

3.4. DOMAIN STRUCTURES

$G(\mathbf{S}_1, \mathbf{S}_j)$	$G$ -orbit of domain pairs	$\bar{J}_{ik}$	sectional layer group of $J_{ik}$
$G(\mathbf{S}_1   \mathbf{n}   \mathbf{S}_j)$	$G$ -orbit of simple domain twins	$\hat{J}_{ik}$	face group, trivial subgroup, floating subgroup of sectional group of $J_{ik}$
$\mathbf{n}$	normal to a plane $p$	$r_{ik}^*$	symmetry operation of $\bar{J}_{ik}$ that exchanges $\mathbf{S}_i$ and $\mathbf{S}_k$
$p$	plane of a domain wall, domain wall plane	$\underline{s}_{ik}$	symmetry operation of $\bar{J}_{ik}$ that inverts $\mathbf{n}$ into $-\mathbf{n}$
$\mathbf{R}_1, \mathbf{R}_2, \dots, \mathbf{R}_i, \dots$	secondary ferroic single-domain states	$\underline{t}_{ik}^*$	symmetry operation of $\bar{J}_{ik}$ that exchanges $\mathbf{S}_i$ and $\mathbf{S}_k$ and inverts $\mathbf{n}$ into $-\mathbf{n}$
$\mathbf{R}_1^+, \mathbf{R}_1^-, \mathbf{R}_2^+, \mathbf{R}_2^-, \dots$	disoriented secondary ferroic domain states	$\mathbf{T}_{ik}(\mathbf{n})$	symmetry group of the twin $\mathbf{T}_{ik}(\mathbf{n})$
$\mathbf{sd} (0 \leq s < 1)$	location of a plane in crystal lattice	$\mathbf{W}_{ik}(\mathbf{n})$	symmetry group of the domain wall $\mathbf{W}_{ik}(\mathbf{n})$
$\mathbf{S}_1, \mathbf{S}_2, \dots, \mathbf{S}_i, \dots$	principal single-domain states (orientation states, variants)	$\mathcal{T}_i$	translational subgroup of $\mathcal{F}_i$
$\mathbf{S}_1^+, \mathbf{S}_1^-, \mathbf{S}_2^+, \mathbf{S}_2^-, \dots$	disoriented domain states	$\mathcal{T}_{ik}$	translational subgroup of $\mathcal{F}_{ik}$
$\mathbf{S}_1^-, \mathbf{S}_2^-, \dots, \mathbf{S}_i^-, \dots$	basic (microscopic) single-domain states (structural variants)		
$(\mathbf{S}_i, \mathbf{S}_k)$	ordered domain pair = ordered pair of domain states $\mathbf{S}_i$ and $\mathbf{S}_k$		
$\{\mathbf{S}_i, \mathbf{S}_k\}$	unordered domain pair = unordered pair of domain states $\mathbf{S}_i$ and $\mathbf{S}_k$		
$(\mathbf{S}_i   \mathbf{n}   \mathbf{S}_k)$	simple domain twin formed from single-domain states		
$(\mathbf{S}_i^+   \mathbf{n}   \mathbf{S}_k^-)$	simple ferroelastic domain twin with a compatible domain wall		
$[\mathbf{S}_i   \mathbf{n}   \mathbf{S}_k]$	domain wall in the simple twin $(\mathbf{S}_i   \mathbf{n}   \mathbf{S}_k)$		
$\mathbf{T}_{ik}(\mathbf{n})$ or $\mathbf{T}_{ik}$	simple domain twin – short symbol		
$\mathbf{W}_{ik}(\mathbf{n})$ or $\mathbf{W}_{ik}$	domain wall – short symbol		
$\varphi$	shear angle, obliquity		
$\pm \frac{1}{2} \varphi$	disorientation angle of a domain state		

(b) Symmetry groups – point groups in a continuum description and space groups in a microscopic description

