

REFERENCES

- [1] S.H. Pyke, Sol-gel synthesis of lead titanate and lead zirconate titanate thin film, University of Leeds. UK. 1991.
- [2] A. Okada, Some electrical and optical properties of ferroelectric lead zirconate-lead-titanate thin films. *J. Appl. Phys.*, **48**[7] (1977) 2905-2909.
- [3] S. Matsubara, N. Shohata and M. Mikami, Epitaxial growth of PbTiO_3 on $\text{MgAl}_2\text{O}_4/\text{Si}$ substrate, *Jpn. J. Appl. Phys.*, **24** (1985) 10-12.
- [4] R.A. Roy, K.F. Etzold and J.J. Cuomo, Ferroelectric Thin Films, in Myers and A.I. Kingon (Ed.), Pittsburgh, 1990.
- [5] Y. Matsui, M. Okuyama, M. Noda and Y. Hamakawa, A study of electronic states near the interface in ferroelectric--semiconductor heterojunction prepared by rf sputtering of PbTiO_3 , *J. Appl. Phys.*, **A 28** (1982) 161-166.
- [6] D.A. Barrow, T.E. Petroff and M. Sayer, Thick ceramic coating using a sol gel based ceramic-ceramic 0-3 composite, *Surf. Coat. Tech.*, **76-77** (1995) 113-118.
- [7] D.L. Corker, Q. Zhang, R.W. Whatmore and C. Perrin, PZT 'composite' ferroelectric thick films, *J. Eur. Ceram. Soc.*, **22** (2002) 383 -390.
- [8] M. Sayer, P. Nolan and C.M. Hansson, Scanning electron microscopy without pain the environmental SEM, *J. Can. Ceram. Soc.*, **62** (1993) 104-105.
- [9] C.L. Zhao, Z.H. Wang, W.G. Zhu and O.K. Tan, Sol-gel derived PZT thick films with nano-sized microstructure, Fall meeting, MRS2002, Boston, 2002.

- [10] C. Zhao, Z. Wang, W. Zhu, O. Tan and H. Hng, Microstructure and properties of PZT53/47 thick films derived from sols with submicron-sized PZT particle, *Ceram. Int.*, **30** (2004) 1925 -1927.
- [11] S.R. Darvish and A.C. Rastogi, Ferroelectric behaviour of PZT thin films with secondary TiO₂ phase induced defects, *J. Phys. D: Appl. Phys.*, **33** (2000) 2117-2124.
- [12] M.T.N. Pham, B.A. Boukamp, H.J.M. Bouwmeester and D.H.A. Blank, Microstructural and electrical properties of nanocomposite PZT/Pt thin films made by pulsed laser deposition, *Ceram. Int.*, **30** (2004) 1499-1503.
- [13] H.J. Hwang, M. Toriyama, T. Sekino, and K. Niihara, In-situ Fabrication of ceramic/metal nanocomposites by reduction reaction in barium titanate-metal oxide systems, *J. Euro. Ceram. Soc.*, **18** (1998) 2193 -2199.
- [14] X.J. Lou, Polarization fatigue in ferroelectric thin films and related materials, *J. Appl. Phys.*, **105** (2009) 024101–024124.
- [15] H.J. Hwang, T. Sekino, K. Ota and K. Niihara, Perovskite-type BaTiO₃ ceramics containing particulate SiC. part I structure variation and phase transformation, *J. Mat. Sci.*, **31** (1996) 4617-4624.
- [16] H.J. Hwang, M. Toriyama, T. Sekino, and K. Niihara, In-situ Fabrication of ceramic/metal nanocomposites by reduction reaction in barium titanate-metal oxide systems, *J. Euro. Ceram. Soc.*, **18** (1998) 2193 -2199.

- [17] H.J. Hwang, K. Tajima, M. Sando, M. Toriyama and K. Niihara, Microstructure and mechanical properties of lead zirconate titanate (PZT) nanocomposites with platinum particles, *J. Ceram. Soc. Jpn.*, **108** (2000) 339 -344.
- [18] J-F. Li, K. Takagi, N. Terakubo and R. Watanabe, Electrical and mechanical properties of piezoelectric ceramic/metal composites in the $\text{Pb}(\text{Zr,Ti})\text{O}_3/\text{Pt}$ system, *Appl. Phys. Letter.* **79** (2001) 2441-2443.
- [19] N. Duan, J.E. ten Elshof and H. Verweij, Sintering and electrical properties of PZT/Pt dual-phase composites, *J. Euro. Ceram. Soc.*, **21** (2001) 2325 -2329.
- [20] K. Takagi, J-F. Li, S. Yokoyama, R. Watanabe, A. Almajid and M. Taya, Design and fabrication of functionally graded PZT/Pt piezoelectric bimorph actuator, *Sci. Techno. Adv. Mater.*, **3** (2002) 217-224.
- [21] K. Takagi, J-F. Li, S. Yokoyama and R. Watanabe, Fabrication and evaluation of PZT/Pt piezoelectric composites and functionally graded actuators, *J. Euro. Ceram. Soc.*, **23** (2003) 1577-1583.
- [22] K. Tajima, H.J. Hwang, M. Sando and K. Niihara, PZT nanocomposites reinforced by small amount of oxides, *J. Euro. Ceram. Soc.*, **19** (1999) 1179-1182.
- [23] K. Tajima, H.J. Hwang, M. Sando and K. Niihara, 28GHz microwave sintering for high performance PZT-based nanocomposites, *Key Engineering Materials*, **161-163** (1999) 505 -508.

