32223
S/139/61/000/004/016/023
Determination of the optical E032/E314

Acknowledgments to Assistant A.M. Gulyayev and L.P. Pavlov who supplied the germanium films which were used in an experimental check on the theory. There are 3 figures and 3 Soviet references.

ASSOCIATION: IAA im Dzerzhinskogo (IAA im. Dzerzhinskiy)
Moskovskiy energeticheskiy institut
(Moscow Power-engineering Institute)

SUBMITTED: January 28 1960 (initially)
February 6 1961 (after revision)

4

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22069

9.7140 (1164)

S/200/61/000/005/001/002
D227/D303

AUTHORS: Kirenskiy, L. V., Buravikhin, V. A., Kan, S. V., and Degtyarev, I. F.

TITLE: Domain structure of thin ferromagnetic films

PERIODICAL: Akademiya nauk SSSR. Sibirskoye otdeleniye. Izvestiya, no. 5, 1961, 3-9

TEXT: In recent years, a series of theoretical and experimental investigations have been carried out on the domain structures and the structures of domain shells in thin ferro-magnetic films by T. Kaczer (Ref. 4: K Doménove struktuře tenkých ferromagnetyckych vrstev, Českolovenský časopis pro fysiku, 7, 516 (1957), I. N. Shklyarevskiy (Ref. 18: K voprosu ob izmerenii tolshchin tonkikh plenok s pomoshch'yu liniy ravnogo khromaticheskogo poryadka, t. "Optika i Spektroskopiya", 5, 617 (1958), L. V. Kirenskiy, I. F. Degtyarev (Ref. 19: O temperaturnoy ustoychivosti domennoy struktury v kristallakh kremnistogo zheleza, ZhETF., 35,

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22068

S/200/61/000/005/001/002
D227/D303

Domain structure...

3, (9), 584 (1958)), R. M. Moon (Ref. 15: Internal structure of cross-tied walls in thin Permalloy films through high-resolution Bitter techniques, j. Appl. Phys., 30, 82, 1959), I. B. Gomi, Y. Odani (Ref. 16: Chain wall in Permalloy Thin Films, j. of the Physical society of Japan, 15, 3, 535, 1960) and C. E. Fuller (Ref. 17: Domains patterns and reversals by wall movements of thin films of iron and nickel iron, j. Phys., et radium, 20, No. 2-3, 310, 1959). The study of thin films opens up the possibility of applying known microscopic methods of investigation in the study of microscopic properties of matter. Investigation of ferro-magnetic properties of thin films could be useful in clarifying problems of ferro-magnetic theory and here provide useful data for massive ferro-magnetic samples. Detailed study of space distribution of self-magnetism in thin ferro-magnetic films appears an important stage on the way to developing the theory of technical magnetization. The practical study of the

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Domain structure...

properties of thin ferro-magnetic films could lead to perfecting the "memory" elements of modern computers. Mainly due to their comparatively simple production and better rate of demagnetization they have important advantages over ferrite cores in computers. The study of the configuration of the domain structure of ferro-magnetic films and its dependability on the technology of preparation, chemical composition and thickness, and also the change of domain structure in the magnetic field, could provide the best choice of "memory" elements of computers and electronic machines. Missing from most of the work already done in the study of domain structure of thin ferro-magnetic films, is the effect of technology of film preparation, film thickness on the configuration of domain structure and also film changes in the process of magnetization and demagnetization. The present work deals with the effect of the technology of preparation and thickness of the film of alloy consisting of 80% nickel, 17% iron, and 3% molybdenum on the configuration of their domain

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Domain structure...

structure as well as the change in film domain structure of this alloy and also of the alloy containing 50% nickel, 50% iron in the magnetic field. To prepare ferromagnetic films a vacuum device was used, whose diffusion pump yields a vacuum aggregate VA-05-1. Films were obtained by melting the above-mentioned alloys in a tungsten crucible and developing films on optically polished glass having the form of a rectangle of 10 x 40 mm, 8 x 36 mm, and also on discs of 2 to 8 mm diameter. The films were placed in a magnetic field produced by a pair of Helmholtz coils. The direction of the field was in the plane of the films. The films of alloy Fe-Ni-Mo were prepared as follows: (a) Base temperature of 350°C., in a magnetic field of 125, 100, 75, 50, 25 and 4 oersteds; (b) Base temperature 420, 350, 150 and 50°C., in a field of 100 oersteds; (c) The films of alloy Fe-Ni-Mo of different thicknesses from 6150 Å to 140 Å, and also films of alloy Fe-Ni were prepared at base temperatures up to 350°C and in a field of 100 oersteds. The films prepared in the magnetic

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Domain structure...

field possessed uniform anistrophy along the axis which corresponded to the direction of applied magnetic field. The thicknesses of the films were measured by the universal monochrometer UM-2 by means of the lines of uniform chromatic order. Domain structure was investigated by the method of powder figures with a magnification of 280 on the MBI-6 microscope and also by the method of Kerr's meridian magneto-optical effect as quoted in Ref. 19 (Op. cit.). The powder method enables the study of domain structure at high magnification, the details of boundaries and domains, and it possesses appreciable inertness. Hence for the study of change of domain structure with a rapidly changing field, the non-inert method of Kerr's meridian magneto-optical method is used which unfortunately does not enable study at high magnification. To use this method, the ferro-magnetic film heated to 250°C, was covered in vacuum with a thin dielectric layer of zinc sulphide. This decreases the destructive effect of temperature on the anisotropy of films and during covering

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D227/D303

Domain structure...

with sulphide a magnetic field of 70 oersteds was applied parallel to the direction of the field used during the evaporation of metal. The dielectric layer appreciably increases the deflection angle of plane polarized light and this increases the contrast between adjacent domains making visual inspection possible. Subsequent work over three months has not detected any change in the behavior of domains and the zinc sulphide layer. The ferro-magnetic films, prepared on the basis of heating above 200°C possessed a time-stable domain structure, mechanical strength and chemical stability. The domain structure of ferro-magnetic films depends largely on the demagnetization conditions. Increasing the angle between the demagnetizing field and the magnetization axis, the structure becomes very fine, the direction of domain boundaries usually following the magnetization axis. The domain structure also depends on the demagnetization rate of films. The most correct structure is obtained at slow demagnetization; a high demagnetization rate gives large domains and their structures are less con-

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D227/D303

Domain structure...

trollable. A decrease in the thickness of ferro-magnetic films gives rise to a tendency to bend the boundaries and to give boundaries with cross connections. The study of the magnetization process indicates that it proceeds as follows: (a) For the thickness (about 500-700 Å) and for dissimilar films, the domains grow along the orientation of the applied field, with clear-cut boundaries; (b) corresponding films with thicknesses greater than 1000 Å change in domain structure, occur along the axis of the magnetizing field and a mixing of boundaries takes place. When magnetizing at an angle of 45°, it could happen that the motion of boundaries does not occur, but inside the poorly oriented domains, the bending of magnetic vectors results, gradually gripping all domains; on the other hand magnetizing at an angle of 90°, the boundary mixing does not take place and magnetic vectors turn smoothly toward the direction of the field. The reverse magnetization process usually starts with clearly defined nuclei, the growth of which is analogous to the magnetization process. There are 9 figures and 19 references: 3 Soviet

X

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S/200/61/000/005/001/002
D227/D303

Domain structure...

bloc and 16 non-Soviet-bloc. The references to the English-language publications read as follows: I. By. Gomi, I Odani, Chain wall in Permalloy Thin Films, j. of the Physical society of Japan, 15, 3, 535, 1960; C. E. Fuller, Domains patterns and reversals by wall movements of thin films of iron and nickel iron, j. Phys., et radium, 20, No. 2-3, 310, 1959; M. Prutton, The observation of domain structure in magnetic thin films by means of the Kerr magneto-optia effect, Philos. Mag., 4, No 45, 1063, 1959; and H. W. Fuller, H. Rubinstein, Observations made on domain walls in thin films, j. Appl. Phys., 30, 84, 1959.

ASSOCIATION: Institut fiziki, Sibirskogo otdeleniya AN SSSR gos. Pedinstitut, Krasnoyarsk (Institute of Physics, Siberian Section, AS USSR, State Ped. Institute, Krasnoyarsk)

SUBMITTED: August 12, 1960

Card 8/8

30472

24,2200 (1137,1147,1164)

S/139/61/000/005/009/014
E194/E135

AUTHORS: Kirenskiy, L.V., Drokin, A.I., Cherkashin, V.S., and Smolin, R.P.

TITLE: Ideal magnetisation curves of ferro-magnetics

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy, Fizika, no.5, 1961, 78-83

TEXT: The concept of an ideal hysteresis-less magnetisation curve of ferromagnetics has existed for a long time. Various methods of producing the ideal curves have been used, such as application to the specimen of d.c. and a.c. with amplitude decreasing to zero, application of successive heating and cooling, and also magnetic shock. It was considered that these various kinds of treatment would suffice to establish a condition of parallel magnetisation in neighbouring ferromagnetic domains. The problem of whether or not ideal curves produced in different ways coincide has still not been resolved and this was the object of the present investigation. The ideal curves were obtained by applying to the specimen direct and alternating fields of amplitude diminishing to zero by ultrasonic mechanical shaking

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and rapping and by temperature variation, heating the sample to temperatures both below and above the Curie point followed by cooling to the initial temperatures. For temperatures below the Curie point the process was repeated four times. The tests were made with the materials listed in Table 1. Sample 4 was highly work hardened. These compositions were chosen because they had a fairly wide hysteresis loop and comparatively low Curie points. No special heat treatment was applied because this would narrow the hysteresis loops and reduce the differences between materials. Measurements were made in a vertical astatic magnetometer. Kondorskiy's indication that the method of demagnetisation could affect the shape of the magnetisation curves was found to be true in practice. Accordingly, before every measurement the samples were demagnetised by heating to the Curie point followed by cooling in the absence of a magnetic field. Fig.2 shows graphs of the relation between the magnetisation and field for the nickel specimen No.1. The initial curve No.1 lies below all the others and only at high fields does it intersect curve 2, which was produced by ultrasonic mechanical treatment; curve 2' was obtained by mechanical treatment whilst reducing the magnetic field. The hysteresis-less curve could not be obtained by ultrasonic treatment because when the treatment was made more intensive the specimen failed. Curve 3 was obtained by temperature cycling, heating from 20 to 250 °C and recooling to 20 °C. Curve 4 was obtained by applying to the specimen an alternating field diminishing to zero. Very similar curves were obtained for samples Nos. 2 and 3. It was confirmed on sample No.4 that hysteresisless curves obtained in different ways approach one another and coincide if uniform mechanical stresses, within the elastic limit, are applied to the sample during the measurements. Within the elastic limit, compression of the specimen extends the hysteresis loop and it is possible that under these conditions the hysteresisless curves might differ. However, this would be difficult to check because of bending of the sample. The investigations showed that mechanical treatments (impact and ultrasonic oscillation) generally do not give hysteresis-less curves. Evidently, such treatment may not be sufficient to overcome the potential energy barrier and to establish parallel

Ideal magnetisation curves of ... S/139/61/000/005/009/014
E194/E135

magnetisation in neighbouring domains. Temperature variations with simultaneous application of a direct magnetic field can give hysteresisless magnetisation curves however, usually these do not coincide with one another. When uniform mechanical stress is applied, the hysteresis curves obtained by different methods coincide in the limit.

There are 5 figures, 1 table and 22 references: 12 Soviet-bloc, 1 Russian translation from non-Soviet publication, and 9 non-Soviet-bloc. The English language references read as follows:

Ref.2: J. Ewing, Trans. Roy. Soc., Vol.1, 565, 1885.

Ref.9: J.R. Ashworth, Ferromagnetism, London, 1938.

ASSOCIATION: Institut fiziki SO AN SSSR
(Institute of Physics, SO AS USSR)
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(Krasnoyarsk Pedagogical Institute)

SUBMITTED: August 1, 1960

Card 4/4

24.2200 (1137, 1158, 1147) 21358
18.7530 1145, also 1164, 1160 S/126/61/011/004/005/023
E073/E535

AUTHORS: Kirenskiy, L. V., Buravikhin V. A. and Savchenko, M.K.