$F$	point-group symmetry of the ferroic phase (domain state not specified)
$\mathcal{F}$	space-group symmetry of the ferroic phase (domain state not specified)
$F_i$	point-group symmetry of a principal domain state $\mathbf{S}_i$
$\mathcal{F}_i$	space-group symmetry of a basic (microscopic) domain state $\mathbf{S}_i$
$F_{ik}$	point-group symmetry (stabilizer in $G$ ) of the ordered domain pair $(\mathbf{S}_i, \mathbf{S}_k)$
$\mathcal{F}_{ik}$	space-group symmetry (stabilizer in $\mathcal{G}$ ) of the ordered domain pair $(\mathbf{S}_i, \mathbf{S}_k)$
$\bar{F}_{ik}$	sectional layer group of $F_{ik}$
$\hat{F}_{ik}$	face group, trivial layer group, scanning group of $F_{ik}$
Fam $G$	crystal family of the group $G$
$G$	point-group symmetry of the parent phase
$\mathcal{G}$	space-group symmetry of the parent phase
$g$	point-group symmetry operation of the group $G(\mathcal{G})$
$\mathbf{g}$	space-group symmetry operation of the group $\mathcal{G}$
$g_{ik}$	switching operation in domain pair $(\mathbf{S}_i, \mathbf{S}_k)$ , transforms $\mathbf{S}_i$ into $\mathbf{S}_k$
$g_{ik}^*$	transposing operation in domain pair $(\mathbf{S}_i, \mathbf{S}_k)$ , exchanges $\mathbf{S}_i$ and $\mathbf{S}_k$ , twinning operation of a non-ferroelastic domain pair $(\mathbf{S}_i, \mathbf{S}_k)$
$I_G(\mathbf{S}_i)$	stabilizer (isotropy group) of $\mathbf{S}_i$ in $G$
$\mathcal{I}_{\mathcal{G}}(\mathbf{S}_i)$	stabilizer (isotropy group) of $\mathbf{S}_i$ in $\mathcal{G}$
$J_{ik}$	point-group symmetry (stabilizer in $G$ ) of the unordered domain pair $\{\mathbf{S}_i, \mathbf{S}_k\}$
$J_{ik}^*$	point-group symmetry (stabilizer in $G$ ) of a completely transposable domain pair $\{\mathbf{S}_i, \mathbf{S}_k\}$
$\mathcal{J}_{ik}$	space-group symmetry (stabilizer in $\mathcal{G}$ ) of the unordered domain pair $\{\mathbf{S}_i, \mathbf{S}_k\}$
$K_{ik}$	twinning group of the domain pair $(\mathbf{S}_i, \mathbf{S}_k)$
$K_{ik}^*$	twinning group of a completely transposable domain pair $(\mathbf{S}_i, \mathbf{S}_k)$
$L_i$	intermediate group, $F_i \in L_i \in G$

(c) Components of property tensors

$\varepsilon$	enantiomorphism
$P_i$	polarization
$u_\mu$	strain
$g_\mu$	optical activity
$d_{i\mu}$	piezoelectricity
$A_{iv}$	electrogyration
$s_{\mu\nu}$	linear elasticity
$Q_{\mu\nu}$	electrostriction

$i = 1, 2, 3; \mu, \nu = 1, 2, \dots, 6.$

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References

Aizu, K. (1969). Possible species of 'ferroelastic' crystals and of simultaneously ferroelectric and ferroelastic crystals. *J. Phys. Soc. Jpn*, **27**, 387–396.

Aizu, K. (1970a). Possible species of ferromagnetic, ferroelectric and ferroelastic crystals. *Phys. Rev. B*, **2**, 754–772.

Aizu, K. (1970b). Determination of the state parameters and formulation of spontaneous strain for ferroelastics. *J. Phys. Soc. Jpn*, **28**, 706–716.

Aizu, K. (1972). Electrical, mechanical and electromechanical orders of state shifts in nonmagnetic ferroic crystals. *J. Phys. Soc. Jpn*, **32**, 1287–1301.

Aizu, K. (1973). Second-order ferroic state shifts. *J. Phys. Soc. Jpn*, **34**, 121–128.

Altmann, S. L. & Herzig, P. (1994). *Point-group theory tables*. Oxford: Clarendon Press.