- [24] K. Tajima, H.J. Hwang, M. Sando and K. Niihara, Mechanical and electrical properties change for PZT by an addition of small amount of oxide, *J. Ceram. Soc. Jpn.*, **108** (2000) 607-610.
- [25] C. Puchmark, G. Rujjijanukul, S. Jiansirisomboon, T. Tunkasiri, N. Vittayakorn, T. Comyn and S.J. Milne, Mechanical property evaluation of PZT/ Al_2O_3 composites prepared by a simple solid-state mixed oxide method, *Curr. Appl. Phys.* **6** (2006) 323-326.
- [26] P.H. Xiang, X.L. Dong, H. Chen, Z. Zhang and J.K. Guo, Mechanical and electrical properties of small amount of oxides reinforced PZT ceramics, *J. Ceram. Int.*, **29** (2003) 499 -503.
- [27] P.H. Xiang, X.L. Dong, C.D. Feng and Y.L. Wang, Fabrication of NiO nanoparticle-coated lead zirconate titanate powders by the heterogeneous precipitation method, *J. Am. Ceram. Soc.*, **86** (2004) 1631-1634.
- [28] P.H. Xiang, X-L. Dong, C-D. Feng, N. Zhong and J-K. Guo, Sintering behavior, mechanical and electrical properties of lead zirconate titanate/NiO composites from coated powders, *Ceram. Inter.*, **30** (2004) 765 -772.
- [29] S. Jiansirisomboon, M. Promsawat, O. Namsar and A. Watcharapasorn, Fabrication- structure – properties relations of nano-sized NiO incorporated PZT ceramics, *Mater. Chem. Phys.*, **117** (2009) 80-85.
- [30] P.H. Xiang, X.L. Dong, C.D. Feng, H. Chen and Y.L. Wang, Microstructure and mechanical properties of small amounts of In_2O_3 reinforced $\text{Pb}(\text{Zr}_x\text{Ti}_{1-x})\text{O}_3$ ceramics, *Mater. Res. Bull.*, **38** (2003) 1147-1154.

- [31] S. Jiansirisomboon, T. Sreesattabud and A. Watcharapasorn, Electrical and mechanical properties of ferroelectric lead zirconate titanate/tungsten oxide ceramics, *Ceram. Int.*, **34** (2008) 719-722.
- [32] M. Promsawat, A. Watcharapasorn, T. Sreesattabud and S. Jiansirisomboon, Effect of ZnO nano – particulates on structure and properties of PZT/ZnO ceramics, *Ferroelectrics*, **382** (2009) 166-172.
- [33] A.M. Bratkovsky and A.P. Levanyuk, *Phys. Rev. Lett.*, **84** (2000) 3177.
- [34] J.H. Jang and K.H. Yoon, Electric fatigue properties of sol-gel-derived $\text{Pb}(\text{Zr,Ti})\text{O}_3/\text{PbZrO}_3$ multilayered thin films, *Appl. Phys. Lett.* **75** (1999) 130–132.
- [35] Q. Zhang and R.W. Whatmore, Low fatigue lead zirconate titanate-based capacitor modified by manganese for nonvolatile memories, *Mat. Sci. Eng. B.* **109** (2004) 136–140.
- [36] R.D. Klissurska, K.G. Brooks, N. Setter, Acceptor dopant effects on endurance of PZT thin films, *Ferroelectrics*, **225** (1999) 977–984.
- [37] S. Jiansirisomboon, T. Sreesattabud, A. Watcharapasorn, Electrical and mechanical properties of ferroelectric lead zirconate titanate/tungsten oxide ceramics, *Ceram. Int.*, **34** (2008) 719–722.
- [38] G.H. Haertling, Ferroelectric ceramics: History and technology, *J. Am. Ceram. Soc.*, **82** (1999) 797- 818.
- [39] A.J. Moulson and J.M. Herbert, Electroceramics: Materials, Properties, Applications, 2nd, in Chichester (ed.), John Wiley & Sons Ltd., 2003.

- [40] B. Jaffe, W.R. Cook and H. Jaffe, in *Piezoelectric Ceramics*, Academic Press, London, 1971.
- [41] K. Uchino, *Ferroelectrics Devices*, New York, Marcel Dekker, 2000.
- [42] R. Gerson, Variation in ferroelectric characteristics of lead zirconate titanate ceramics due to minor chemical modifications, *J. Appl. Phys.*, **31** (1960) 188-194.
- [43] X. Yuhuan, *Ferroelectric Materials and Their Applications*, Amsterdam and Tokyo, North-Holland, 1991.
- [44] Q. Tan, Z. Xu, J.F. Li and D. Viehland, Influence of lower-valent A-site modifications on the structure-property relation of lead zirconate titanate, *J. Appl. Phys.*, **80** (1996) 5866-5874.
- [45] B.H. Park, B.S. Kang, S.D. Bu, T.W. Noh, J. Lee and W. Jo, Lanthanum-substituted bismuth titanate for use in non-volatile memories, *Nature*, **401** (1999) 682-684.
- [46] D.A. Barrow, T.E. Petroff and M. Sayer, Thick ceramic coating using a sol gel based ceramic-ceramic 0-3 composite, *Surf. Coat. Tech.*, **76-77** (1995) 113-118.
- [47] K. Lefki and G.J.M. Dormans, Measurement of piezoelectric coefficients of ferroelectric thin films. *J. Appl. Phys.*, **76** (1994) 1764-1767.
- [48] D. Damjanovic, K.G. Brooks, A. Kholkin, M. Kohli, T. Maeder, P. Muralt and N. Setter, Properties of Piezoelectric PZT Thin Films for Microactuator Applications. in: E.P. George, S. Takahashi, S. Trolier-Mckinstry, K. Uchino and M. Wun-Fogle (Eds.), *Materials for Smart Systems*, MRS, Boston, MA, 1994, p. 429.