TITLE: Motion Picture Study of the Processes of Changes in the Magnetic Structure of Thin Ferromagnetic Film in a Magnetic Field

PERIODICAL: Fizika metallov i metallovedeniye, 1961, Vol.11, No.4, pp.529-532 + 2 plates

TEXT: Changes in the domain structure of thin films of two alloys (50% Fe, 50% Ni and 17% Fe, 80% Ni, 3% Mo) were studied by means of motion picture photograpny, using the powder pattern method. The films were produced on a polished glass base 1 x 10 x 40 mm heated to 350°C by thermal deposition in a vacuum of 7×10^{-6} mm Hg applying an external magnetic field of 100 Oe. In every case the alloy evaporated from the crucible in 30 sec, which was taken as an indication that the composition of the ferromagnetic films differed only very slightly from the initial composition of the alloy. The film thickness varied between 760 and 2470 Å. Study of the photographs indicates that the features of magnetization of thin ferromagnetic films can be summarized as follows:

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Motion Picture Study of the ... S/126/61/011/004/005/023
E073/E535

1. The domain structure of all ferromagnetic film remains stable until the magnetic field reaches some critical value;
2. In relatively thick films, magnetization occurs with intermittent displacement of domain boundaries when the magnetic field reaches a critical value;
3. No boundary displacement was observed in thinner films; their magnetization takes place by destroying domain boundaries and, in some cases, there was a change in their structure or appearance of new boundaries, which sub-divided the unsuitably oriented domains into individual sub-domains. There is also a change in the structure of the main boundaries. There are 4 figures and 8 references: 2 Soviet and 6 non-Soviet.

ASSOCIATIONS: Institut fiziki SO AN SSSR
(Institute of Physics SO AS USSR);
Krasnoyarskiy pedagogicheskiy institut
(Krasnoyarsk Pedagogic Institute)

SUBMITTED: September 10, 1960

Card 2/2

24.2200

25788
S/048/61/025/005/002/024
B104/B201

AUTHORS: Kirenskiy, L. V. and Buravikhin, V. A.

TITLE: Effect of mode of production and thickness of thin ferromagnetic Fe-Ni films upon their domain structure

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya, v. 25, no. 5, 1961, 569-573

TEXT: The present investigation was the subject of a lecture delivered at a symposium on thin ferromagnetic films (Krasnoyarsk, July 4 to 7, 1960). The authors studied the effect of production conditions, thickness, and annealing of films alloyed with 80% Ni, 17% Fe, and 3% Mo upon their domain structure. The alloy was sputtered from a tungsten crucible in vacuum ($7\cdot10^{-6}$ mm Hg) onto polished glass plates ($1\cdot10\cdot40$ mm) in the presence of a magnetic field produced by a pair of Helmholtz coils and the direction of which coincided with the film plane. Films were prepared under the following conditions: (1) the base was heated to 350°C, the magnetic field strengths amounted to 125, 100, 75, 50, 25, and 4 oersteds; (2) at a field strength of 100 oersteds the bases were heated

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Effect of mode of production ...

to 420, 350, 150, and 50°C; (3) films of thicknesses ranging between 6150 and 140 Å were prepared at a base temperature of 350°C and at 100 oersteds. The film thicknesses were optically determined, while the magnetic powder method and a microscope served for determining the domain structure. The direction of magnetization in the films coincided with the direction of the magnetic field during production. The part played by the angle between a demagnetizing field and the direction of easiest magnetizing of the film was studied. The number of boundaries was found to increase on an enlargement of this angle, while their direction was conserved. This direction coincides with the direction of the magnetic field applied in the process. At 125 oersteds the boundaries are almost straight and parallel, whereas they become increasingly curved with dropping field strength. Films produced on a backing kept at a temperature below 100°C, were brittle and oxidized quickly. In addition, films with thicknesses between 6150 and 1340 Å were found to have domains with very straight boundaries, coinciding with the magnetic field direction. Films with thicknesses between 1200 and 800 Å had somewhat curved boundaries. These curvatures rose on a decrease of the film thickness.

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They are explained by the heavy magnetization at exiguous thicknesses, in connection with the weakly marked uniaxial anisotropy, the low saturation, and the strong inhomogeneity of the film at the edges. Films 530, 880, and 1200 Å thick prepared at 100 oersteds on unheated backings, were annealed for some hours at 450°C in vacuum ($2\cdot10^{-5}$ mm Hg) in a magnetic field of 500 oersteds. The direction of this field was in the film plane and it was oriented under various angles to the direction of easiest magnetizing. The latter direction was proved to shift to the direction of the magnetic field applied in the annealing process. There are 3 figures and 9 references: 1 Soviet-bloc and 8 non-Soviet-bloc.

ASSOCIATION: Institut fiziki Sibirskogo otdeleniya Akademii nauk SSSR (Institute of Physics of the Siberian Department, Academy of Sciences USSR), Krasnoyarskiy gos. pedagogicheskiy institut (Krasnoyarsk State Pedagogic Institute)

24.2200

25789
S/048/61/025/005/003/024
B104/B201

AUTHORS: Kirenskiy, L. V. and Buravikhin, V. A.

TITLE: Domain boundaries of thin ferromagnetic films

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya, v. 25, no. 5, 1961, 574-576

TEXT: The present investigation was the subject of a lecture delivered at a symposium on thin ferromagnetic films (Krasnoyarsk, July 4 to 7, 1960). The authors conducted an experimental study on the polarity of boundaries of thin ferromagnetic films differing as to composition and thickness. Thin films of ferromagnetic iron, cobalt, and 80% Ni, 17% Fe, 3% Mo alloy were utilized for the purpose. The films were prepared by sputtering in vacuum ($2\cdot10^{-5}$ mm Hg) onto a glass backing heated to 350°C. The uniaxial anisotropy was brought about by a magnetic field (100 oersteds) during the sputtering process. The boundaries were determined with the aid of magnetic powder suspensions in a microscope. As is shown by micropictures, the domain structure consists, if no magnetic field is applied during the microscopic examination, of almost plane-parallel

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B104/B201

domains with distinct thin edges. If a magnetic field (220 oersteds) is applied in perpendicular to a film surface, more magnetic powder particles gather on a boundary of a domain. If the magnetic field direction is changed by 180°, more particles gather at the boundary at which there were less particles before, and vice versa. This is convincing evidence of the alternating polarity of the Bloch walls in thin ferromagnetic films. This observation is generally not made on massive ferromagnetic crystallites. This change in polarity is observed not only on straight, right-angled boundaries, but on zigzag boundaries as well. In case of cobalt films and films of the abovementioned alloy, Néel boundaries were established on films less than 500 Å thick and on iron films less than 250 Å thick. The particles are uniformly concentrated on these boundaries. The double boundaries appearing when applying a magnetic field oriented in perpendicular to the film are demonstrated on pictures of a 560 Å film of the alloy. If the magnetic field is absent, the boundaries will be thick lines. When applying a magnetic field (±10 oersteds) parallel to the film plane, a change is observed in the occupation of the double lines by powder particles. To summarize: (1) double boundaries in thin ferromagnetic films are Bloch walls with opposite polarity; (2) Bloch walls of

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Domain boundaries of thin ...

thin ferromagnetic films have an alternating polarity; (3) Néel boundaries appear on a reduction of the film thickness, beginning from a determined thickness which depends on the film composition. These boundaries have no sign-changing polarity. There are 4 figures and 11 references: 1 Soviet-bloc and 10 non-Soviet-bloc. The most important references to English-language publications read as follows: Néel L., Comp. Rend., 241, 533 (1955); Williams H., et al., J. Appl. Phys., 28, 548 (1957); Huber E., et al., J. Appl. Phys., 29, 294, (1958); Kaczer J., J. Appl. Phys., 29, 569 (1958).

ASSOCIATION: Institut fiziki Sibirskogo otdeleniya Akademii nauk SSSR (Institute of Physics of the Siberian Department, Academy of Sciences USSR), Krasnoyarskiy gos. pedagogicheskiy institut (Krasnoyarsk State Pedagogic Institute)

Card 3/3

24,2200

25790
S/048/61/025/005/004/024
B104/B201

AUTHORS: Kirenskiy, L. V., Buravikhin, V. A., and Zvegintsev, A.G.

TITLE: Domain structure and coercive force of thin ferromagnetic films

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya, v. 25, no. 5, 1961, 577-580

TEXT: The present investigation was the subject of a lecture delivered at a symposium on thin ferromagnetic films (Krasnoyarsk, July 4 to 7, 1960). The authors studied the dynamics of the domain structures of ferromagnetic films in a magnetic field and examined the effect of the film thickness upon the dynamics. A relationship was established between the coercive force and the character of this dynamics. The experiments were conducted with iron and cobalt films, and with films of a nickel alloy (80% Ni, 17% Fe, and 3% Mo). The films were prepared by sputtering in vacuum ($8\cdot10^{-6}$ mm Hg) onto polished glass. Sputtering took place in a magnetic field (100 oersteds) produced by a pair of Helmholtz coils. The

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B104/B20?

direction of the magnetic field was in the film plane. An axis of easiest magnetizing was formed as a result. During production of the films on which the domain structure and the coercive force were studied as functions of thickness, the glass backings were heated to a temperature of 300°C. Other films were sputtered at room temperature. The domains were found to increase with a diminution of the film thickness, and the boundary curvatures to become more pronounced. The structure of the domains is not modified up to a certain critical field strength which is dependent upon the film thickness. In a field above the critical field strength, a magnetization at thicknesses of 800 Å and over causes a displacement of boundaries. New boundaries, being almost perpendicular to the main boundaries, appear in films ranging from 500 to 800 Å on an increase of the field strength beyond the critical one in domains oriented unfavorably with respect to the field direction. This is explained by a formation of "subdomains". No boundary displacements were established in films having thicknesses from 500 to 150 Å. "Subdomains" under equal conditions as above could be observed. Figs. 4 and 5 graphically present the coercive forces of the three film types as functions of their thickness. In Fig. 6, the coercive force for the three film types is shown as a

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Domain structure and coercive ...

function of the temperature of a vacuum annealing (1 hr) in a magnetic field of 500 oersteds. As results from a discussion of the diagrams, the coercive force attains a maximum if only one domain extends over the film thickness. The diminution of the coercive force with a rise of the annealing temperature is explained by the elimination of internal film stresses which are particularly strong in films produced on unheated glass backings. If the direction of the magnetic field in the annealing process does not coincide with that of easiest magnetizing, the latter disappears, and a new direction of easiest magnetizing arises, which coincides with the direction of the magnetic field in the annealing process. There are 6 figures and 10 references 1 Soviet-bloc and 9 non-Soviet-bloc.

ASSOCIATION: Institut fiziki Sibirskogo otdeleniya Akademii nauk SSSR (Institute of Physics of the Siberian Department, Academy of Sciences USSR), Krasnoyarskiy gos. pedagogicheskiy institut (Krasnoyarsk State Pedagogic Institute)

Card 3/5

24,3600

25792
S/048/61/025/005/006/024
B104/B2??

AUTHORS: Kirenskiy, L. V., Kan, S. V., and Degtyarev, I. F.

TITLE: Study of the magnetic structure of thin ferromagnetic films with the aid of the magnetooptical Kerr effect

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya, v. 25, no. 5, 1961, 584-591

TEXT: The present investigation was the subject of a lecture delivered at a symposium on thin ferromagnetic films (Krasnoyarsk, July 4 to 7, 1960). The development of magnetooptical methods for the observation of domain structures is fairly recent (H.J. Williams et al., Phys. Rev., 82, 119 (1951); C. Fowler et al., Phys. Rev., 94, 52 (1954)). M. Prutton (Philos. Mag., 4, 45, 1063 (1959)) has indicated a method and an apparatus for the visual observation of ferromagnetic films. No usable results obtained by this method have been, however, published heretofore. The deficiencies of the magnetic powder methods used for most of the studies in this field are enumerated, and next, the studies conducted by the present authors on the magnetic structure of thin ferromagnetic films.