Amin, A. & Newnham, R. E. (1980). Tertiary ferroics. *Phys. Status Solidi A*, **61**, 215–219.

Barkley, J. R. & Jeitschko, W. (1973). Antiphase boundaries and their interactions with domain walls in ferroelastic–ferroelectric  $Gd_2(MoO_4)_3$ . *J. Appl. Phys.* **44**, 938–944.

Bertagnolli, E., Kittinger, E. & Tichý, J. (1978). Observation of reversible elastic Dauphiné twinning in alpha-quartz. *J. Phys. (Paris) Lett.* **39**, 295–297.

Bertagnolli, E., Kittinger, E. & Tichý, J. (1979). Ferrobielastic hysteresis in alpha-quartz. *J. Appl. Phys.* **50**, 6267–6271.

Boulesteix, C. (1984). A survey of domains and domain walls generated by crystallographic phase transitions causing a change of the lattice. *Phys. Status Solidi A*, **86**, 11–42.

Bradley, C. J. & Cracknell, A. P. (1972). *The mathematical theory of symmetry in solids*. Oxford: Clarendon Press.

Bul'bich, A. A. & Gufan, Yu. M. (1989a). Inevitable symmetry lowering in a domain wall near a reordering phase transition. *Sov. Phys. JETP*, **67**, 1153–1157.

Bul'bich, A. A. & Gufan, Yu. M. (1989b). Phase transition in domain walls. *Ferroelectrics*, **172**, 351–359.

Cahn, R. W. (1954). Twinned crystals. *Adv. Phys.* **3**, 363–445.

Calleja, M., Dove, M. T. & Salje, E. K. H. (2001). Anisotropic ionic transport in quartz: the effect of twin boundaries. *J. Phys. Condens. Matter*, **13**, 9445–9454.