- [49] S. Trolier-Mckinsty and P. Muralt, Thin Film Piezoelectrics for MEMS, *J. Electroceram.* **12** (2004) 7–17.
- [50] N. Ledermann, P. Muralt, J. Baborowski, S. Gentil, K. Mukati, M. Cantoni, A. Seifert and N. Setter, {100}-textured, piezoelectric $\text{Pb}(\text{Zr}_x, \text{Ti}_{1-x})\text{O}_3$ thin films for MEMS: Integration, deposition and properties, *Sens. Actuator A.*, **105** (2003) 162-170.
- [51] P. Muralt, Piezoelectric thin films for MEMS, *Integr. Ferroelect.*, **17** (1997) 297-307.
- [52] H.D. Chen, K.R. Udayakumar, C.J. Gaskey, L.E. Cross, J.J. Bernstein and L.C. Niles, Fabrication and electrical properties of lead zirconate titanate thick films, *J. Am. Ceram. Soc.*, **79** (1996) 2189-2192.
- [53] S.A. Wilson, R.-P.J. Jourdain, Q. Zhang, R.A. Dorey, C.R. Bowen, M. Willander, Q.U. Wahab, M. Willander, S. Al-hilli, O. Nur, E. Quandt, C. Johansson, E. Pagounis, M. Kohl, J. Matovic, B. Samel, W.V.D. Wijngaart, E.W.H. Jager, D. Carlsson, Z. Djinojic, M. Wegener, C. Moldovan, R. Iosub, E. Abad, M. Wendlandt, C. Rusu, C. Persson, New materials for micro-scale sensors and actuators: An engineering review, *Mater. Sci. Eng. R Rep.*, **56** (2007) 1–129.
- [54] A. Seifert, N. Ledermann, S. Hiboux, J. Baborowski, P. Muralt, and N. Setter, Processing optimization of solution derived $\text{PbZr}_{1-x}\text{Ti}_x\text{O}_3$ thin films for piezoelectric applications. *Integr. Ferroelectr.*, **35**[1–4] (2001) 1889-1896.

- [55] K. Kakimoto, H. Kakimoto, S. Fujita and Y. Masuda, Control of crystal orientation and piezoelectric response of lead zirconate titanate thin films near the morphotropic phase boundary. *J. Am. Ceram. Soc.*, **85**[4] (2002) 1019-1021.
- [56] J. Marshall, Q. Zhang, Z. Huang and R.W. Whatmore, Orientation control of low temperature deposited sol-gel PZT52/48 films. *Ferroelectrics*, **318** (2005) 41-48.
- [57] B.A. Tuttle, T.J. Garino, J.A. Voight, T.J. Headley, D. Dimos and M.O. Eatough, in: O. Auciello and R. Waser (Eds.), Science and Technology of Electroceramic Thin Films, Kluwer Academic Publishers, The Netherlands, 1995, p. 117.
- [58] F. Jona and G. Shirane, *Ferroelectric Crystals*, Pergamon Press, New York, 1962.
- [59] T.M. Shaw, S. Trolier-McKinstry and P.C. McIntyre, The properties of ferroelectric films at small dimensions, *Annu. Rev. Mater. Sci.*, **30** (2000) 263-298.
- [60] A. Pignolet, C. Schafer, K.M. Satyalakshmi, C. Harnagea, D. Hesse, U. Gosele, Orientation dependence of ferroelectricity in pulsed-laser-deposited epitaxial bismuth-layered perovskite thin films, *Appl. Phys.*, **A 70** (2000) 283-291.
- [61] H.N. Lee, A. Visinui, S. Senz, C. Harnagea, A. Pignolet, D. Hesse, U. Gosele, Structural and electrical anisotropy of (001), (116), and (103)-oriented epitaxial $\text{SrBi}_2\text{Ta}_2\text{O}_9$ thin films on SrTiO_3 substrates grown by pulsed laser deposition, *J. Appl. Phys.*, **88** (2000) 6658-6664.