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B104/B[illegible]

Study of the magnetic structure...

using the magnetooptical longitudinal Kerr effect, are described. Nickel alloy films (80% Ni, 17% Fe, 3% Mo) were sputtered in vacuum (10^{-5} mm Hg) onto polished glass backings. The uniaxial magnetic anisotropy while producing the films was brought about by a [illegible]-oe field oriented in the film plane. The glass backings had temperatures up to [illegible]. For the visual observation and for photographing the domain, a thin dielectric zinc sulfide layer was sputtered at $10^{-[illegible]}$ mm Hg, and a [illegible]-oe magnetic field, being oriented in the same way as the one in the production of the ferromagnetic film, was applied. This layer increased the angle of rotation of the reflected plane-polarized light, whereby the contrast between the domains was augmented. The experimental setup is presented in Fig. 1. The properties of various films studied with this setup were found to differ. The directions of easiest and heavy magnetizing were determined from the domain structure of the specimens, which appeared after the films were demagnetized. When applying a field being perpendicular to the field used in the production of the film, the contrast between the domains dropped with a rise of the field strength, without the domain configuration changing noticeably, or the favorably oriented domains appeared. The authors discuss the effect of demagnetization conditions upon the domain

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B104/B201

structure, and the modification of the domain structure of films during the magnetizing process. To summarize: (1) A very fine domain structure appears on an increase of the angle between the direction of the demagnetizing process and the axis of easiest magnetizing of the films; (2) a structure consisting of coarse domains, differing and undefined in shape, was established in case of a fast demagnetization. A fine domain structure appeared on a slow demagnetization. A study of magnetization indicated that (1) domains grow abruptly on thin (500 - 600 Å) and non-uniform films; (2) on an increase of the film thickness and of the angle between the magnetic field and the direction of easiest magnetizing the domain boundaries are shifted uniformly in case of uniform films. In case of a magnetization in the direction of difficult magnetizing the configuration of the domains does not change, but the contrasts between the domains become weaker and disappear once saturation is attained. The contrast between the domains is restored in part when the field is disconnected; (3) if a field with the direction at 45° is applied, a brightening of dark fields (or a darkening of bright fields) will be observed. There are 7 figures and 7 references: 2 Soviet-bloc and 5 non-Soviet-bloc.

25792
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B104/B201

Study of the magnetic structure ...

ASSOCIATION: Institut fiziki Sibirskogo otdeleniya Akademii nauk SSSR (Institute of Physics of the Siberian Department, Academy of Sciences USSR), Krasnoyarskiy gos. pedagogicheskiy institut (Krasnoyarsk State Pedagogical Institute)

Fig. 1

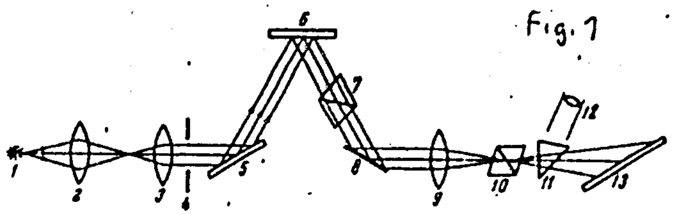

Fig. 1: Scheme of optical arrangement. Legend: 1, light source; 2, condenser; 3, collimator; 4, diaphragm; 5 and 6, mirror; 7, polarizer; 8, specimen; 9, objective; 10, analyzer; 11, prism; 12, observation tube; 13, photographic film.

Card 4/4

24,2200

AUTHORS: Kirenskiy, L. V. and [illegible]

TITLE: Study of the domain structure [illegible] ferromagnetic films with slow magnetic [illegible]

PERIODICAL: Akademiya nauk SSSR [illegible] fizicheskaya, v. 25, no. 5, 1961, [illegible]

TEXT: The present investigation was [illegible] lecture delivered at a symposium on thin ferromagnetic films [illegible] July 4 to 7, 1960). The authors studied the magnetic structure of ferromagnetic films with the aid of the longitudinal Kerr effect in [illegible] a slow magnetic reversal. The possible difference between slow and fast magnetic reversal is pointed out. The production of specimens and investigation methods are described in the present issue (Kirenskiy et al., Izv. Akad. nauk., ser. fiz., v. 25, no. 5, p. 584). The film properties differed very markedly in part because of the effect of factors, not controlled during the preparation of the films, upon the said properties. The quality of the films cannot yet, in the authors' opinion, be fully controlled today

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during production. In addition, the films undergo magnetic reversal depending upon their initial state. Thus, a domain structure was not observed to appear on homogeneous films saturated in very strong fields (up to 500 oersteds), and the magnetic reversal occurred by rotation of the magnetization vector. Magnetic reversal in inhomogeneous fields always began with the formation of nuclei with reverse magnetization. Bright wedge patterns growing jump-like arise at the upper end of a film (580 Å) with the gradual growth of a magnetic field oriented in the direction of easiest magnetizing. These changes are ascribed to inhomogeneities of the film. This state of saturation is conserved when switching off the field, which is convincing evidence of the magnetic reversal depending markedly upon the degree of homogeneity of the film. An entirely different character of transformation is observed in films of thicknesses around 800 Å. If the magnetic field is oriented in the direction of easiest magnetizing, the film as a whole will undergo an abrupt magnetic reversal at a given field strength. The authors had to overcome great difficulties to obtain nuclei with reverse magnetizations. The films had to be well demagnetized for this purpose. If the films were magnetized in very strong fields, a rotation of the magnetization vector

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Study of the domain structure of [illegible]

was observed with a magnetic reversal at an angle of [illegible]-40 [illegible]. This character of magnetic reversal was [illegible] up to about 800 A thick, the domain [illegible] magnetic reversal, oriented in the direction [illegible] films about 1100 A thick both form and contrast [illegible] domains changed with growing angle of magnetic reversal. [illegible] demagnetization by an alternating field oriented along the [illegible], a structure consisting of straight [illegible]. The magnetic reversal along the direction of [illegible] at the opposite [illegible] of the film [illegible] magnetization appears [illegible] domain [illegible] of boundaries [illegible] a magnetic reversal [illegible] small jumps, without a uniform displacement of [illegible] visible; (2) homogeneous films 800 A thick [illegible] magnetizing behave as a single-domain specimen. However, [illegible] with enlarging angle between the magnetization [illegible] easiest magnetization takes place by way of [illegible] magnetic reversal nuclei and a displacement of the domain boundaries [illegible]

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[illegible] 4

Study of the domain structure of ... B[illegible] 4/[illegible]

films, excepting those [illegible] Å thick, a slow displacement of boundaries in a constant magnetic field was established; 4) with growing film thickness and enlargement of the angle between the field direction and the direction of easiest magnetizing, an ever more uniform displacement of the boundaries is observed. In addition, the reproducibility of patterns is also found to improve with repeated magnetic [illegible]. There are [illegible] figures and [illegible] references: [illegible] Soviet-bloc and 4 non-Soviet-bloc. The most important reference to English language publications reads as follows: [illegible] Mitchell E.N., J. Appl. Phys. 2[illegible], 4 [illegible] [illegible]

ASSOCIATION. Inst[illegible] fiziki [illegible] AN SSSR (Institute of Physics of the [illegible] Academy of [illegible] SSSR)

Card 4/4

24.2200

25794
S/048/61/025/005/008/024
B104/B201

AUTHORS: Kirenskiy, L. V., Buravikhin, V. A., and Savchenko, M. K.

TITLE: Modification of the domain structure of ferromagnetic films in a magnetic field

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya. v. 25, no. 5, 1961, 596-598

TEXT: The present investigation was the subject of a lecture delivered at a symposium on thin ferromagnetic films (Krasnoyarsk, July 4 to 7, 1960). The authors studied the behavior of the domain structures of thin films obtained from two alloys (80% Ni, 17% Fe, 3% Mo; and 50% Fe, 50% Ni) in a magnetic field during magnetization and magnetic reversal along the direction of easiest magnetizing. The domain structure was observed by the magnetic powder method. The modifications of the domain structure with magnetic reversal were recorded by a motion-picture camera (12 pictures per second). These pictures show that the domain structure of well demagnetized 2470 Å specimens of the Fe-Ni alloy is not modified up to a magnetization field strength of 9.3 oersteds. In case of massive

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Modification of the domain ...

specimens the displacement of the domain boundaries begins already at very low field strengths. A further rise of the field strength is accompanied by a displacement of boundaries at a varying rate. A saturation is attained at 17.6 oersteds. Similar results were obtained on a specimen of the same alloy having a thickness of 760 Å. In experiments on the magnetic reversal of Fe-Ni films, the latter were first magnetized up to saturation. When applying the reverse field no domain structure was observed up to - 3.4 oersteds. At -3.5 oersteds wedge-shaped boundaries appeared, which separated the domains of reverse magnetization. Up to -6.5 oersteds no modification of this domain structure was observed. The wedges grew in a field of 7 oersteds, and their magnetization coincided with the field. The domain structure disappeared at -15 oersteds Films of Fe-Ni-Mo alloy, 1200 Å thick, were examined in a magnetic field which was oriented at angles of 0, 45, and 90° to the direction of easiest magnetizing. In the first case they presented no modification of the domain structure up to 10.5 oersteds, in the second case up to 12.6 oersteds, and in the third case up to 15 oersteds. In case of a slight increase of the magnetic field strength, a slight displacement of the boundaries was observed in the first and in the second case; on a

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Modification of the domain ...

further stronger rise of the magnetic field strength a fast magnetic reversal was observed in parts of the domain structure, the magnetization of which was oriented in opposite direction to the field. In the third case, a displacement of boundaries was hardly observable. The magnetic reversal took place by rotational processes. Saturation was attained at 11.6, 15, and 15.8 oersteds. To summarize: (1) all ferromagnetic films display a domain structure that is stable within certain values of the magnetic field strength; (2) in relatively thick films the magnetic reversal takes place by a displacement of boundaries, which begins after a critical field strength value; (3) with a decrease of the film thickness magnetization occurs in a determined field strength range by boundary displacement and rotational processes. In very thin films magnetization occurs by very fast magnetic reversal of unfavorably oriented domains. There are 4 figures and 7 references: 1 Soviet-bloc and 6 non-Soviet-bloc.

ASSOCIATION: Institut fiziki Sibirskogo otdeleniya Akademii nauk SSSR (Institute of Physics of the Siberian Department, Academy of Sciences USSR), Krasnoyarskiy gos. pedagogicheskiy institut (Krasnoyarsk State Pedagogic Institute)

Card 3/3

24,7900

25805
S/048/61/025/005/019/024
B117/B201

AUTHORS: Kirenskiy, L. V., Ignatchenko, V. A., and Baklanov, O. G.

