[redacted]

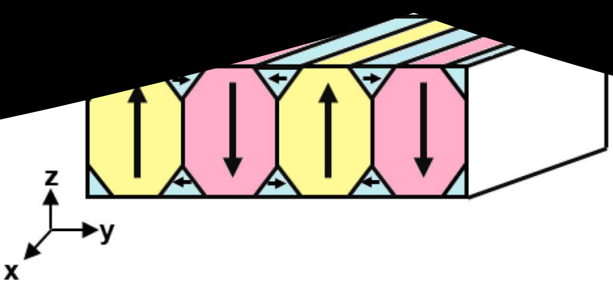

Fig. 1. Schematics of a ferromagnetic thin film with low magnetocrystalline anisotropy in z-direction and closure domains on the surfaces.

36 nm thick FePd layer is grown by shuttered growth at room temperature, followed by a second layer of 34 nm grown by codeposition at $T_s = 500$ K. The layer thicknesses were measured and calibrated using X-ray reflectometry (XRR) measurements. X-ray diffractometry was used to evaluate the long-range ordering of the FePd films [9]. It is observed that (a) S1 has highest degree of structural ordering, (b) S2 has no long range ordering, and (c) S3 shows moderate long-range [redacted] ordering.

3. Magnetization analysis

Fig. 2 shows the hysteresis loops of the three samples wh[redacted] magnetization M is plotted as a function of the applied field[redacted] observed that S1 has a strong PMA along ⟨001⟩-direction, w[redacted] has a strong in-plane anisotropy. However, in S3 the ⟨001[redacted] still denotes the easy axis but with a higher in-plane compo[redacted] S1.

Due to the different strength of magnetocrystalline ani[redacted] three samples, we need to consider the effective uniax[redacted] constant K_{eff} as the sum of the magnetocrystalline and[redacted] sotropy constants $K_{eff} = K_u + K_{sh}$. K_{eff} can be obtained[redacted] the integral over the difference from the out-of-plane [redacted] hysteresis loops [10]:

$$K_{eff} = K_u - \frac{1}{2}\mu_0 M_s^2 = \int_0^{M_s} (H_\perp - H_{||}) dM,$$ [redacted]

where M_s is given in [A/m], $\mu_0 H_s$ in [T] and K_{eff} in[redacted] we deduce K_u to determine the quality factor Q of t[redacted] which can be calculated by the ratio of K_u and th[redacted] constant $K_{sh} = \frac{1}{2}\mu_0 M_s^2$ [11]. For $Q > 1$ the thin film[redacted] whereas $Q < 1$ denotes an in-plane easy axis of ma[redacted] Q-values and K_u for the three samples are listed in[redacted]

Fig. 3 shows the MFM images of the three as [redacted] strong PMA in S1 ($Q = 2.17$) results in a maze doma[redacted] is no preferred in-plane orientation [Fig. 3(a)]. S[redacted]

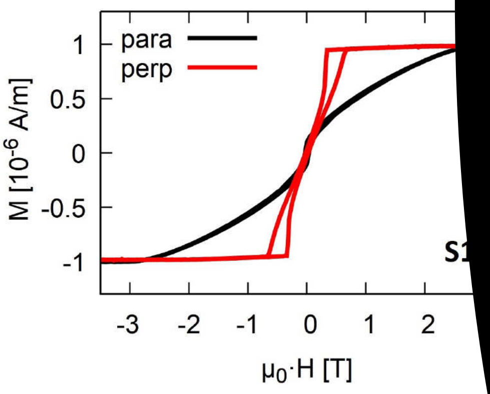

Fig. 2. Hysteresis loops of S1, S2 and S3 measured at 300 K[redacted] orientation) and perpendicular to the surface plane ("perp",[redacted]

Parameters	[redacted]
K_u [kJ/m^3]	[redacted]
Q	[redacted]

plane magnet[redacted] [Fig. 3(b)]. [redacted] aligned d[redacted] sidering[redacted] other[redacted] the[redacted] pa[redacted]

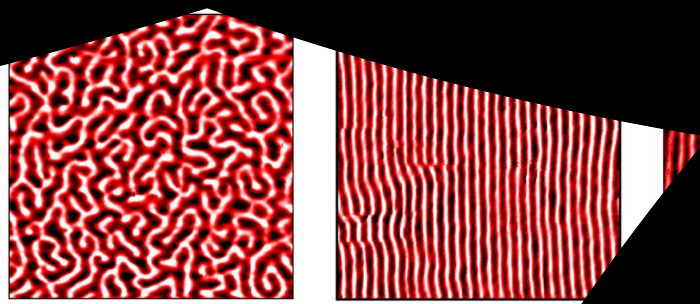

Fig. 3. $3 \times 3\,\mu$m MFM measurements in the as grown state of the [redacted]

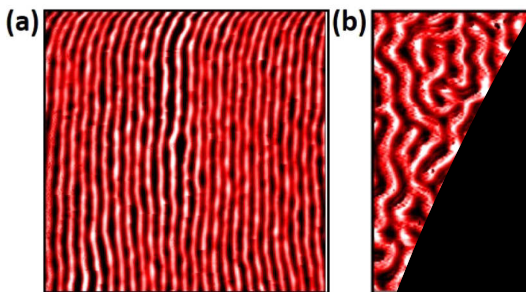

Fig. 4. $3 \times 3\,\mu$m MFM measurements at 0 applied field of S3 after app[redacted]
(c) after in-plane oscillating demagnetization.