- [62] T. Kojima, T. Watanabe, H. Funakubo, K. Saito, M. Osada, M. Kakihana, Ferroelectric properties of lanthanide-substituted $\text{Bi}_4\text{Ti}_3\text{O}_{12}$ epitaxial thin films grown by metalorganic chemical vapor deposition, *J. Appl. Phys.*, **93** (2003) 1707-1712.
- [63] T. Watanabe, H. Funakubo, K. Saito, Ferroelectric property of epitaxial $\text{Bi}_4\text{Ti}_3\text{O}_{12}$ films prepared by metalorganic chemical vapor deposition, *J. Mater. Res.*, **16** (2001) 303-307.
- [64] K. Ishikawa, H. Funakubo, K. Saito, T. Suzuki, Y. Nishi, M. Fujimoto, Crystal structure and electrical properties of epitaxial $\text{SrBi}_2\text{Ta}_2\text{O}_9$ films, *J. Appl. Phys.*, **87** (2000) 8018-8023.
- [65] H.N. Lee, D. Hesse, N. Zakharov, U. Gosele, Ferroelectric $\text{Bi}_{3.25}\text{La}_{0.75}\text{Ti}_3\text{O}_{12}$ films of uniform a-axis orientation on silicon substrates, *Science*, **296** (2002) 2006-2009.
- [66] J. Lettieri, M.A. Zurbuchen, Y. Jia, D.G. Schlom, S.K. Streiffer, M.E. Hawley, Epitaxial growth of non-c-oriented $\text{SrBi}_2\text{Nb}_2\text{O}_9$ on (111) SrTiO_3 , *Appl. Phys. Lett.*, **76** (2000) 2937-2939.
- [67] C.M. Foster, Z. Li, M. Buckett, D. Miller, P.M. Baldo, L.E. Rehn, G.R. Bai, D. Guo, H. You, K.L. Merkle, Substrate effects on the structure of epitaxial PbTiO_3 thin films prepared on MgO , LaAlO_3 , and SrTiO_3 by metalorganic chemical-vapor deposition, *J. Appl. Phys.*, **78** (1995) 2607-2622.
- [68] M.S. Silberberg, Chemistry: The Molecular Nature of Matter and Change (4th edition ed.), McGraw-Hill, New York, 2006, 431-434.

- [69] R. Behrisch, *Sputtering by Particle Bombardment I*, Berlin, Springer, 1981.
- [70] P. Sigmund, Mechanisms and theory of physical sputtering by particle impact, *Nucl. Instr. Meth. Phys. Res. B* **27** (1987) 1-20.
- [71] R. Behrisch and W. Eckstein, *Sputtering by Particle Bombardment: Experiments and Computer Calculations from Threshold to MeV Energies*, Berlin, Springer, 2007.
- [72] A. Namiki, T. Kawai, K. Ichige, Angle-resolved time-of-flight spectra of neutral particles desorbed from laser irradiated CdS, *Surf. Sci.*, **166** (1986) 129-140.
- [73] D. Chrisey and G. Hubler, *Pulsed Laser Deposition of Thin Films*, John Wiley & Sons Ltd., 1994.
- [74] W. Simmler, *Ullmann's Encyclopedia of Industrial Chemistry: Silicon Compounds, Inorganic*, Wiley-VCH, Weinheim, 2002.
- [75] W. Geffcken, E. Berger, Deutsches Reichspatent 736 411, *Jenaer Glaswerk Schott & Gen.*, Jena 1939.
- [76] H. Dislich and P. Hinz, History and principles of the sol-gel process, and some new multicomponent oxide coatings, *J. Non-Cryst. Solids* **48** (1982) 11-16.
- [77] J.L. Woodhead, Sol-gel process for ceramic particles, *Silicates Ind.*, **37** (1972) 191-194.
- [78] B.E. Yoldas, Preparation of glasses and ceramics from metal -organic compounds, *J. Mater. Sci.*, **12** (1977) 1203-1208.
- [79] J.J. Ebelman and M. Bouquet Sur de, nouvelles combinaisons de l'acide borique avec les ethers et sur l'ether sulfureux, *Ann. Chim. Phys.*, **17** (1846) 54-73.

- [78] R.W. Schwartz, Chemical Solution Deposition of Perovskite Thin Films, *Chem. Mater.*, **9** (1997) 2325-2340.
- [79] L.M. Sheppard, Advances in Processing of Ferroelectric thin films, *Ceram. Bull.*, **71** (1992) 85-95.
- [80] R.W. Schwartz, T. Schneller, and R. Waser, Chemical solution deposition of electronic oxide thin films, *C. R. Chim.*, **7** (2004) 433-461.
- [81] B.A. Tuttle and R.W. Schwartz, Solution deposition of ferroelectric thin films, *Mater. Res. Bull.*, **21** (1996) 49-54.
- [82] J. Fukushima, K. Kodaira and T. Matsushita, Preparation of ferroelectric PZT films by thermal decomposition of organometallic compounds, *J. Mater. Sci.*, **19** (1984) 595-598.
- [83] K.B. Budd, S.K. Dey and D.A. Payne, Sol-gel processing of PbTiO_3 , PbZrTiO_3 , PZT and PLZT thin films, *Br. Ceram. Proc.*, **36** (1985) 107-121.
- [84] S.K. Dey, K.D. Budd and D.A. Payne, Thin-film ferroelectrics of PZT of sol-gel processing, *IEEE Trans. UFFC.*, **35** (1988) 80-81.
- [85] D. Liu, R.M. Kennedy, G. Korony, S. Makl, J.P. Mevissen, J.M. Hock and R. Heistand, Integrated thin film capacitor arrays, *II, Proc. SPIE.*, **3830** (1999) 431-437.
- [86] C.J. Brinker and G.W. Scherer, Sol-Gel Science, Academic Press, New York, 1990.