### 3. PHASE TRANSITIONS, TWINNING AND DOMAIN STRUCTURES

- Cao, W. & Barsch, G. R. (1990). *Landau–Ginzburg model of interphase boundaries in improper ferroelastic perovskites of  $D_{4h}^{18}$  symmetry*. *Phys. Rev. B*, **41**, 4334–4348.
- Carpenter, M. A., Salje, E. K. H. & Graeme-Barber, A. (1998). *Spontaneous strain as a determinant of thermodynamic properties for phase transitions in minerals*. *Eur. J. Mineral.* **10**, 621–691.
- Catti, M. & Ferraris, G. (1976). *Twinning by merohedry and X-ray structure determination*. *Acta Cryst.* **A32**, 163–165.
- Chen, X. J., Liu, J. S., Zhu, J. S. & Wang, Y. N. (2000). *Group theoretical analysis of the domain structure of  $SrBi_2Ta_2O_9$  ferroelectric ceramic*. *J. Phys. Condens. Matter*, **12**, 3745–3749.
- Christian, J. W. (1975). *The theory of transformations in metals and alloys*. Oxford: Pergamon Press.
- Chrosch, J. & Salje, E. K. H. (1999). *Temperature dependence of the domain wall width in  $LaAlO_3$* . *J. Appl. Phys.* **85**, 722–727.
- Curien, H. & Donnay, J. D. H. (1959). *The symmetry of the complete twin*. *Am. Mineral.* **44**, 1067–1070.
- Curien, H. & Le Corre, Y. (1958). *Notation des macles à l'aide du symbolisme des groupes de couleurs de Chubnikov*. *Bull. Soc. Fr. Mineral. Cristallogr.* **81**, 126–132.
- Dolino, G. (1985). In *Modern problems in condensed matter sciences*. Vol. 2, *Incommensurate phases in dielectrics*, edited by R. Blinc & A. P. Levanyuk, pp. 207–231. Amsterdam: North-Holland.
- Dudnik, E. F. & Shuvalov, L. A. (1989). *Domain structure and phase boundaries in ferroelastics*. *Ferroelectrics*, **98**, 207–234.
- Erhart, J. & Cao, W. (2001). *Effective symmetry and physical properties of twinned perovskite ferroelectric single crystals*. *J. Mater. Res.* **16**, 570–578.
- Fatuzzo, E. & Merz, W. J. (1967). *Ferroelectricity*. Amsterdam: North-Holland.
- Fesenko, E. G., Gavrilyachenko, B. G. & Semenchov, A. F. (1990). *Domain structure in multiaxial ferroelectric crystals*. Rostov on Don: Publishing House of the Rostov University (in Russian).
- Fousek, J. (1971). *Permissible domain walls in ferroelectric species*. *Czech. J. Phys. B*, **21**, 955–968.
- Fousek, J. & Janovec, V. (1969). *The orientation of domain walls in twinned ferroelectric crystals*. *J. Appl. Phys.* **40**, 135–142.
- Friedel, G. (1926). *Leçons de cristallographie*. Nancy, Paris, Strasbourg: Berger-Levrault. Reprint (1964). Paris: Blanchard.
- Fuksa, J. (1997). *The role of the twinning group of a domain pair in tensor distinction of domain states*. *Ferroelectrics*, **204**, 135–155.
- Fuksa, J. & Janovec, V. (1995). *Permutation classification of domain pairs*. *Ferroelectrics*, **172**, 343–350.
- Grell, H., Krause, C. & Grell, J. (1989). *Tables of the 80 plane space groups in three dimensions*. Berlin: Akademie der Wissenschaften der DDR.
- Hahn, Th. & Wondratschek, H. (1994). *Symmetry of crystals. Introduction to International Tables for Crystallography Vol. A*. Sofia: Heron Press.