TITLE: Ferromagnetic resonance in thin films

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya, v. 25, no. 5, 1961, 640-642

TEXT: The present investigation was the subject of a lecture delivered at a symposium on thin ferromagnetic films (Krasnoyarsk, July 4 to 7, 1960). The phenomenon of ferromagnetic resonance was used for measuring the saturation magnetization and the anisotropy constant of thin ferromagnetic films. A block diagram of the system used for the purpose is shown in Fig. 1. The superhigh frequency vibrations generated by a 43И (43I) standard generator are modulated by the rectangular pulses from generator Г. The chain consisting of a tee junction H_0, a detector D_0, an amplifier, and an oscilloscope serves for supervising the generator operation. The main part of the superhigh frequency power incides upon aperture S which connects the resonant chamber to the waveguide circuit. A cylindrical

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Ferromagnetic resonance in thin films

chamber with TE_{11} mode is utilized. The disk-shaped specimens are placed at the rear chamber wall The reflected wave reaching the detector D_2 via junction H_2 is measured. To augment the sensitivity of the system, the ground level of the signal from the detector D_2 is compensated by the opposite phase of the signal from detector D_1. The difference of these signals is transmitted to the amplifier, and, subsequently, to the detector which had been synchronized by the pulses coming from the generator Γ. The amplified and rectified signal is recorded by galvanometer A. Oscilloscope O_2 controls the work of the phase detector and of the compensator. The resonant chamber is placed into a constant magnetic field which is oriented in parallel to the film plane and in perpendicular to the magnetic component of the superhigh frequency field The electromagnet is fed by a stabilized УИП-1 (UIP-1) source. The thin films were prepared by cathode sputtering in vacuum ($\sim 10^{-5}$ mm Hg) Disk-shaped cover glasses 18 mm in diameter served as backings. The backing temperature during sputtering was about 300°C To create an artificial anisotropy a constant field of ~100 oe is applied in the film plane during sputtering. Several permalloy films (80 % Ni, 17 % Fe, 3 % Mo) and a cobalt film were

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Ferromagnetic resonance in thin films

examined. The permalloy composition was not controlled after sputtering. The film thickness was determined with the aid of a УМ-2 (UM-2) monochromator by the method described by I. N. Shklyareyskiy (Ref. 4: Optika i spektroskopiya, 5, № 5, 617 (1958)). Sputtering took place at high temperatures. Since the coefficients of thermal expansion of metal and backing during cooling are unequal, radially symmetrical elastic stresses arise in the film. The active demagnetizing fields corresponding to them were calculated by J. R. MacDonald (Ref. 5: Proc. Phys. Soc., 64, 968 (1951)) and J. H. E. Griffiths (Ref. 1: Physica, 17, 253 (1951)). General formulas for the effective fields of crystallographic anisotropy were obtained by MacDonald (Ref. 5) for single crystals, in particular for hexagonal ones:

$$H_1^{\text{ан}} = \frac{2}{I_s}[(K_1' + 2K_2')(\gamma_{31}^2 - \gamma_{21}^2) + 2K_2'(3\gamma_{11}^2 - \gamma_{31}^2)\gamma_{31}^2], \quad (4)$$

$$H_2^{\text{ан}} = \frac{2}{I_s}[(K_1' + 2K_2')(\gamma_{31}^2 - \gamma_{11}^2) + 2K_2'(3\gamma_{11}^2 - \gamma_{31}^2)\gamma_{31}^2].$$

Formally, the anisotropy of thin films of non-crystallographic origin can be expressed by formulas of this type (4), where K_1' and K'_2 are the

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effective anisotropy constants. The results obtained from the measurement of the saturation magnetization of a thin permalloy film have shown a qualitative agreement of the saturation magnetization as a function of thickness with data given in Ref. 3 (Tannenwald P. E., Seavey M. N., J. phys. et radium, 20, 323 (1959)) for an 80 % Ni, 20 % Fe film. The sharp magnetization drop was, however, observed with thicknesses larger than those of Ref. 3 by one order of magnitude. Possibly, this is to be explained by the varying chemical composition. Even more likely, however, an insufficient homogeneity of the films employed is responsible for this phenomenon. No anisotropy was established on permalloy films, i.e., it cannot exceed 10^3 erg cm^{-3}. On the cobalt film (d = 3200 Å) the resonant field was found to be distinctly dependent upon the rotational angle of the film. The anisotropy constant K_1' can be easily calculated from formula (4) if assuming $K_2' = 0$. In this case, $H^a = (2K_1'/I_s) = 175$ oe. When assuming that $J_s = 1.42 \cdot 10^3$, it follows that $K_1' = 1.24 \cdot 10^5$ erg cm^{-3}.

T. A. Stepanova is thanked for her assistance. There are 3 figures and 5 references: 1 Soviet-bloc and 4 non-Soviet-bloc.

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Ferromagnetic resonance in thin films

ASSOCIATION: Institut fiziki Sibirskogo otdeleniya Akademii nauk SSSR (Institute of Physics of the Siberian Department, Academy of Sciences USSR)

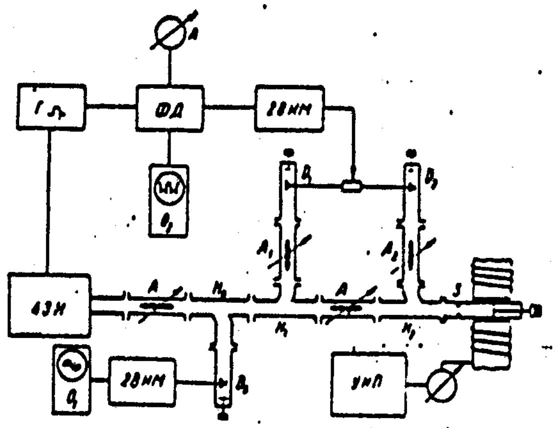

Fig.1

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B116/B138

AUTHORS: Spivak, G. V., Kirenskiy, L. V., Ivanov, R. D., and Sedov, N. N.

TITLE: Development of mirror-type electron microscopy of magnetic microfields

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya, v. 25, no. 12, 1961, 1465 - 1469

TEXT: The authors present electron-optical photomicrographs of domain structures of various ferromagnetic materials and compare them with powder patterns. The distribution of the local magnetic fields scattered by the specimen is obtained from the contrast. G. V. Spivak, I. N. Prilezhayeva, and V. K. Azovtsev (Dokl. AN SSSR, 105, 965 (1955)) were the first to recommend the electron mirror for photographing magnetic microfields. They carried out their experiments at the laboratoriya elektronnoy optiki MGU (Electron Optics Laboratory of MGU). The electron mirror has the following advantages over the methods of secondary electron emission or photoeffect: high field sensitivity (the illuminating electron beam is stopped by an

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electric field in front of the specimen, i. e. "probing" of the spatial field structure; high contrast, due to the forwards and backwards motion of the electron; and the possibility of examining the magnetic structure at different distances from the source of the microfield. The optical system can be traversed by both slow and fast electrons. A 50-kv voltage focuses the reflected electrons and enhances the resolving power of the instrument. Domain structure electron-mirror pictures of a $PbO(Fe_2O_3)_6$ crystal magnification: 400, 800, and 1500), cobalt (400 and 800), and a cobalt film (~1000 Å, 400 times), were in good agreement with ones produced by the powder method (400). The local magnetic fields were determined from the contrast. Calculations have shown that the contrast depends on the product Hz (z = extent of the H-field). The magnetic field decreases almost exponentially. Results are shown in Fig. 6. Finally it is noted that magnetic fields can be examined under an electron mirror microscope and that their their strength can be measured at different distances from the specimen. The magnification here achieved (about 2000) can be further increased. There are 6 figures and 7 Soviet references.

Development of mirror-type...

ASSOCIATION: Fizicheskiy fakul'tet Moskovskogo gos. universiteta im. M. V. Lomonosova (Division of Physics of Moscow State University imeni M. V. Lomonosov), Institut fiziki Sibirskogo otdeleniya Akademii nauk SSSR (Institute of Physics of the Siberian Department of the Academy of Sciences USSR)

Fig. 6. (a) Field above the artificial specimen, measured with a bismuth micrometer at different magnetic biasing currents $H = H_0 e^{-z/z_0}$; (b) mirror calibration curve; (c) scattering field above the hexagonal plane of the $PbO(Fe_2O_3)_6$ crystal, $z_0 = 0.02$ mm; (d) scattering field above the hexagonal axis which is nearly parallel to the cobalt face, $z_0 = 0.05$ mm. Legend: z_0 is a constant, B_1 and B_2 are the various degrees of brightness on the screen.

31604
S/048/61/025/012/009/022
B116/B138

24.2200

AUTHORS: Kirenskiy, L. V., Drokin, A. I., Dylgerov, V. D., Sudakov, N. I., and Zagirova, Ye. K.

TITLE: Temperature dependence of the first anisotropy constant and magnetic structure of iron-manganese ferrites

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya, v. 25, no. 12, 1961, 1472 - 1476

TEXT: The temperature dependence of the first magnetic anisotropy constant K_1 of an iron-manganese ferrite single crystal was studied in the (100) plane, and its domain structure in the (110) plane. Balls 4 - 8 mm diam were made from specimens grown in a Verneuil's apparatus from $MnFe_2O_4$ with manganese excess (25% Mn_3O_4) by A. A. Popova at the Institut kristallografii AN SSSR (Institute of Crystallography AS USSR). To find K_1 and $K_1(T)$ the torques acting on the specimen in a uniform magnetic field were measured on an Akulov anisometer with a slightly modified strain gauge (error in measurement, ≤ 2%). Torque curves were first recorded in

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different fields at room and oxygen temperatures, as a function of the angle between the direction of field and the [100] axis. Then the continuous variation in maximum torque in the (100) plane was examined in the temperature range -183 - +300° - -183°. A field strength of 5100 produced saturation. Powder patterns were produced by W. S. Elmore's method (Ref.11, see below). The graphs show that at 22°K torque is nearly zero in fields of up to 750 oe. Between 750 and 1000 oe it increases, reaching $0.71 \cdot 10^{-4}$ $erg \cdot cm^{-3}$, after which it remains constant. In fields of up to 3000 oe there was a sharp increase at the temperature of boiling oxygen. The linearity of $K_1 = f(T^2)$ means that the Bryukhatov-Kirenskiy law holds for this type of crystal also. Extrapolation to absolute zero yielded $K_0 = 17 \cdot 10^4$ $erg \cdot cm^{-3}$. The nature of a domain structure is found to be dependant on the direction of demagnetization. With demagnetization in the [110] direction, the powder patterns in the (110) plane form thick, parallel lines perpendicular to one of the axes of easy magnetization. A secondary, wedge-shaped structure between the principal lines, indicates that the surface deviates slightly from the (110) plane. Domain structure remains constant under magnetization in the [110] direction up to 400 oe; up to 600 oe only the secondary structure is changed. Between 750 and

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B116/B138

Temperature dependence of the first....

(1959); Ref. 5: Smith, A. W., Williams, G. W., Canad. J. Phys., 38, 9, 1187 (1960).

ASSOCIATION: Institut fiziki Sibirskogo otdeleniya Akademii nauk SSSR (Institute of Physics of the Siberian Department of the Academy of Sciences USSR), Institut tsvetnykh metallov im. M. I. Kalinina (Institute of Nonferrous Metals imeni M. I. Kalinin), Krasnoyarskiy pedagogicheskiy institut (Krasnoyarsk Pedagogical Institute)

Card 4/4

S/048/61/025/012/014/022
B117/B104

AUTHORS: Kirenskiy, L. V., and Afoshin, V. S.

TITLE: Rotational hysteresis of magnetostriction in ferromagnetics

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya, v. 25, no. 12, 1961, 1492 - 1494

TEXT: Rolled polycrystalline nickel with a reduction from 3.3 to 1 mm was used to study the rotational hysteresis of magnetostriction (RHM). The disc-shaped specimen had 18 mm in diameter and was annealed in vacuum at 1100°C. Rotating the field through 360° with respect to the initial angle, RHM was determined in the clockwise and counterclockwise directions after magnetostriction had changed. RHM was measured as a function of H at fixed values of the angle φ and as a function of φ at fixed values of the field H. First of all, the quantities had to be determined which permit a quantitative determination of RHM: (1) The difference $\Delta\lambda$ between the final and initial values of magnetostriction after the cycle has been completed. (2) the mean value of RHM (with respect to the area) or its

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relative magnitude $(\Delta\lambda)_{mean}/\lambda_0$ can be determined by the relation

$$(\Delta\lambda)_{mean} = 1/2\pi \int_0^{2\pi} |\Delta\lambda| d\varphi$$

Here, λ_0 is the maximum value of magnetostriction in the direction $\varphi = 0$ which conforms with the rolling direction. In qualitative respect, the curves of the function $\Delta\lambda$ (H) at φ = const and $(\Delta\lambda)_{mean}/\lambda_0 = f(H)$ have been found to agree with the shape of the corresponding curves of the temperature-dependent magnetic hysteresis. Comparing the curves of technical magnetization with the type of the change of $\Delta\lambda(H)$ reveals a characteristic particularity: In fields whose magnetization is due to a reversible boundary displacement, both, the magnitudes of $\Delta\lambda$ or $(\Delta\lambda)_{mean}$ and of the hysteresis of any other property are small. An increase in the field causes the irreversible displacements to grow and also an increase in the amount of RHM, which thus reaches a certain maximum value. This is in conformity with present-day notions on the magnetization mechanism in ferromagnetics. In strong fields the displacements become less

89728

S/020/61/136/003/011/027
B019/B056

24,2200 (1137,1147,1158)

AUTHORS: Kirenskiy, L. V., and Buravikhin, V. A.