- [87] S.D. Ramamurthi and D.A. Payne, Structural investigations of prehydrolyzed precursors used in the sol-gel processing of lead titanate, *J. Am. Ceram. Soc.*, **8** (1990) 2547-2551.
- [88] D.R. Uhlmann, J.T. Dawley, W.H. Poisl, B.J.J. Zelinski, G. Teowee, Ferroelectric films, *J. Sol-Gel Sci. Techn.*, **19** (2000) 53-64.
- [89] B. Jaffe, W.R. Cook and H. Jaffe, in *Piezoelectric Ceramics*, Academic Press, London, 1971.
- [90] D. Damjanovic, Piezoelectric properties of perovskite ferroelectrics: Unsolved problems and future research, *Ann. Chim. Sci. Mater.*, **26** (2001) 99-106.
- [91] C. Cao, in: Donglu Shi (Ed.), *Functional Thin Films and Functional Materials*, Springer, Heidelberg, 2003.
- [92] S.O. Kasap, *Principles of Electronic Materials and Devices*, McGraw-Hill, New Delhi, 2007.
- [93] J. Valasek, Piezo-Electric and Allied Phenomena in Rochelle Salt, *Phys. Rev.*, **17** (1921) 475-481.
- [94] Y. Xu, *Ferroelectric Materials and Their Applications*, Elsevier Sci. Publ., Amsterdam, 1991.
- [95] R. Landauer, Electrostatic considerations in BaTiO₃ domain formation during polarization reversal, *J. Appl. Phys.*, **28** (1957) 227-234.
- [96] M.E. Lines and A.M. Glass, *Principles and Applications of Ferroelectrics and Related Materials*, Clarendon Press, Oxford, 1977.

- [97] K.M. Rabe, C.H. Ahn and J-M.Triscone, Physics of ferroelectrics, Springer, Heidelberg, 2007.
- [98] C.B. Sawyer and C.H. Tower, Rochelle Salt as a Dielectric, *Phys. Rev.*, **35** (1930) 269-273.
- [99] M. Ozgul, Polarization switching and fatigue anisotropy in relaxor-lead titanate ferroelectric single crystals. Ph.D.: The Pennsylvania State University, 2003.
- [100] R. Williams, Surface layer and decay of the switching properties of barium titanate, *J. Phys. Chem. Solids.*, **26** (1965) 399-405.
- [101] J.J. Lee, C.L. Thio and S.B. Desu, Electrode contacts on ferroelectric $\text{Pb}(\text{Zr}_x\text{Ti}_{1-x})\text{O}_3$ and $\text{SrBi}_2\text{Ta}_2\text{O}_9$ thin films and their influence on fatigue properties, *J. Appl. Phys.*, **78** (1995) 5073.
- [102] Q.Y. Jiang, E.C. Subbarao and L.E. Cross, Effect of composition and temperature on electric fatigue of La-doped lead zirconate titanate ceramics, *J. Appl. Phys.*, **75** (1994) 7433-7443.
- [103] H.N. Al-shareef, O. Auciello and A. Kingon, Electrical properties of ferroelectric thin-film capacitors with hybrid (Pt, RuO_2) electrodes for nonvolatile memory applications, *J. Appl. Phys.*, **77** (1995) 2146-2154.
- [104] U. Chon, J.S. Shim and H.M. Jang, Ferroelectric properties and crystal structure of praseodymium-modified bismuth titanate, *J. Appl. Phys.*, **93** (2003) 4769-4775.
- [105] J.F. Scott, C.A. Araujo, B.M. Melnick, L.D. McMillan and R. Zuleeg, Quantitative measurement of space-charge effects in lead zirconate titanate memories, *J. Appl. Phys.*, **70** (1991) 382-388.

- [106] H.N. Al-shareef, D. Dimos, W.L. Warren and B.A. Tuttle, A model for optical and electrical polarization fatigue in $\text{SrBi}_2\text{Ta}_2\text{O}_9$ and $\text{Pb}(\text{Zr,Ti})\text{O}_3$, *Integr. Ferroelectr.*, **15** (1997) 1-4.
- [107] E.L. Colla, D.V. Taylor, A.K. Tagantsev and N. Setter, Discrimination between bulk and interface scenarios for the suppression of the switchable polarization (fatigue) in $\text{Pb}(\text{Zr,Ti})\text{O}_3$ thin films capacitors with Pt electrodes, *Appl. Phys. Lett.*, **72** (1998) 2478-2480.
- [108] D.J. Johnson, D.T. Amm, E. Griswold, K. Sreenivas, G. Yi and M. Sayer, Measuring fatigue in PZT thin films, *Mater. Res. Soc. Symp. Proc.*, **200** (1990) 289-295.
- [109] T. Mihara, H. Watanabe and C.A.P. Araujo, Characteristic change due to polarization fatigue of sol-gel ferroelectric $\text{Pb}(\text{Zr}_{0.4}\text{Ti}_{0.6})\text{O}_3$ thin-film capacitors, *Jpn. J. Appl. Phys.*, **33** (1994) 5281-5286.
- [110] W.L. Warren, B.A. Tuttle and D. Dimos, Ferroelectric fatigue in perovskite oxides, *Appl. Phys. Lett.*, **67** (1995) 1426-1428.
- [111] N. Sriprang, D. Kaewchinda, J.D. Kennedy and S.J. Milne, Processing and sol chemistry of a triol-based sol-gel route for preparing lead zirconate titanate thin films, *J. Am. Ceram. Soc.*, **83** (2000) 1914-1920.
- [112] M. Naksata, Structure Development in PZT Thin Films, The University of Leeds, Department of Materials, School of Process, Environmental and Materials Engineering, Leeds, UK, 2001.