- Hatch, D. M. & Cao, W. (1999). *Determination of domain and domain wall formation at ferroic transitions*. *Ferroelectrics*, **222**, 1–10.
- Hatch, D. M., Ghose, S. & Stokes, H. (1990). *Phase transitions in leucite,  $KAl_2O_6$ . I. Symmetry analysis with order parameter treatment and the resulting microscopic distortions*. *Phys. Chem. Mineral.* **17**, 220–227.
- Hatt, R. A. & Hatch, D. M. (1999). *Order parameter profiles in ferroic phase transitions*. *Ferroelectrics*, **226**, 61–78.
- Holser, W. T. (1958a). *Relation of symmetry to structure in twinning*. *Z. Kristallogr.* **110**, 249–265.
- Holser, W. T. (1958b). *Point groups and plane groups in a two-sided plane and their subgroups*. *Z. Kristallogr.* **110**, 266–281.
- Houchmandzadeh, B., Lajzerowicz, J. & Salje, E. K. H. (1991). *Order parameter coupling and chirality of domain walls*. *J. Phys. Condens. Matter*, **3**, 5163–5169.
- Huang, X. R., Jiang, S. S., Hu, X. B. & Liu, W. J. (1997). *Theory of twinning structures in the orthorhombic phase of ferroelectric perovskites*. *J. Phys. Condens. Matter*, **9**, 4467–4482.
- IEEE Standards on Piezoelectricity* (1987). IEEE Std 176-987. New York: The Institute of Electrical and Electronics Engineers, Inc.
- Indenbom, V. L. (1982). In *Modern crystallography II*, edited by B. K. Vainshtein, V. M. Fridkin & V. L. Indenbom, pp. 387–396. Berlin: Springer.
- International Tables for Crystallography* (2002). Vol. A, *Space-group symmetry*, 5th edition, edited by Th. Hahn. Dordrecht: Kluwer Academic Publishers.
- International Tables for Crystallography* (2002). Vol. E, *Subperiodic groups*, edited by V. Kopský & D. B. Litvin. Dordrecht: Kluwer Academic Publishers.
- Ishibashi, Y. (1990). *Structure and physical properties of domain walls*. *Ferroelectrics*, **104**, 299–310.
- Ishibashi, Y. (1992). *Domain walls in crystals with incommensurate phases. II*. *J. Phys. Soc. Jpn.* **61**, 357–362.
- Ishibashi, Y. (1993). *The  $90^\circ$ -wall in the tetragonal phase of  $BaTiO_3$ -type ferroelectrics*. *J. Phys. Soc. Jpn.* **62**, 1044–1047.
- Janovec, V. (1972). *Group analysis of domains and domain pairs*. *Czech. J. Phys. B*, **22**, 974–994.
- Janovec, V. (1976). *Symmetry approach to domain structures*. *Ferroelectrics*, **12**, 43–53.
- Janovec, V. (1981). *Symmetry and structure of domain walls*. *Ferroelectrics*, **35**, 105–110.
- Janovec, V., Litvin, D. B. & Fuksa, J. (1995). *Transposable domain pairs and domain distinction*. *Ferroelectrics*, **172**, 351–359.
- Janovec, V., Richterová, L. & Litvin, D. B. (1993). *Non-ferroelastic twin laws and distinction of domains in non-ferroelastic phases*. *Ferroelectrics*, **140**, 95–100.
- Janovec, V., Schranz, W., Warhanek, H. & Zikmund, Z. (1989). *Symmetry analysis of domain structure in KSCN crystals*. *Ferroelectrics*, **98**, 171–189.
- Janovec, V. & Zikmund, Z. (1993). *Microscopic structure of domain walls and antiphase boundaries in calomel crystals*. *Ferroelectrics*, **140**, 89–93.