TITLE: Polarization of Domain Boundaries in Thin Ferromagnetic Films

PERIODICAL: Doklady Akademii nauk SSSR, 1961, Vol. 136, No. 3, pp. 575-576

TEXT: The polarization of domain boundaries in thin ferromagnetic films, which had been produced by thermal deposition of an alloy with 17% Fe, 80% Ni, and 3% Mo in a vacuum of $2\cdot10^{-5}$ mm Hg on a glass substrate and heated to 350°C, is here investigated. During production, the films were in a magnetic field of 100 oersteds. The domain boundaries were examined under a microscope by observing the powder patterns. In this connection, it was found that in thin ferromagnetic films, double boundaries are Bloch boundaries of opposite polarity. This is in agreement with the theoretical results obtained by Kaszer (Ref. 5). Bloch boundaries in thin ferromagnetic films have alternate polarity, which is probably in

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89728

Polarization of Domain Boundaries in Thin Ferromagnetic Films

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B019/B056

connection with the pre-history of the film. Néel boundaries have no sharply defined polarity but become more distinct only with the superposition of a sufficiently strong magnetic field perpendicular to the plane of the film. It was possible to show in this paper that applying a magnetic field perpendicular to the plane of the film makes it possible to draw some conclusions as to the nature of boundary layers in films. There are 3 figures and 11 references: 1 Soviet, 2 German, 1 Japanese, and 6 US.

ASSOCIATION: Institut fiziki Sibirskogo Otdeleniya Akademii nauk SSSR (Institute of Physics of the Siberian Branch of the Academy of Sciences USSR)

PRESENTED: August 9, 1960, by A. V. Shubnikov, Academician

SUBMITTED: August 8, 1960

Card 2/2

34181
S/048/62/026/002/030/032
B117/B138

24,2200 (1147,1164,1482)

AUTHORS: Kirenskiy, L. V., Kan, S. V., and Savchenko, M. K.

TITLE: Behavior of the domain structure of thin ferromagnetic films at different temperatures

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya, v. 26, no. 2, 1962, 310 - 314

TEXT: This paper was presented at a conference on magnetism and antiferromagnetism. The authors studied the behavior of the domain structure of ferromagnetic films at different temperatures. Fe, Ni, Fe-Ni, and Fe-Ni-Mo films were produced by hot metal spraying in a vacuum (10^{-5} mm Hg) on to polished glass (350°C) in a magnetic field of 120 oe. The optical device used for observation of the domain structure has already been described (Ref. 11: Kirenskiy, L. V., Kan, S. V., Degtyarev, I. F., Izv. AN SSSR, Ser. fiz., 25, no. 5 (1961)). The temperature dependence of the domain structure was studied on a specially designed apparatus (Fig. 1) with which the temperature in the specimens could be varied between -150 and +650°C. To avoid misting and oxidation of the specimen in the chamber the pressure
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Behavior of the domain ...

was kept at 10^{-3} mm Hg during the experiments. In the absence of magnetic field the domain structure of all the specimens was highly stable. The behavior of the domain structure at various different temperatures is largely determined by the magnetic field strength. Magnetic reversal nucleation usually occurs in some sections of the film at quite low temperatures. With repeated magnetic reversal they are easily reproducible. At higher temperatures the number of nuclei increases, they grow, and the boundaries begin to move more rapidly and smoothly. When nuclei are formed magnetic reversal can only be achieved by increasing the temperature. H_s and H_o are temperature dependent. In some materials they decrease as the temperature rises. The curve for iron films at temperatures above 500°C showed an anomalous course, probably due to the different thermal expansion of base and film. There are 4 figures and 11 references: 3 Soviet and 8 non-Soviet. The three most recent references to the English-language publications read as follows: Smith D. O., Electronics, 32, 44 (1959); Murphy M., Control Engng., no. 10, 38 (1959); Olmen R. W., Mitchell E. N., J. Appl. phys., 30, 258 (1959).

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Behavior of the domain ... B117/B138

ASSOCIATION: Institut fiziki Sibirskogo otdeleniya Akademii nauk SSSR (Institute of Physics of the Siberian Department of the Academy of Sciences USSR)

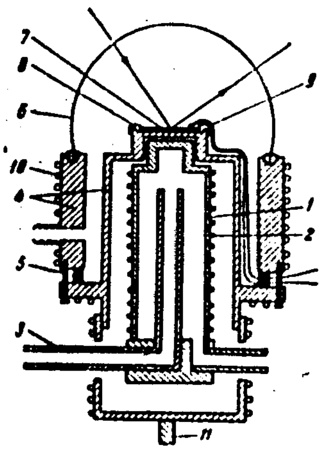

Fig. 1. Apparatus for studying the temperature dependence of domain structure. Legend: (1) heater (cooler); (2) bifilar winding; (3) tube for liquid nitrogen and its vapors; (4) vacuum chamber; (5) rubber packing; (6) glass dome; (7) specimen; (8) clamp for specimen; (9) thermocouple; (10) heating cooling coil; (11) fastening screw.

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KIRENSKIY, L.V.; RYABININ, V.P.

Study of the law of approach to saturation on iron silicide single crystals at various temperatures. Kristallografiia 7 no.4:634-637 Jl-Ag '62. (MIRA 15:11)

1. Institut fiziki Sibirskogo otdeleniya AN SSSR i Krasnoyarskiy pedagogicheskiy institut.

(Iron silicide crystals)

KIRENSKIY, Leonid Vasil'yevich; MATSONASHVILI, B.N., red.izd-va;
POLENOVA, T.P., tekhn. red.; MAKAGONOVA, I.A., tekhn.red.

[Magnetism] Magnetizm. Moskva, Izd-vo AN SSSR, 1963. 139 p
(MIRA 16:9)

(Magnetism)

KIRENSKIY, L.V.; SALANSKIY, N.M.; RODICHEV, A.M.

The Barkhausen effect at the approach of the hysteresis loop to a rectangle. Fiz. met. i metalloved. 16 no.4:630-632 O '63. (MIRA 16:12)

1. Institut fiziki AN SSSR.

KIRENSKIY, L.V.; KUZNETSOV, V.Ye.; U.ATOV, V.U.

[Dynamic magnetostriction of iron] Dinamicheskaia magnitostriktsiia zheleza. [n.p.]. AN SSSR. Sibirskoe otd-nie. In-t fiziki, 1964. 29 p. (MIRA 17:7)

ACCESSION NR: AP4039408 S/0070/64/009/003/0429/0432

AUTHORS: Antipin, I. P.; Kirenskiy, L. V.; Savchenko, M. K.

TITLE: The domain structure of nickel crystals, associated with mechanical deformations

SOURCE: Kristallografiya, v. 9, no. 3, 1964, 429-432

TOPIC TAGS: nickel, domain structure, domain reorganization, powder method, magnetization, plastic deformation, reorganization irreversibility

ABSTRACT: In nickel, in view of the large increase of magneto-stricture and the small anisotropic constant associated with an increase in stress, a significant reorganization of the domain structure takes place. The existence of 71 and 109 degree spatial relationships of the domains determines the unique character of this reorientation. The nickel samples used here were parallelepipeds with a maximum grain diameter of 4 mm selected from a list of electrolytic nickel. The crystals were chosen with surfaces lying on or near to the (211) and (110) planes, in accordance with the criterion of M. Yamamoto and T. Iwata (Sci. Repts Res Inst. Tohoku Univ. A5, 433, 1958; A8, 293, 1956). Observations were made by the powder method. All stresses were unidirectional. Four sets of pictures showed the

ACCESSION NR: AP4039408

disappearance of domain structure under stress and its failure to reappear when the load was removed. Two sets of pictures dealt with the (211) plane which has one axis of simple magnetization along which the domain structure lay. Stress was applied parallel to the domain boundary line in one case and perpendicular in another. The other two sets of pictures dealt with the (110) plane in which there are two directions of simple magnetization lying at 71 or 109 degrees to each other. Stress, in this case, produced at first dendritic domain structures when applied perpendicular to the original domain. The domain structure in nickel crystals is very sensitive to mechanical stress. The distinctive property of the domain structure is its irreversibility. Even after the action of very small stresses (less than 0.01 kg/mm^2), the domain structure did not return to its initial state. The irreversibility was explained by plastic deformation which probably could not be observed except by the powder method. Orig. art. has: 4 figures.

ASSOCIATION: Institut fiziki SO AN SSSR (Institute of Physics, SO AN SSSR)

SUBMITTED: 17Jul63 DATE ACQ: 18Jun64 ENCL: 00

SUB CODE: MM NO REF SOV: 001 OTHER: 001

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ACCESSION NR: AP[illegible]

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ASSOCIATION: [illegible] (Institute of Physics AN [illegible] SSR)

SUBMITTED: [illegible] ENCL: 00 SUB CODE: GP, SS

NR REF SOV: 002 OTHER: 001

Card 2/2

KIRENSKIY, L.V.; SALANSKIY, N.M.; RODICHEV, A.M.

Reversible and irreversible processes in the magnetic reversal of an elastically stretched-out iron-nickel polycrystal (Barkhausen effect appearing as the hysteresis loop approaches a rectangular shape). Izv. AN SSSR. Ser. fiz. 28 no.1:164-168 Ja '64. (MIRA 17:1)

1. Institut fiziki Sibirskogo otdeleniya AN SSSR.

AP4010321 S/0048/64/028/001/0198/0201

AUTHOR: Kirenskiy, L.V.; Patyukova, Z.M.

TITLE: Investigation of elastic hysteresis of the thermoelastic effect in nickel and niclo-silicon alloys /Report, Symposium on Questions of Ferro- and Antiferromagnetism held in Krasnoyarsk, 25 June to 7 July 1962/

SOURCE: AN SSSR. Izvestiya. Seriya fizicheskaya, n.28, no.1, 1964, 198-201

TOPIC TAGS: thermoelastic effect, thermo-emf, Thomson effect, stress hysteresis, hysteresis loop, magnetoelastic effect, nickel, nickel-silicon alloy

ABSRTRACT: The Thomson (thermo-emf) effect in ferromagnets is characterized by some distinctive and interating features connected with the presence in them of spontaneous magnetization. There have, however, been few investigations of the hysteresis of the thermoelastic effect, that is, of the difference between the thermo-emf curves obtained incident to application and removal of stress in the case of iron and other ferromagnetic specimens. The present work was concerned with investigation of hysteresis of the elastic thermo-emf in nickel and nickel-silicon alloys containing 0.5 to 4% Si by weight, both in the absence of an external field

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and in the case of preliminary magnetization of the specimen. The experimental set-up and procedure have been described earlier by one of the authors (Z.M.Patyukova, IZV.AN SSSR,Ser.fiz.28,172,1963)(see Abstract ACC NR AP4010316). The results of the stress cycling experiments for demagnetized and magnetized specimens are presented in the form of curves. It was found that preliminary application of a magnetic field does not change the general character of the hysteresis up to fields close to the value for technical saturation, the point at which hysteresis disappears. A residual effect, observed in magnetized specimens, disappears after demagnetization of the specimen in the unstressed state and the initial shape of the thermo-emf curves is re-established. A magnetic field applied prior to application of the tensile stress leads at first to increase in the area of the hysteresis loop (to a maximum value in a field of about 38 Oe) and then to rapid decrease of the area with further increase of the field. In cases of plastic deformation "negative" hysteresis is observed. Elastic hysteresis of the thermoelastic effect in ferromagnets may be attributed to irreversible changes in the domain structure under the influence of elastic stresses. Orig.art.has: 4 figures.