- [113] H.K.D.H. Bhadeshia, Thermal analysis techniques: Differential thermal analysis, Material Science and Metallurgy, University of Cambridge, Cambridge, UK, 1974.
- [114] A.W. Coats, J.P. Redfern, Thermogravimetric Analysis: A Review, *Analyst*, **88** (1963) 906–924.
- [115] A. Einstein, Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt, *Annalen der Physik*, **17**(6) (1905) 132-148.
- [116] K.C.A. Smith and C.W. Oatley, The scanning electron microscope and its fields of application, *Br. J. Appl. Phys.*, **6** (11) (1955) 391-399.
- [117] T. Zhu and W. Yang, Fatigue crack growth in ferroelectrics driven by cyclic electric loading, *Mech. Phys. Solids*, **47** (1999) 81-97.
- [118] J. Nuffer, D.C. Lupascu and J. Rodel, Stability of pinning centers in fatigued lead-zirconate-titanate, *Appl. Phys. Lett.*, **80**(6) (2002) 1049-1051.
- [119] K.G. Brooks, I.M. Reaney, R. Klissurska, Y. Huang, L. Bursill and N. Setter, Orientation of rapid thermally annealed lead zirconate titanate thin films on (111) Pt substrates, *J. Mater. Res.*, **9** (1994) 2540-2553.
- [120] R. Sirera, M.L. Calzada, F. Carmona and B. Jimenez, Physicochemical characterisation of lead titanate solutions applied to the processing of thin films, *Sol–Gel Sci. Tech.*, **2** (1994) 545-549.
- [121] B. Malic, M. Kosec, I. Arcon and A. Kodre, Homogeneity issues in chemical solution deposition of $\text{Pb}(\text{Zr,Ti})\text{O}_3$ thin films, *J. Eur. Ceram. Soc.*, **25** (2005) 2241–2246.

- [122] J. Perez, P.M. Vilarinho, A.L. Kholkin and A. Almeida, Sol-gel reaction stability studied: Influence in the formation temperature and properties of ferroelectric thin films, *Mater. Res. Bull.*, **44** (2009) 515-521.
- [123] P.S. Anderson and S. Guerin, Optimization of synthesis of the solid solution, $\text{Pb}(\text{Zr}_{1-x}\text{Ti}_x)\text{O}_3$ on a single substrate using a high-throughput modified molecular-beam epitaxy technique, *J. Mater. Res.*, **24**[1] (2009) 164-172.
- [124] Y. Otani, N. Abe, S. Okamura and T. Shiosaki, Influence of Post-Annealing on the characteristics of $\text{Pb}(\text{Zr,Ti})\text{O}_3$ thin films deposited by liquid delivery MOCVD using a cocktail solution, *Integr. Ferroelectr.*, **59** (2003) 1475-1482.
- [125] C. Zhu, Z. Yong, Y. Chentao and Y. Bangchao, Investigation the effects of the excess Pb content and annealing conditions on the microstructure and ferroelectric Properties of PZT (52-48) films prepared by Sol-Gel method, *Appl. Surf. Sci.*, **253** (2006)1500-1505.
- [126] C. Zhu, Y. Chentao, L. Bo and Y. Bangchao, Investigation on the effects of PbO content and seeding layers of TiO_2 and ZrO_2 on the orientation and microstructure of $\text{Pb}(\text{Zr}_{0.52}\text{Ti}_{0.48})\text{O}_3$ ferroelectric films grown by reverse dip-coating method of sol-gel,” *Mater. Lett.*, **60** (2006)1559-1564.
- [127] M.E. Souni, M. Abed, C.H. Solterbeck and A. Piorra, Crystallization kinetics and dielectric properties of solution deposited, La doped PZT thin films, *Mater. Sci. Eng.*, **B94** (2002) 229–236.
- [128] M.E. Souni and A. Piorra, On the crystallization kinetics of solution deposited PZT thin films, *Mater. Res. Bull.*, **36** (2001) 2563–2575.

