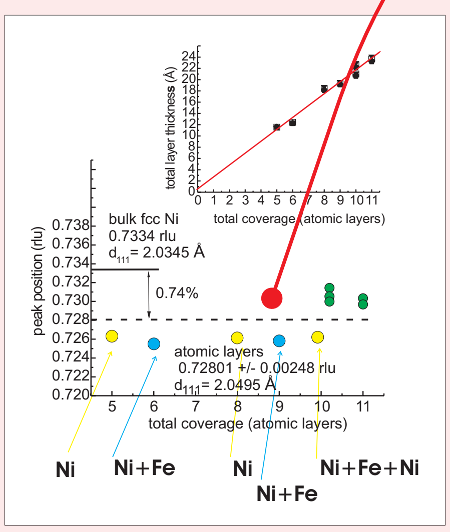
layer filling from STM
decent layer-by-layer for 8 ML at 300 K



Structural relaxation upon adlayer coverage:



structural relaxation is VERY SMALL
d(111) < 0.002 A



calculated from a narrowing of peaks with increasing layer deposition:
$t[A] \quad 0.886 / FWHM [A^{1}]$

the magnitude of the structural relaxation upon adlayer coverage is a factor 10 too small to induce a SRT driven by magnetoelasticity with bulk coupling constants

What is the reason for the SRT?
Possibly surface anisotropy:
fcc Fe(111) favors out-of-plane magnetization

References:
growth and stress 1 ML Ni / W(110):
Meyerheim et al., PRB 67 (2003) 155422.
strain and magnetic anisotropy:
Sander, Rep. Prog. Phys. 62 (1999) 809.
J. Phys. Cond. Matt. 16 (2004) R603.