- Jerphagnon, J., Chemla, D. & Bonneville, R. (1978). *The description of the physical properties of condensed matter using irreducible tensors*. *Adv. Phys.* **27**, 609–650.
- Jona, F. & Shirane, G. (1962). *Ferroelectric crystals*. Oxford: Pergamon Press.
- Kalonji, G. (1985). *A roadmap for the use of interfacial symmetry groups*. *J. Phys. (Paris) Colloq.* **46**, 49–556.
- Känzig, W. (1957). *Ferroelectrics and antiferroelectrics*. In *Solid state physics IV*, edited by F. Seitz & D. Turnbull, pp. 1–197. New York: Academic Press.
- Klassen-Neklyudova, M. V. (1964). *Mechanical twinning of crystals*. New York: Consultants Bureau.
- Knox, R. S. & Gold, A. (1967). *Symmetry in the solid state. Introduction*. New York: W. A. Benjamin.
- Koch, E. (1999). *Twinning*. In *International tables for crystallography*, Vol. C, *Mathematical, physical and chemical tables*, 2nd edition, edited by A. J. C. Wilson & E. Prince, Section 1.3. Dordrecht: Kluwer Academic Publishers.
- Koňák, Č., Kopský, V. & Smutný, F. (1978). *Gyrotropic phase transitions*. *J. Phys. Solid State Phys.* **11**, 2493–2518.
- Kopský, V. (1979). *Tensorial covariants for the 32 crystal point groups*. *Acta Cryst.* **A35**, 83–95.
- Kopský, V. (1982). *Group lattices, subduction of bases and fine domain structures for magnetic point groups*. Prague: Academia.
- Kopský, V. (1993). *Translation normalizers of Euclidean motion groups*. *J. Math. Phys.* **34**, 1548–1576.
- Kopský, V. (2001). *Tensor parameters of ferroic phase transitions I. Theory and tables*. *Phase Transit.* **73**, 1–422.
- Lines, M. E. & Glass, A. M. (1977). *Principles and applications of ferroelectric and related materials*. Oxford: Clarendon Press.
- Litvin, D. B. & Janovec, V. (1999). *Classification of domain pairs and tensor distinction*. *Ferroelectrics*, **222**, 87–93.
- Locherer, K. R., Chrosch, J. & Salje, E. K. H. (1998). *Diffuse X-ray scattering in  $WO_3$* . *Phase Transit.* **67**, 51–63.
- Mitsui, T., Tatsuzaki, I. & Nakamura, E. (1976). *An introduction to the physics of ferroelectrics*. New York: Gordon & Breach.
- Newnham, R. E. (1974). *Domains in minerals*. *Am. Mineral.* **59**, 906–918.
- Newnham, R. E. (1975). *Structure–property relations*. Berlin: Springer.
- Newnham, R. E. & Cross, L. E. (1974a). *Symmetry of secondary ferroics I*. *Mater. Res. Bull.* **9**, 927–934.
- Newnham, R. E. & Cross, L. E. (1974b). *Symmetry of secondary ferroics II*. *Mater. Res. Bull.* **9**, 1021–1032.
- Newnham, R. E., Miller, C. S., Cross, L. E. & Cline, T. W. (1975). *Tailored domain patterns in piezoelectric crystals*. *Phys. Status Solidi A*, **32**, 69–78.
- Newnham, R. E. & Skinner, D. P. Jr (1976). *Polycrystalline secondary ferroics*. *Mater. Res. Bull.* **11**, 1273–1284.
- Nye, J. F. (1985). *Physical properties of crystals*. Oxford: Clarendon Press.
- Opechowski, W. (1986). *Crystallographic and metacrystallographic groups*. Amsterdam: North-Holland.