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AP4010321

ASSOCIATION: Institut fiziki Sibirskogo otdeleniya, Akademii nauk, SSSR (Institute of Physics, Siberian Division, Academy of Sciences); Yeniseyskiy pedagogicheskiy institut (Yenisey Pedagogical Institute)

SUBMITTED: 00 DATE ACQ: 10Feb64 ENCL: 00

SUB CODE: PH NR REF SOV: 008 OTHER: 000

Card 3/3

ACCESSION NR: AP4023405 S/0048/64/028/003/0545/0552

AUTHOR: Kirenskiy, L.V.; Drokin, A.I.; Dy*lgerov, V.D.; Sudakov, N.I.; Sinegubov,V.I

TITLE: Domain structure in ferrites and its dynamics in varying and rotating magnetic fields /Report, Symposium on Ferromagnetism and Ferroelectricity held in Leningrad 30 May to 5 June 1963/

SOURCE: AN SSSR: Izvestiya. Seriya fizicheskaya, v.28, no.3, 1964, 545-552

TOPIC TAGS: ferrite, domain structure, ferrite domain structure, garnet ferrite, garnet ferrite domain structure, spinel ferrite, spinel ferrite domain structure, hexagonal ferrite domain structure, double domain structure, domain wall fine structure

ABSTRACT: The domain structure of a number of ferrite single crystals having the garnet, spinel or hexagonal structure was investigated. The powder method of W.S. Elmore (Phys.Rev.51,10,1092, 1938) was employed to reveal the domains. The polarity of the domain boundaries was determined with the aid of the polar Kerr effect, employing a previously described technique (V.D.Dy*lgerov and A.I.Drokin, Kristallografiya,5,6,945,1960); A.I.Drokin, V.D.Dy*lgerov and B.V.Beznosikov, Ibid.9,3,465,

ACCESSION NR: AP4023405

1962). The Yb, Ho, Er and Gd garnet ferrites were obtained as single crystals from melts. Lead hexaferrite was also prepared in this way. Crystals of Co-Fe, Mn-Fe and Mg-Mn ferrites with the spinel structure were grown in an oxy-hydrogen flame. Spheres of 4 to 8 mm diameter were obtained. These wer annealed above the Curie point and oriented in a magnetic field. The planes to be investigated were ground flat, polished and treated with hot sulfuric acid to destroy surface mosaic. Lead hexaferrite was found to have a domain structure similar to that of cobalt. The ferrites with the garnet structure had very complex domain structures, for which it does not seem possible to construct a model. "Stringy" walls, double banded walls, and curved walls were observed in different materials. The curved domain walls of gadolinium ferrite garnet would shift under the influence of an applied magnetic field. The domain structure of the spinel ferrites was somewhat less complex. The presence of double domain structure was established. Successive walls would have opposite polarity, and in the presence of a gradually increasing magnetic field alternate walls would first disappear, the remaining walls disappearing only when the field became stronger. Sometimes a single domain wall would separate into two under the influence of a field; in such a case the two new walls would have the same polarity as the old, thus interrupting the regular alternation of polarity. Wide do-

ACCESSION NR: AP4023405

main walls were observed in which a fine structure could be perceived. Such complex walls exhibited alternations of polarity, as though they were composed of several walls having opposite polarities. It is suggested that the double domain structure of ferrites may be due to the interaction between the two magnetic sublattices, each striving to establish its own domain pattern. Orig.art.has: 5 figures.

ASSOCIATION: Institut fiziki Sibirskogo otdeleniya Akademii nauk SSSR (Institute of Physics, Siberian Division, Academy of Sciences, SSSR)

SUBMITTED: 00 DATE ACQ: 10Apr64 ENCL: 00

SUB CODE: PH NR REF SOV: 014 OTHER: 010

Card 3/3

S/0048/64/028/003/0559/0567

ACCESSION NR: AP4023407

AUTHOR: Kirenskiy, L.V.; Savchenko, M.K.; Degtyarev, I.F.; Kan, S.V.; Antipin, I.P.; Tropin, Yu.D.; Edel'man, I.S.

TITLE: Domain structure of ferromagnetic crystals, films, and whiskers, and changes of the structure under the influence of different factors /Report, Symposium on Ferromagnetism and Ferroelectricity held in Leningrad 30 May to 5 June 1963/

SOURCE: AN SSSR. Izvestiya. Seriya fizicheskaya, v.28, no.3, 1964, 559-567

TOPIC TAGS: crystal domain structure, film domain structure, whisker domain structure, domain structure variation, demagnetization condition domain influence, iron crystal domains, iron film asymmetric hysteresis, iron whisker domain

ABSTRACT: This paper summarizes a large amount of information concerning the domain structure of crystals, films, and whiskers, and its change under the influence of magnetizing fields, stress, temperature, and conditions of demagnetization. The topics discussed include the changes in the domain structure of silicon iron crystals during magnetization in various directions; the effect of mechanical stress on the domain structure of silicon iron crystals; the influence of mechanical stress

ACCESSION NR: AP4023407

on the domain structure in the (110) and (211) faces of nickel crystals; the effect of demagnetization rate on domain size in thin cobalt films; the effect of temperature on the variation of domain structure under the influence of magnetizing fields in thin cobalt films; the variations of domain structure in thin iron films during traversal of an asymmetric hysteresis loop in a transverse field; and the domain structure on the (001) surface of iron whiskers (100 to 200 micron diameter) grown in the [110] direction. The report is illustrated with 47 reproductions of domain structure photographs. Among the different kinds of behavior of domain structure mentioned or discussed are the following. When iron crystals are magnetized in the easy direction, the process of domain wall motion stops short of saturation, and the remaining narrow unfavored domains disappear suddenly. When the magnetizing field makes a sufficiently great angle with the preferred magnetization direction, initial magnetization takes place by domain wall shift; this is followed by a restructuring of the domains, after which further wall shifting occurs. The final approach to saturation is by ordinary rotation. The herring bone or fir tree domain structure on the (110) face of nickel crystals gives way under the influence of mechanical stress to a simple structure. At greater stresses the domains disappear entirely. At still greater stresses a simple domain structure reappears, but the domains are now relat-

ACCESSION NR: AP4023407

ed to the other magnetization axis. The net result is thus a 109° rotation of the domains. The size of the domains in cobalt films increases with the rate of demagnetization by alternating field. This is related to the formation of wedge shaped domains, one within another. When a thin cobalt film is cooled from above the Curie point in a field free environment, an equilibrium domain structure is not formed. The domain structure of a thin iron film was found to change largely by wall shift during traversal of an asymmetric hysteresis loop in the presence of a constant transverse field. This is not in accord with the explanation of these asymmetric hysteresis loops given by V.V.Kobelev (Petli gisterezisa odnoosny*kh ferromagnitny*kh plenok. ITM i VT AN SSSR,M.,1961) on the basis of a model in which the magnetization was assumed to rotate uniformly. Orig.art.has: 9 figures.

ASSOCIATION: Institut fiziki Sibirskogo otdeleniya Akademii nauk SSSR(Institute of Physics, Siberian Division, Academy of Sciences,SSSR); Krasnoyarskiy pedagogicheskiy institut (Krasnoyarsk Pedagogical Institute)

SUBMITTED: 00 DATE ACQ: 10Apr64 ENCL: 00

SUB CODE: PH NR REF SOV: 005 OTHER: 003

Card 3/3

KIRENSKIY, L.V., GRONIN, A.I.; LAPTEY, D.A.; TARASOVA, N.V.

[Temperature magnetic hysteresis in ferromagnetics and ferrites] Temperaturnyi magnitnyi gisterezis ferromagnetikov i ferritov. Novosibirsk, Red.-izd. otdel Sibirskogo otd-niia AN SSSR, 1965. 157 p. (MIRA 18:11)

KIRENSKIY, L.V.; KUZNETSOV, V.Ye.; USATOV, V.U.

Magnetostriction of iron in field variables. Fiz. met. i metalloved. 20 no.2:221-225 Ag '65. (MIRA 18:9)

1. Institut fiziki Sibirskogo otdeleniya AN SSSR.

APPROVED FOR RELEASE: 09/17/2001 CIA-RDP86-00513R000722610017-5"

GORYUNOVA, N.A.; KIRENSKIY, L.V.; KLASSEN-NEKLYUDOVA, M.V.

Colloquium on solid state physics held in Rumania. Vest. AN SSSR 35 no.4:82 Ap '65. (MIRA 18:6)

L 15398-66 EWT(m)/EWP(t)/EWP(b) IJP(c) JD

ACC NR: AP5027223 SOURCE CODE: UR/0020/65/164/006/1267/1268

AUTHOR: Kirenskiy, L. V. (Corresponding member AN SSSR); Pyn'ko, V. G.

ORG: Institute of Physics, Siberian Section of the Academy of Sciences SSSR (Institute fiziki Sibirskogo otdeleniya Akademii nauk SSSR)

TITLE: Anisotropy of epitaxial cobalt films

SOURCE: AN SSSR. Doklady, v. 164, no. 6, 1965, 1267-1268, and bottom half of insert facing page 1260

TOPIC TAGS: cobalt, magnetic thin film, epitaxial growth

ABSTRACT: Fully oriented cobalt films may be obtained at 10^{-4} mm Hg by thermal spray-coating of freshly cleaved NaCl crystals heated to 200C. The present investigation of the domain structure and hysteresis loops of such films shows that they have an unstable axis of easy magnetization. Theoretical consideration shows that the presence of α-phase crystallites within the epitaxial cobalt film seems to decrease the negative anisotropy, and if such crystallites are present in sufficient quantities, they could create a "positive" total anisotropy, such as in films deposited on NaCl crystals. No such α-phase crystallites could be observed on cobalt films deposited on LiF crystals at 250C the anisotropy of which is always negative. This is evidence in favor of the hypothesis that the α-crystallites with an increased oxygen content are responsible for the appearance of "positive" anisotropy. This is in agreement with the results

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UDC: 538.245

Card 2/2

L 7940-66 EWT(l)/EWT(m)/EWP(i)/EWA(d)/EWP(t)/EWP(z)/EWP(b)/EWA(h) IJP

ACC NR: AP5027839 SOURCE CODE: UR/0020/65/165/001/0081/0084

36

AUTHOR: Kirenskiy, L.V. (Corresponding member AN SSSR); Chistyakov, N.S.

ORG: Physics Institute of the Siberian Department of the Academy of Sciences, SSSR, Krasnoyarsk (Institut fiziki Sibirskogo otdeleniya Akademii nauk SSSR)

B

TITLE: Some possible practical uses of ferromagnetic films at ultrahigh frequencies

SOURCE: AN SSSR. Doklady, v. 165, no. 1, 1965, 81-84

TOPIC TAGS: ferromagnetic film, magnetic thin film, thin film circuit, UHF oscillator

ABSTRACT: The use of ferrite elements in UHF devices is often inconvenient because of their considerable size, large control power requirement, and slow response, resulting in increased interest in the possible utilization of ferromagnetic film. The authors investigated the UHF properties (f = 9,000 Mc) of thin ferromagnetic films in weak magnetic fields at a large distance from the ferromagnetic resonance. The 17Fe80Ni3Mo permalloy films with uniaxial magnetic anisotropy were produced by vacuum evaporation at $\sim 10^{-5}$ mm Hg on a glass support heated up to 200C. The tests included studies of 1) the influence of weak perpendicular magnetic fields on the variations in UHF susceptibility during remagnetization of the film at a certain angle to the easy magnetization axis (Fig. 1) and 2) the shift in eigenfrequency of resonators as a function of the thickness of single and multilayer films (Fig. 2). The films were separated by insulating silicon monoxide layers. Results show that the UHF multilayer film systems in weak magnetic fields are superior to single-layer film units in that the multilayer systems have a greater effect on the UHF fields. It is expected that after the development of an

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ACC NR: AP5027839

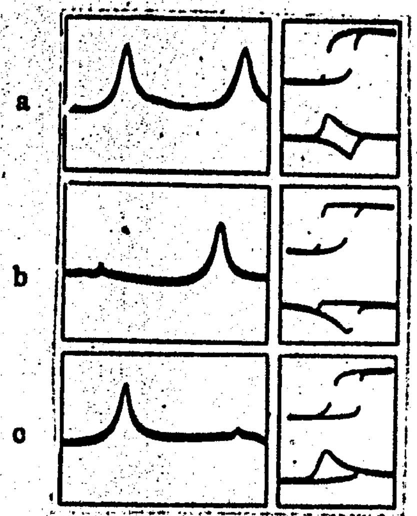

Fig. 1. Influence of the weak perpendicular field $H_\perp$ on the changes of UHF permeability during film remagnetization at an angle of $\varphi = 40°$ with respect to the axis of easy magnetization; a - $H_\perp = 0$, b - $H_\perp = 2$ Oe; c - $H_\perp = -2$ Oe

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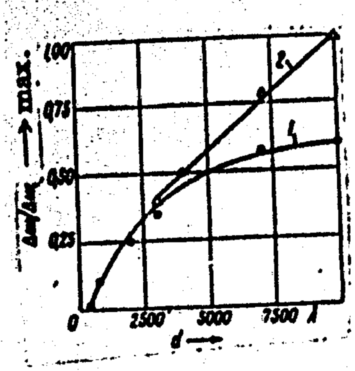

Fig. 2. Relative resonator eigenfrequency shift as funtion of the single-layer film thickness (1) and the overall thickness of the metal within a multilayer system (2)

appropriate technological production process, they will find widespread application in UHF engineering. Orig. art. has: 3 formulas and 2 figures. [08]

SUB CODE: 09/ SUBM DATE: 23Jun65/ ORIG REF: 003/ OTH REF: 001/ ATD PRESS: 4147

Card 3/3

L 26750-66 EWT(1)/EWT(m)/EWA(d)/T/EWP(t) IJP(c) JD/HW/GG

ACC NR: AP6011480 SOURCE CODE: UR/0070/66/011/002/0346/0348

AUTHOR: Kirenskiy, L. V.; Galepov, P. S.; Turpanov, I. A.