- [129] Ma, J.H., X.J. Meng, J.L. Sun, T. Lin, F.W. Shi, G.S. Wang and J.H. Chu, Effect of excess Pb on crystallinity and ferroelectric properties of PZT(40/60) films on LaNiO₃ coated Si substrates by MOD technique, *Appl. Surf. Sci.*, **240** (2005) 275-279.
- [130] Q.L. Zhao, M.S. Cao, J. Yuan, W.L. Song, R. Lu, D.W. Wang, and D.Q. Zhang, Preparation and electrical properties of Pb(Zr_{0.52}Ti_{0.48})O₃ thick films embedded with ZnO nanowhiskers by a hybrid sol-gel route. *J. Alloy. Compd.*, **492** (2010) 264–268.
- [131] K. Niihara, New design concept of structural ceramics-ceramic nanocomposites, *J. Ceram. Soc. Jpn.*, **99**(10) (1991) 974–982.
- [132] H.L. Zhang, J.F. Li, B.P. Zhang, and W. Jiang, Enhanced mechanical properties in Ag-particle-dispersed PZT piezoelectric composites for actuator applications, *Mat. Sci. Eng. A.*, **498** (2008) 272–277.
- [133] K. Tajima, H.J. Hwang, and M. Sando, Electric-Field-Induced Crack Growth Behavior in PZT/Al₂O₃ Composites, *J. Am. Ceram. Soc.*, **93** (2000) 651–653.
- [134] P.H. Xiang, X.L. Dong, C.D. Feng, N. Zhong, and J.K. Guo, Sintering behavior, mechanical and electrical properties of lead zirconatetitanate/NiO composites from coated powders, *Ceram. Int.*, **30** (2004) 765–772.
- [135] H.J. Hwang, K. Tajima, M. Sando, M. Toriyama, and K. Niihara, Fatigue Behavior of PZT-Based Nanocomposites with Fine Platinum Particles, *J. Am. Ceram. Soc.*, **81** (1998) 3325–3328.

- [136] H.W. Wang, D.A. Hall, and F.R. Sale, Phase homogeneity and segregation in PZT powders prepared by thermal decomposition of metal-EDTA complexes derived from nitrate and chloride solutions, *J. Am. Ceram. Soc.*, **75**(1) (1992) 124–130.
- [137] S. Çörekçi, K. Kızılkaya, T. Asar, M.K. Öztürk, M. Çakmak and S. Özçelik, Effects of Thermal Annealing and Film Thickness on the Structural and Morphological Properties of Titanium Dioxide Films, *Acta. Phys. Pol. A.*, **121** (2012) 247-248.
- [138] M. Ohring, Materials Science of Thin Films, Academic Press, San Diego, 2002.
- [139] Y.S. Sung and M.H. Kim, Effects of B-site donor and acceptor doping in Pb-free (Bi_{0.5}Na_{0.5})TiO₃ ceramicx, Ferroelectrics, I. Coondoo (Ed.), InTech, Shanghai, 2010.
- [140] Y. Li, W. Chen, J. Zhou, Q. Xu, H. Sun and M. Liao, Dielectric and ferroelectric properties of [Bi_{0.5}(Na_{1-y}K_xLi_y)_{0.5}]TiO₃ lead-free Na_{0.5}Bi_{0.5}TiO₃-K_{0.5}Bi_{0.5}TiO₃ ferroelectric ceramics, *Ceram. Int.*, **31** (2005) 139-142.
- [141] G.V. Lewis, R.A. Catlow and R.E.W. Casselton, PTCT effect in BaTiO₃, *J. Am. Ceram. Soc.*, **68** (1985) 555-558.
- [142] P. Lucuta, F.L. Constantinescu and D. Barb, Structure dependence on sintering temperature of lead zirconate-titanate solid solutions, *J. Am. Ceram. Soc.*, **68** (1985) 533-537.
- [143] M. Drofenik, Grain size and conductivities anomaly in donor – doped barium titanate, *Acta Chim. Slov.*, **46**(3) (1999) 355-364.

- [144] S. Shannigrahi and K. Yao, Structure and properties of WO_3 -doped $\text{Pb}_{0.97}\text{La}_{0.03}(\text{Zr}_{0.52}\text{Ti}_{0.48})\text{O}_3$ ferroelectric thin films prepared by a sol-gel process, *J. Am. Ceram. Soc.*, **98**(3) (2005) 034104–034109.
- [145] W. Liu, W. Chen, L. Yang, L. Zhang, Y. Wang, C. Zhou, S. Li, and X. Ren, Ferroelectric aging effect in hybrid-doped BaTiO_3 ceramics and the associated large recoverable electrostrain, *Appl. Phys. Lett.*, **89** (2006) 172908–172910.
- [146] A.P. Eremenko, N.B. Kofanova, L.E. Pustovaya, A.G. Rudskaya, B.S. Kul'buzhev, and M.F. Kupriyanov, Specific features of the structure and dielectric relaxation of PbWO_4 in the temperature range $20 \leq T \leq 550^\circ\text{C}$, *Phys. Solid State+*, **46**(10) 1(2004) 849–1851.
- [147] A.J. Bell, Factors influencing the piezoelectric behavior of PZT and other “morphotropic phase boundary” ferroelectrics, *J. Mater. Sci.*, **41** (2006) 13-25.
- [148] B.M. Jin, J. Kim and S.C. Kim, Effects of grain size on the electrical properties of $\text{PbZr}_{0.52}\text{Ti}_{0.48}\text{O}_3$ ceramics, *Appl. Phys. A.*, **65** (1997) 53-56.
- [149] G.H. Haertling and W.J. Zimmer, Analysis of hot-pressing parameters for lead zirconate-lead titanate ceramics containing two atom percent bismuth, *Am. Ceram. Soc. Bull.*, **45** (1966) 1084-1089.
- [150] J.F. Scott and C.A.P. Dearanzo, Ferroelectric memories, *Science*, **246** (1989) 1400-1405.
- [151] A.K. Tagantsev, I. Stolichnov, E.L. Colla, and N. Setter, Polarization fatigue in ferroelectric films: Basic experimental findings, phenomenological scenarios, and microscopic features, *J. Appl. Phys.*, **90** (2001) 1387–1402.