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- Palmer, D. C., Putnis, A. & Salje, E. K. H. (1988). *Twinning in tetragonal leucite*. *Phys. Chem. Mineral.* **16**, 298–303.
- Pond, R. C. & Bollmann, W. (1979). *The symmetry and interfacial structure of bicrystals*. *Philos. Trans. R. Soc. London Ser. A*, **292**, 449–472.
- Pond, R. C. & Vlachavas, D. S. (1983). *Bicrystallography*. *Proc. R. Soc. London Ser. A*, **386**, 95–143.
- Přivratská, J. & Janovec, V. (1997). *Pyromagnetic domain walls connecting antiferromagnetic non-ferroelastic domains*. *Ferroelectrics*, **204**, 321–331.
- Přivratská, J. & Janovec, V. (1999). *Spontaneous polarization and/or magnetization in non-ferroelastic domain walls: symmetry predictions*. *Ferroelectrics*, **222**, 23–32.
- Přivratská, J., Janovec, V. & Machonský, L. (2000). *Tensor properties discriminating domain walls from non-ferroelastic domains*. *Ferroelectrics*, **240**, 83–92.
- Putnis, A. (1992). *Introduction to mineral sciences*. Cambridge University Press.
- Rosenman, G., Skliar, A., Eger, D., Oron, M. & Katz, M. (1998). *Low temperature periodic electrical poling of flux-grown  $\text{KTiOPO}_4$  and isomorphic crystals*. *Appl. Phys. Lett.* **73**, 3650–3652.
- Rosová, A. (1999). *Real domain structure origination in (110) mechanical twinning in  $\text{YBa}_2\text{Cu}_3\text{O}_{7-y}$* . In *Studies of high temperature superconductors*, Vol. 28, edited by A. Narlikar, pp. 125–148. New York: Nova Science Publishers.
- Rosová, A., Boulesteix, C. & Vávra, I. (1993). *Role of microtwins in twin lamella intersections and interconnections in  $\text{YBa}_2\text{Cu}_3\text{O}_{7-y}$* . *Physica C*, **214**, 247–256.
- Rychetský, I. & Schranz, W. (1993). *Antiphase boundaries in  $\text{Hg}_2\text{Br}_2$  and  $\text{KSCN}$* . *J. Phys. Condens. Matter*, **5**, 1455–1472.
- Rychetský, I. & Schranz, W. (1994). *Ferroelastic domain walls in  $\text{Hg}_2\text{Br}_2$  and  $\text{KSCN}$* . *J. Phys. Condens. Matter*, **6**, 11159–11165.
- Saint-Grégoire, P. & Janovec, V. (1989). *Modulated phases in crystals: Symmetry of walls and wall lattices. Example of quartz*. In *Nonlinear coherent structures*, edited by M. Bartes & J. Léon. *Lecture notes in physics*, Vol. 353, pp. 117–126. Berlin: Springer.
- Saint-Grégoire, P., Janovec, V. & Kopský, V. (1997). *A sample analysis of domain walls in simple cubic phase of  $\text{C}_{60}$* . *Ferroelectrics*, **191**, 73–78.
- Salje, E. K. H. (1990). *Phase transitions in ferroelastic and co-elastic crystals*, 1st edition. Cambridge University Press.
- Salje, E. K. H. (1991). *Strain-related transformation twinning in minerals*. *Neues Jahrb. Mineral. Abh.* **163**, 43–86.
- Salje, E. K. H. (2000a). *Mesoscopic twin patterns in ferroelastic and co-elastic minerals*. *Rev. Mineral. Geochem.* **39**, 65–84.
- Salje, E. K. H. (2000b). *Ferroelasticity*. *Contemp. Phys.* **41**, 79–91.
- Sapriel, J. (1975). *Domain-wall orientations in ferroelastics*. *Phys. Rev. B*, **12**, 5128–5140.
- Schlenker, J. L., Gibbs, G. V. & Boisen, M. B. (1978). *Strain-tensor components expressed in terms of lattice parameters*. *Acta Cryst.* **A34**, 52–54.
- Schmid, H. (1991). *Polarized light microscopy of the ferroelastic domains of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$* . *Phase Transit.* **30**, 205–214.
- Schmid, H. (1993). *Polarized light microscopy (PLM) of ferroelectric and ferroelastic domains in transmitted and reflected light*. In *Ferroelectric ceramics*, edited by N. Setter & E. L. Colla, pp. 107–126. Basel: Birkhäuser.
- Schmid, H., Burkhardt, E., Walker, E., Brixel, W., Clin, M., Rivera, J.-P., Jorda, J.-L., François, M. & Yvon, K. (1988). *Polarized light and X-ray precession study of the ferroelastic domains of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$* . *Z. Phys. B Condens. Matter*, **72**, 305–322.
- Schranz, W. (1995). *Domains and interfaces near ferroic phase transitions*. *Key Eng. Mater.* **101–102**, 41–60.
- Scott, J. (1998). *The physics of ferroelectric ceramic thin films for memory applications*. *Ferroelectrics Rev.* **1**, 1–129.
- Scott, J. (2000). *Ferroelectric memories*. Heidelberg: Springer.
- Shmyt'ko, I. M., Shekhtman, V. Sh., Ossipyan, Yu. A. & Afonikova, N. S. (1987). *Twin structure and structure of twin boundaries in 1-2-3- $\text{O}_{7-\delta}$  crystals*. *Ferroelectrics*, **97**, 151–170.