From the resulting detector image [Fig. 5(a)] the follo[redacted] observed – (i) the specular spot at $Q_y = 0\,\text{nm}^{-1}$ and Q_z [redacted] with an incident angle of 0.97° and (ii) two peaks on th[redacted] with $Q_z = 0.169\,\text{nm}^{-1}$ (marked by a horizontal line in Fig[redacted] The Q_y-Q_z-map and the intensity as function of Q_y at Q[redacted]

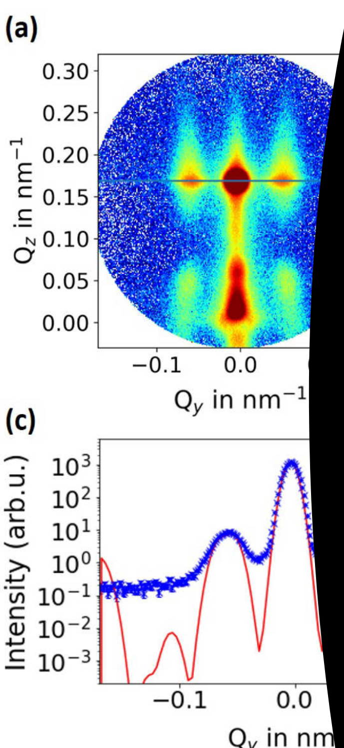

Fig. 5. (a) Q_y-Q_z scan of FePd with parallelly aligned m[redacted] $Q_z = 0.169\,\text{nm}^{-1}$ of the experiment (blue) and the simulatio[redacted] interpretation of the references to colour in this figure legen[redacted]

[redacted] and depth. [redacted] taken into account due to the [redacted] model are correlations along the x-direction due to [redacted] width fluctuations, and a constant background on the detector. Thus the scattering signals at $Q_y = 0.1\,\text{nm}^{-1}$ in the measurement cannot be resolved. The simulated signals at the edge of the detected Q_y-range (third harmonic GISANS peaks) will be lowered by assuming bending and roughness effects of the magnetic domains in y-direction.

According to such a model, the Q_y-Q_z-map can be reproduced by assuming small closure domains (in the example in Fig. 5(b) and (c) we have used a size and depth of 10 nm of the closure domains). The FePd layer thickness was fixed to 39 nm as a result of X-ray-reflectometry measurements on this sample. From the Q_y-dependence the domain width can be calculated to $w_d = 56$ nm and is close to the values measured in MFM. Both the closure domains and the ferromagnetic domains exhibit a periodicity of 56 nm and overlap at the same Q_y-value. The results show that this model can be used to study the lateral correlations in a domain structured ferromagnet. By inserting magnetic roughness effects in this model, the scattering intensities and peak width will give more detailed information about the width and depth of closure domains. Moreover, the scattering peaks from in-plane ma[redacted] netized closure domains and out-of-plane magnetized domains can [redacted] seperated using a polarized neutron beam with polarization in z- [redacted] direction. Also an evaluation at different incident angles will give [redacted] detailed information on the depth profile of the closure domain[redacted]

5. Summary and outlook

In this work we have shown that a combination of codep[redacted] shuttered growth leads to FePd layers with high PMA a[redacted] parallelly aligned domain formation. A pseudo-reversible [redacted] of the domain pattern of high PMA FePd layers is poss[redacted] plying a saturating magnetic field in the out-of-plane dire[redacted] scattering experiments are carried out to observe the [redacted] the lateral magnetization in the FePd layer with paral[redacted] mains and $Q = 1.8$. For the simulation a model for th[redacted] cluding magnetic domains in the out-of-plane direc[redacted] domains in the in-plane direction was used.

Our simulation of the neutron experiments provid[redacted] experimental results. However, in the model can b[redacted] cluding correlation effects along the x-direction as w[redacted] the domain and closure domain widths. By this the [redacted] peaks towards higher Q_y shall be simulated. Also [redacted] simulation using various incident angles to vary th[redacted]

[redacted] structure o[redacted]

References

[1] B.M. Lairson, B[redacted] (001) and Pt[redacted] https://doi[redacted]

[2] G. Beutie[redacted] E. Dud[redacted] using[redacted] Rev[redacted]

[3] T[redacted]

[4][redacted]