- [152] I.K. Yoo and S.B. Desu, Fatigue modeling of lead zirconate titanate thin films, *Mater. Sci. Eng. B.*, **13** (1992) 319-322.
- [153] M.V. Raymond, J. Chen, and D.M. Smyth, Degradation of ferroelectric thin films: A defect chemistry approach, *Integr. Ferroelectr.*, **5** (1994) 73–78.
- [154] H.C. Chang Shin and J.T. Song, High resolution 3-D imaging for characteristics of (111)-oriented $\text{Pb}(\text{Zr}_{0.53}\text{Ti}_{0.65})\text{O}_3$ thin film by using time-of-flight secondary ion mass spectrometry and piezoresponse force microscopy, *Electron. Mater. Lett.*, **3** (2011) 265-270.
- [155] J. Kim, D. Kim, J.S. Kim, Y. Kim, K.N. Hui and H. Lee, Selective substitution and tetragonality by co-doping of dysprosium and thulium on dielectric properties of barium titanate ceramics, *Electron. Mater. Lett.*, **7**[2] (2011) 155-159.
- [156] B. Guiffard, E. Boucher, L. Lebrun and D. Guyomar, Characteristics of F doped PZT ceramics using different fluorine sources, *Mater. Sci. Eng.. B* **137** (2007) 272-277.
- [157] R.A. Eichel, E. Erüinal, M.D. Drahus, D.M. Symth, J.V. Tol, J. Acker, H. Kungl and M.J. Hoffmann, Local variations in defect polarization and covalent bonding in ferroelectric Cu^{2+} -doped PZT and KNN functional ceramics at the morphotropic phase boundary, *Phys. Chem. Chem. Phys.*, **11** (2009) 8698-8705.
- [158] X. Chao, D. Ma, R. Gu and Z. Yang, Effects of CuO addition on the electrical responses of the low-temperature sintered $\text{Pb}(\text{Zr}_{0.52}\text{Ti}_{0.48})\text{O}_3\text{--Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3})\text{O}_3\text{--Pb}(\text{Zn}_{1/3}\text{Nb}_{2/3})\text{O}_3$ ceramics, *J. Alloys Compd.*, **491** (2010) 698-702.

- [159] M.S. Kim, S. Jeon, S.J. Jeong, I.S. Kim and J.S. Wong, Effect of CuO additions on microstructures and electromechanical properties of $0.4\text{Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3})\text{O}_3\text{-}0.25\text{PbZrO}_3\text{-}0.35\text{PbTiO}_3$ ceramics, *Mater. Lett.*, **4**[4] (2008) 189-192.
- [160] Q.L. Zhao, M.S. Cao, J. Yuan, W.L. Song, R. Lu, D.W. Wang and D.Q. Zhang, Preparation and electrical properties of $\text{Pb}(\text{Zr}_{0.52}\text{Ti}_{0.48})\text{O}_3$ thick films embedded with ZnO nano whiskers by a hybrid sol-gel route, *J. Alloy Compd.*, **492** (2010) 264-268.
- [161] S. Kalpat and K. Uchino, Highly oriented lead zirconium titanate thin films: Growth, control of texture, and its effect on dielectric properties, *J. Appl. Phys.*, **90**[6] (2001) 2703-2710.
- [162] F. Apaydin, H.T. Özkan and K. Yildiz, The effect of CuO on the grain growth of ZnO, *J. Mater. Sci.*, **40** (2005) 677-682.
- [163] C.B. Carter and M.G. Norton, *Ceramic Materials: Science and Engineering*, New York, Springer, 2007.
- [164] C.S. Park, J.W. Lee, S.M. Lee, S.H. Jun and H.E. Kim, Effect of excess PbO on microstructure and orientation of PZT(60/40) films, *J. Electroceram.*, **25** (2010) 20-25.
- [165] S. Priya, H. W. Kim, J. Ryu and K. Uchino, Fractal cluster modeling of the fatigue behavior of lead zirconate titanate, *Appl. Phys. Lett.*, **80** (2002) 1625-1627.

- [166] R.A. Eichel, P. Erhart, P.T. skelin, K. Albe, H. Kungl, M.J. Hoffmann, Defect-Dipole formation in copper-doped PbTiO_3 ferroelectrics, *Phys. Rev. Lett.*, **100** (2008) 095504–095508.
- [167] L.K. Yoo and S.B. Desu, Mechanism of fatigue in ferroelectric thin films, *Phys. Status Solidi, A* **133** (1992) 565.
- [168] L.K. Yoo and S.B. Desu, Fatigue modeling of lead zirconate titanate (PZT) thin films, *Mater. Sci. Eng., B* **13** (1992) 319.
- [169] R.D. Levi and Y. Tsur, The effect of oxygen vacancies in the early stages of BaTiO_3 nanopowder sintering, *Adv. Mater.*, **17** (2005) 1606-1608.