- Shubnikov, A. V. & Kopcik, V. A. (1974). *Symmetry in science and art*. New York: Plenum Press.
- Shur, V. Ya., Batchko, R. G., Rummyantsev, E. L., Miller, G. D., Fejer, M. M. & Byer, R. L. (1999). *Domain engineering: periodic domain patterning in lithium niobate*. *Proc. 11th ISAF*, pp. 399–406. Piscataway, NJ: IEEE.
- Shur, V. Ya., Gruverman, A. L., Letuchev, V. V., Rummyantsev, E. L. & Subbotin, A. L. (1989). *Domain structure of lead germanate*. *Ferroelectrics*, **98**, 29–49.
- Shur, V. Ya., Rummyantsev, E. L., Nikolaeva, E. V., Shishkin, E. I., Batchko, R. G., Fejer, M. M. & Byer, R. L. (2001). *Recent achievements in domain engineering in lithium niobate and lithium tantalate*. *Ferroelectrics*, **257**, 191–202.
- Shuvalov, L. A. (1988). Editor. *Modern crystallography IV. Physical properties of crystals*. Berlin: Springer.
- Shuvalov, L. A., Dudnik, E. F. & Wagin, S. V. (1985). *Domain structure geometry of real ferroelastics*. *Ferroelectrics*, **65**, 143–152.
- Shuvalov, L. A. & Ivanov, N. R. (1964). *Change in the optical activity of ferroelectric crystals on reversal of polarization*. *Sov. Phys. Crystallogr.* **9**, 290–299. (*Kristallografiya*, **9**, 363–372.)
- Sidorkin, A. S. (2002). *Domain structure in ferroelectrics and related materials*. Moscow: Fizmatlit (in Russian).
- Sirotnin, Yu. I. & Shaskolskaya, M. P. (1982). *Fundamentals of crystal physics*. Moscow: Mir.
- Smolenskii, G. A., Bokov, V. A., Isupov, V. A., Krainik, N. N., Pasyukov, R. E. & Shur, M. S. (1984). *Physics of ferroelectric phenomena*. New York: Gordon & Breach.
- Snoeck, E., Saint-Grégoire, P., Janovec, V. & Roucau, C. (1994). *TEM study of 3-q modulated phase of quartz-type under electric field*. *Ferroelectrics*, **155**, 171–176.
- Sonin, E. B. & Tagancev, A. K. (1989). *Structure and phase transitions in antiphase boundaries of improper ferroelectrics*. *Ferroelectrics*, **98**, 291–295.
- Strukov, B. A. & Levanyuk, A. P. (1998). *Ferroelectric phenomena in crystals*. Berlin: Springer.
- Sutton, A. P. & Balluffi, R. W. (1995). *Interfaces in crystalline materials*. Oxford: Clarendon Press.
- Tagancev, A. R. & Sonin, E. B. (1989). *Linear singularities and their motion in improper ferroelectrics*. *Ferroelectrics*, **98**, 297–300.
- Tolédano, J.-C. & Tolédano, P. (1987). *The Landau theory of phase transitions*. Singapore: World Scientific.
- Tolédano, P. & Dmitriev, V. (1996). *Reconstructive phase transitions*. Singapore: World Scientific.
- Tomaszewski, P. E. (1992). *Structural phase transitions in crystals. I. Database. II. Statistical analysis*. *Phase Transit.* **38**, 127–220, 221–228.
- Uchino, K. (2000). *Ferroelectric devices*. New York: Marcel Dekker.
- Vainshtein, B. K. (1994). *Modern crystallography I. Symmetry of crystals*. Berlin: Springer.
- Van Landuyt, J., Van Tendeloo, G., Amelinckx, S. & Walker, M. B. (1985). *Interpretation of Dauphiné-twin-domain configurations resulting from the  $\alpha$ - $\beta$  phase transition in quartz and aluminium phosphate*. *Phys. Rev. B*, **31**, 2986–2992.
- Van Tendeloo, G. & Amelinckx, S. (1974). *Group-theoretical considerations concerning domain formation in ordered alloys*. *Acta Cryst.* **A30**, 431–440.
- Wadhawan, V. K. (1991). *Ferroelasticity: introductory survey and present status*. *Phase Transit.* **34**, 3–18.
- Wadhawan, V. K. (2000). *Introduction to ferroic materials*. The Netherlands: Gordon and Breach.
- Wondratschek, H. & Aroyo, M. I. (2001). *The application of Hermann's group  $\mathcal{M}$  in group-subgroup relations between space groups*. *Acta Cryst.* **A57**, 311–320.
- Wondratschek, H. & Jeitschko, W. (1976). *Twin domains and antiphase domains*. *Acta Cryst.* **A32**, 664–666.
- Xu, Y. (1991). *Ferroelectric materials and their applications*. Amsterdam: North-Holland.
- Yin, J. & Cao, W. (2000). *Domain configurations in domain engineered  $0.995\text{Pb}(\text{Zn}_{1/3}\text{Nb}_{2/3})\text{O}_3$ - $0.045\text{PbTiO}_3$  single crystals*. *J. Appl. Phys.* **87**, 7438–7441.
- Zheludev, I. S. (1988). *Electrical properties of crystals*. In *Modern crystallography IV. Physical properties of crystals*, edited by L. A. Shuvalov, pp. 178–266. Berlin: Springer-Verlag.
- Zieliński, P. (1990). *Group-theoretical description of domains and phase boundaries in crystalline solids*. *Surf. Sci. Rep.* **11**, 179–223.
- Zikmund, Z. (1984). *Symmetry of domain pairs and domain walls*. *Czech. J. Phys. B*, **34**, 932–949.