ORG: Institute of Physics, SO AN SSSR (Institut fiziki SO AN SSSR)

TITLE: Production of thin ferrite films in an inert gas plasma

SOURCE: Kristallografiya, v. 11, no. 2, 1966, 346-348

TOPIC TAGS: magnetic thin film, ferrite, discharge plasma, metal vapor deposition

ABSTRACT: The authors describe the preparation of thin $CuFe_2O_4$ and $NiFe_2O_4$ ferrite films by cathode sputtering of polycrystalline ferrites. The work was stimulated by published data by others (J. Appl. Phys. Suppl. v. 33, 110 and 1150, 1962), where it is indicated that sputtering in the presence of a gas yields ferrites of prescribed properties. The vacuum installation used for the sputtering was made of metal and was designed to sputter ferromagnetic materials in xenon gas. The gas flows through the installation during the sputtering (Fig. 1) and its pressure can be maintained constant during that time. The sputtered material serves as a third electrode in a non-spontaneous discharge plasma. The initial ferrites were prepared by usual ceramic technology. The sputtering procedure is described. Three techniques were used: 1) sputtering on a cold substrate and heating in vacuum, 2) sputtering on a hot substrate without heating the vacuum, and 3) sputtering on a hot substrate with heating in vacuum. All films exhibited a spinel structure with lattice periods coinciding with those of the bulk material. The films of the first

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L 26750-66

ACC NR: AP6011480

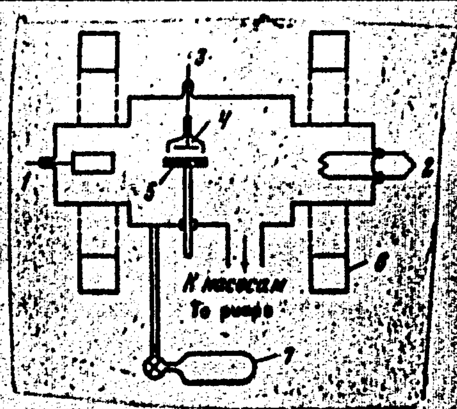

Fig. 1. Diagram of apparatus for cathode sputtering. 1 - Anode, 2 - cathode, 3 - third electrode, 4 - sample, 5 - substrate holder, 6 - Helmholtz coils, 7 - gas supply.

group contained an amorphous phase and had a finely dispersed structure. The largest crystal structure was produced by the third group. Only the third group possessed a measurable hysteresis. Orig. art. has: 4 figures.

SUB CODE: 20/ SUBM DATE: 06Jan65/ ORIG REF: 007/ OTH REF: 010

Card 2/2

coercive force of the films in the multilayer system. This is explained by local magnetic interaction between the magnetic layers. The decrease in coerciveness depends on the thickness of the film and is explained by a change in the character

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ACC NR: AP6033897

of local interaction. Measurements were made of the coefficients of transmission and reflection as a function of the thickness of single-layered films and the total thickness of ferromagnetic metal layers in a multilayer system. It was found that the coefficients of transmission of multilayered systems is substantially greater than that of single-layered film. The characteristics of the transmission of UHF-energy through multilayered films are explained with in the framework of ordinary electrodynamics. [Translation of abstract] [SP]

SUB CODE: 20/ SUBM DATE: 31May66/ ORIG REF: 005/ OTH REF: 015/

Card 2/2

ACC NR: AP6007358 SOURCE CODE: UR/0126/66/021/002/0293/0295

AUTHORS: Kironskiy, L. V.; Izotova, T. P.; Salanskiy, N. M.

ORG: Institute of Physics, SO AN SSSR (Institut fiziki SO AN SSSR); Krasnoyarsk Pedagogic Institute (Krasnoyarskiy pedinstitut)

TITLE: Multilayer thin film systems

SOURCE: Fizika metallov i metallovedeniye, v. 21, no. 2, 1966, 293-295

TOPIC TAGS: iron, nickel, cobalt, ferromagnetic film, ferromagnetic material, QUARTZ

ABSTRACT: The interaction between two-layer ferromagnetic films separated from each other by a 2000 Å thick layer of quartz was studied. The study supplements the results of L. V. Kironskiy, T. P. Izotova, and N. M. Salanskiy (Izv. AN SSSR, ser. fiz., 1965, No. 4, 610). The coercive force in the films and the distribution of Barkhausen jumps as a function of the field strength were determined. The experimental results are presented graphically (see Fig. 1). It is concluded that the bond field strength of the bond $|SiO_2|$Fe-Ni depends mainly on the properties of the high-coercivity layer.

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UDC: 539.216.2:538.22

ACC NR: AP6007358

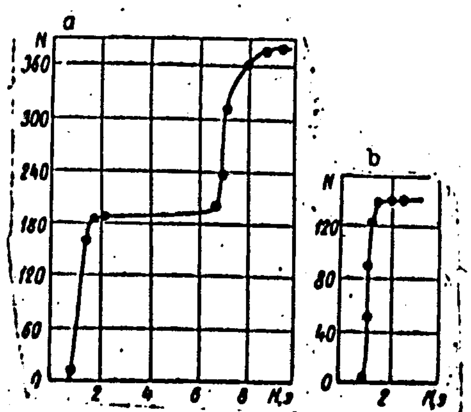

Fig. 1. Integral curves for the distribution of Barkhausen jumps along the field. a - for film of Co/SiO_2/Fe-Ni; b - for film of Fe-Ni (16% Fe, 84% Ni).

Orig. art. has: 4 graphs.

SUB CODE: 11/ SUBM DATE: 09Mar65/ ORIG REF: 001/ OTH REF: 002

Card 2/2

L 09128-67 EWT(m)/EWP(t)/ETI IJP(c) JD/HW

ACC NR: AP6032617 SOURCE CODE: UR/0126/66/022/003/0380/0391

AUTHOR: Kirenskiy, L. V.; Pyn'ko, V. G.; Sukhanova, R. V.; Sivkov, N. I.; Pyn'ko, G. P.; Edel'man, I. S.; Komalov, A. S.; Kan, S. V.; Syrova, N. I.; Zvegintsev, A. G.

ORG: Institute of Physics SO AN SSSR (Institut fiziki SO AN SSSR); Krasnoyarsk Pedagogical Institute (Krasnoyarskiy pedinstitut)

TITLE: Epitaxial films of iron, nickel, and cobalt [report presented at the Conference on Physics of Ferro- and Antiferromagnetism, Sverdlovsk, 5-7 July 1965]

SOURCE: Fizika metallov i metallovedeniye, v. 22, no. 3, 1966, 380-391

TOPIC TAGS: magnetic anisotropy, epitaxial growing, hysteresis loop, metal film

ABSTRACT: The authors study the epitaxial growth of iron, nickel and cobalt films thermally vaporized onto ionic crystals split in air and in a vacuum. It is shown that when the substrates are heated in a vacuum of 10^{-4} mm Hg, the surface state is changed with a favorable effect on epitaxy. The phase composition of the film may be controlled by proper selection of the substrate. The fields of anisotropy of the films are measured and the effect which application of a magnetic field during vaporization has on the magnetic anisotropy of the films is studied. The domain structure of the films and its dynamics are analyzed and the results are used as a basis for explaining the shape of hysteresis loops. The coercive force is measured in films of various thickness. It is shown that the coercive force of the films is always much less than the field of anisotropy and is approximately inversely proportional to the saturation magnetization. Orig. art. has: 13 figures, 1 table, 5 formulas.

SUB CODE: 11, 20/ SUBM DATE: 30Jul65/ ORIG REF: 004/ OTH REF: 007

Card 1/1 nst

UDC: 539.216.25:538.221

L 15385-66 EWT(1)/EWT(m)/EWP(e)/T/EWP(t)/EWP(b) IJP(c) JD/HW/GG

ACC NR: AP6004462 SOURCE CODE: UR/0048/66/030/001/0034/0036

AUTHOR: Kirenskiy, L.V.; Sukhanova, R.V.; Pyn'ko, G.P.

ORG: Institute of Physics, Siberian Section of the Academy of Sciences, SSSR (Institut fiziki Sibirskogo otdeleniya Akademii nauk SSSR)

TITLE: Domain structure of cobalt films grown on NaCl crystals [Transactions of the Second All-Union Symposium on the Physics of Thin Ferromagnetic Films held at Irkutsk 10 July to 15 July, 1964]

SOURCE: AN SSSR. Izvestiya. Seriya fizicheskaya, v.30, no.1, 1966 34-36

TOPIC TAGS: ferromagnetic film, magnetic thin film, cobalt, magnetic domain structure, magnetic anisotropy

ABSTRACT: Cobalt films were deposited at 10^{-4} mm Hg on NaCl crystal cleavage surfaces having temperatures from room temperature to 400°C, and their domain structures were observed by means of a transmission electron microscope. Conditions for obtaining single-crystal films are reported in another communication. Films deposited on substrates at 20°C contained hexagonal, cubic and amorphous phases and had a domain structure that was initially mottled and developed under the influence of an ac field into a structure of coarse domains with weakly developed substructure. The mottled domain structure is ascribed to the presence of nonmagnetic inclusions. Films deposited on substrates heated to 70 to 150°C did not show a mottled domain structure.

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ACC NR: AP6004462

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but the substructure was strongly developed. It was possible to obtain oriented films of β-cobalt crystallites on a 200° substrate. The domain structure of these films showed no substructure. Investigation of the domain structure of the oriented films showed that films of cubic cobalt deposited from molybdenum or tungsten crucibles at 10^{-4} mm Hg have positive magnetic anisotropy, with an anisotropy constant about an order of magnitude less than that of iron. This finding contradicts the results of H.Sato, K.S.Toth, and R.W.Astrue (J.Appl.Phys., 34, 1062 (1963)). Films deposited on substrates heated to 300°C and above had a mottled domain structure which is ascribed to the presence of nonmagnetic inclusions consisting, in this case, of voids. Orig. art. has: 4 figures.

SUB CODE: 20 SUBM DATE: 00 ORIG. REF: 000 OTH REF: 001

Card 2/2

L 15374-66 EWT(m)/T/EWP(t)/EWP(b) IJP(c) JD

ACC NR: AP6004465 SOURCE CODE: UR/0048/66/030/001/0046/0049

37 B

AUTHOR: Kirenskiy, L.V.; Pyn'ko, V.G.; Antipin, I.P.

ORG: Institute of Physics, Siberian Section of the Academy of Sciences, SSSR (Institut fiziki Sibirskogo otdeleniya Akademii nauk SSSR); Krasnoyarsk State Pedagogical Institute (Krasnoyarskiy gosucarstvennyy pedagogicheskiy institut)

TITLE: Domain structure of epitaxial iron films /Transactions of the Second All-Union Symposium on the Physics of Thin Ferromagnetic Films held at Irkutsk 10 July to 15 July 1964/

SOURCE: AN SSSR. Izvestiya. Seriya fizicheskaya, v.30, no. 1, 1966, 46-49

TOPIC TAGS: ferromagnetic film, magnetic thin film, iron, epitaxial growth, sodium chloride, magnetic domain structure

ABSTRACT: The domain structure of 600 to 1000 Å epitaxial iron films vacuum deposited on NaCl substrates was investigated by electron microscopy and by the powder pattern technique. The growth and crystal structure of the films are discussed elsewhere by V.G.Pyn'ko and R.V.Sukhanova (Izv. AN SSSR, Ser. fiz., 30, 43 (1966)/ see Abstract AP6004464/). The films were transferred in water from the NaCl substrate to glass for examination by the powder pattern technique or to 50 x 50 μ grids for examination with the electron microscope. The films could be roughly classified into three types: 1) fully oriented films with the (001) plane in the plane of the film; 2) films with

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ACC NR: AP6004465

crystallites oriented in two or three different ways with the (001) face in the film parallel to the (001) face of the substrate and the [100] axis in the film parallel to the [110] or the [100] axis in the substrate, or with the (110) face in the film parallel to the (100) face in the substrate and the [100] axis in the film parallel to the [100] axis in the substrate; and 3) films containing a large number of randomly oriented crystallites. It was very difficult to obtain a checkerboard domain structure in type 1) films; under the influence of an ac field there usually appeared large rectangles or squares of different sizes. A regular checkerboard structure was obtained in type 2) and 3) films, but the "squares" were rectangular. These checkerboard structures developed in two stages, the domain walls perpendicular to the ac field forming first. Type 1) films initially had a fine domain structure with 180° and modified 90° walls; type 2) films regularly had an initial mottled domain structure; the initial domain structure of type 3) films was like that of type 1) or type 2) films, depending on the substrate temperature and deposition rate. After demagnetization the domains of type 3) films always showed substructure and those of type 1) films did not. The 180° domain walls were continuous except those in type 3) films containing a large number of randomly oriented crystallites. It is concluded that substructure in epitaxial films is associated with anisotropy dispersion, and that 180° domain walls in epitaxial iron films always have an internal structure which, however, may not appear in the electron microscope image. It was not possible to observe the domain structure of the 600 A films. Orig. art. has: 4 figures.

SUB CODE: 20 SUBM DATE: 00 ORIG. REF: 002 OTH REF: 008

Card 2/2

L 17409-66 EWT(m)/T/EWP(e)/EWP(t) IJP(c) JD/HW

ACC NR: AP6004466 SOURCE CODE: UR/0048/66/030/001/0050/0053

AUTHOR: Kirenskiy, L. V.; Sukhanova, R. V.; Pyn'ko, V. G.; Edel'man, I. S.

ORG: Physics Institute of the Siberian section of the SSSR Academy of Sciences (Institut fiziki Sibirskogo otdeleniya Akademii nauk SSSR); Krasnoyarsk State Pedagogical Institute (Krasnoyarsk gosudarstvennyy pedagogicheskiy institut)

TITLE: Single-crystal films of iron-nickel alloys (Transactions of the Second All-Union Symposium on the Physics of Thin Ferromagnetic Films held at Irkutsk 10 July to 15 July 1964)

SOURCE: AN SSSR. Izvestiya. Seriya fizicheskaya, v.30, no. 1, 1966, 50-53 and insert (facing page 45)

TOPIC TAGS: ferromagnetic film, magnetic thin film, permalloy, iron nickel alloy, single crystal, magnetic anisotropy, magnetic coercive force, magnetic domain structure

ABSTRACT: Single-crystal 800 Å films of Fe-Ni alloys (5 to 95% Ni) were obtained by vacuum evaporation at 10^{-3} to 10^{-4} mm Hg onto the heated (250 to 400C) surface of an NaCl crystal, although O. S. Heavens (Proc. Phys. Soc. 78, 33 (1961)) and A. Baltz (J. Appl. Phys., 32, 815 (1961)) found that high vacuum (10^{-9} mm Hg) and annealing was necessary to obtain single-crystal films. No reason for this discrepancy is suggested. The alloys containing less than 20% Ni crystallized in a body-centered lattice with a lattice constant of 2.828 Å and grew with the (001) face and ⟨100⟩ axis parallel to the (001) face and ⟨110⟩ axis, respectively, of the NaCl substrate; the alloys con-

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ACC NR: AP6004466 0

taining more than 20% Ni crystallized in a face-centered cubic lattice with a lattice constant of 3.576 Å and grew with the (001) face and ⟨100⟩ axis parallel to the (001) face and ⟨100⟩ axis, respectively, of the substrate. Microtwinning was observed. The single-crystal films had two mutually perpendicular easy magnetization axes, this was not observed by S. Chikazumi (J. Appl. Phys., 32, 815 (1961)). The anisotropy constant was positive for films containing up to 79.4% Ni and was negative for films containing 82% Ni or more. The coercive force depended strongly on the temperature of the substrate during deposition; the coercive force of films of an undisclosed composition increased from 9 to 80 Oe as the temperature of the substrate during deposition was increased from 250 to 350C. Films deposited at temperatures below 250C were polycrystalline. The single-crystal films either consisted of a single domain with substructure, or were mottled. After demagnetization in a decreasing ac field parallel to the hard axis the films had 90° domain walls in the direction of the hard axis and 180° walls in the direction of the easy axis. When a mottled film was demagnetized along the easy axis, the spots became aligned along substructure lines; when the same film was demagnetized along the hard axis there appeared domain walls consisting of separate points. The presence of substructure makes it possible to determine the directions of the easy axes. The easy axis directions determined from the substructure agreed with those determined from the shapes of the hysteresis loops. Orig. art. has: 5 figures. [15]

SUB CODE: 20/ SUBM DATE: none/ ATD PRESS: 4206

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L 39610-66 EWT(m)/EWP(t) IJP(c)

ACC NR: AP6004470 SOURCE CODE: UR/0048/66/030/001/0068/0070

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TITLE: Superhigh frequency properties of multilayer film systems (Transactions of the Second All-Union Symposium on the Physics of Ferromagnetic Thin Films, held at Irkutsk, 10 July to 15 July 1964)

SOURCE: AN SSSR. Izvestiya. Seriya fizicheskaya, v. 30, no. 1, 1966, 68-70

TOPIC TAGS: ferromagnetic film, magnetic thin film, iron, nickel, molybdenum, quartz, laminated material, superhigh frequency, magnetization, microwave, ferromagnetic material, metal film, waveguide

ABSTRACT: The interaction of multilayer ferromagnetic film systems with microwave frequency fields has been investigated in order to determine whether the limitation imposed by the skin effect on the use of conducting ferromagnetic materials in microwave frequency applications can be obviated by depositing the material in layers that are thinner than the skin depth and are insulated from each other. The films were vacuum evaporated (10^{-5} mm Hg) in a 100-oe magnetic field onto 9-mm diameter circular or 23 x 10 mm rectangular glass plates heated to 200C. The metal (18Fe-79-Ni-3Mo) films were 1000 Å thick and were separated by 1500-2000-Å quartz films. Each metal film and its covering quartz film were deposited without breaking the vacuum. The vacuum was then broken and the crucibles recharged for deposition of the successive

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ACC NR: AP6004470

metal and quartz layers. Systems containing up to ten metal layers were investigated. The absorption of 3.2 cm microwaves by the film systems was investigated. The films were mounted so as to cover the entire area of a waveguide but with no electrical connection between the metal films and the waveguide wall, and the attenuation in the waveguide was measured. The attenuation was practically the same for a ten-layer film system as for a single film. The magnetization switching of the film system in a weak sinusoidal microwave frequency field was investigated by the technique described at the present symposium by N.S.Chistyakov and V.A.Ignatchenko (Izv. AN SSSR, Ser.fiz., 30, 61 (1966)). The signal obtained by this technique, which depends on the reaction exerted by the ferromagnetic film system on the superhigh frequency magnetic field in a resonator, increased rapidly with increasing number of layers. The observed behavior is ascribed to breakup of the eddy currents by the insulating quartz films, and it is concluded that further study will reveal possibilities for the practical application of multilayer ferromagnetic thin film systems. Orig. art. has: 1 figure. [15]

SUB CODE: 20/ SUBM DATE: none/ ORIG. REF: 001/

ATD PRESS: 4201

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L 15177-66 EWT(m)/EWP(e)/EWA(d)/EWP(t)/EWP(z)/EWP(b) IJP(c) JD/HW

ACC NR: AP6004477 SOURCE CODE: UR/0048/66/030/001/0091/0092

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B

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TITLE: Domain structure and switching of single-crystal nickel films /Transactions of the Second All-Union Symposium on the Physics of Thin Ferromagnetic Films held at Irkutsk 10 July to 15 July, 1964/

SOURCE: AN SSSR. Izvestiya. Seriya fizicheskaya, v. 30, no. 1, 1966, 91-92

TOPIC TAGS: ferromagnetic film, magnetic thin film, nickel, magnetization, single crystal, magnetic domain structure, epitaxial growing, sodium chloride

ABSTRACT: Nickel films from 200 to 1200 Å thick were deposited on NaCl substrates at 120°C, the minimum temperature for epitaxy, and their domain structures and dynamics were investigated. The (001) planes and [100] axes of the epitaxial films were parallel to the (001) planes and [100] axes, respectively, of the substrates. The easy axis in the plane of the film was in or close to the [110] direction. Epitaxial nickel films deposited on NaCl at higher temperatures usually have a fine mottled domain structure and switch by nonuniform rotation. The domain structure of the "cold" films and their switching behavior varied with the thickness. The domains of

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the films thicker than 500 Å exhibited substructure and the walls evinced a complex internal structure. Domain formation took place over the full area of the film and switching was accomplished by domain destruction without significant wall movement. These films were characterized by inclined hysteresis loops. This behavior is ascribed to inclination of the easy axis to the plane of the film, owing to the absence in that plane of a [111] axis. The easy axis of a film from 300 to 500 Å thick lay in the plane of the film in the [110] direction. These films were rather uniform and amplitude dispersion of the anisotropy was not detected. The domains were large and domain wall movement played a significant role in the switching process. Switching of films less than 300 Å thick began with the appearance of substructure owing to the nonuniform rotation of the magnetization. The behavior of these films is ascribed to amplitude dispersion of the anisotropy due to nonuniform thickness of the film. Orig. art. has: 4 figures.

SUB CODE: 20 SUBM DATE: 00 ORIG. REF: 000 OTH REF: 000

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ACC NR: AP6004478 L 15423-66 EWT(1)/EWT(m)/T/EWP(t)/EWP(b) IJP(c) JD/GG

SOURCE CODE: UR/0048/66/030/001/0093/0094 46 45 B

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21,44,55

TITLE: Concerning the coercive force of films with biaxial magnetic anisotropy /Transactions of the Second All-Union Symposium on the Physics of Thin Ferromagnetic Films held at Irkutsk 10 July to 15 July, 1964/

SOURCE: AN SSSR. Izvestiya. Seriya fizicheskaya, v.30, no. 1, 1966, 93-94, and insert facing p. 94 and 95

TOPIC TAGS: ferromagnetic film, magnetic thin film, magnetic domain structure, magnetic anisotropy, magnetic coercive force,

ABSTRACT: The coercive forces in directions forming angles of 0, 25, and 45° with an easy axis of a film with strong biaxial magnetic anisotropy are calculated on the basis of a model according to which switching takes place by processes of formation and displacement of 90° domain walls. The model adopted for switching at 25° to an easy axis involves successive formation and displacement of two sets of 90° walls and leads to two values of the coercive force. The presence of two values of the coercive force is revealed by steps in the hysteresis loops of epitaxial iron films. The calculated

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coercive forces are compared with experimental values derived from hysteresis loops. The calculated coercive forces were normalized to agree with the experimental value for 0° inclination to an easy axis, and good agreement between theory and experiment is shown for the remaining three values (two at 25° and one at 45°). It is concluded that the coercive force of films with strong biaxial magnetic anisotropy is due mainly to domain wall displacement and not to nucleation. Orig. art. has: 5 formulas, 2 figures, and 1 table.

SUB CODE: 20 SUBM DATE: 00 ORIG. REF: 002 OTH REF: 001

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