

ASIGURAREA CALITĂȚII – QUALITY ASSURANCE

CUPRINS – CONTENTS

- ❑ **The Standard ISO 9001:2015. Changes and Challenges** 2
Ioan C. Bacivarov
- ❑ **Quality Management in Dental Health Care in the Republic of Serbia** 8
Jasmina Tekic, Vidosav Majtorovic
- ❑ **Detection of Mean Shifts by Statistical Approaches** 14
Part 2: Context of Non-Gaussian or Autocorrelated Observations
Teodor Tiplica
- ❑ **High-Power LEDs Lighting Systems Reliability – Understanding of Degradation Processes** 22
Titu-Marius I. Băjenescu

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, photocopied, recorded or other wise, without written permission from the editor. When authors submit their papers for publication, they agree that the copyright for their article be transferred to the Romanian Society for Quality Assurance (SRAC), if and only if the articles are accepted for publication. The copyright covers the exclusive rights to reproduce and distribute the article, including reprints and translations.

Permission for other use. The copyright owner's consent does not extend to copying for general distribution, for promotion, for creating new works, or for resale. Specific written permission must be obtained from the publisher for such copying.

Disclaimer. Whilst every effort is made by the publishers and the Editorial Board to see that no inaccurate or misleading data, opinion or statement appear in this journal, they wish to make it clear that the data and opinions appearing in the articles, as well as linguistic accuracy, are the sole responsibility of the author.

The materials in this publication is for general information only and is not intended to provide specific advice or recommendations for any individual. The publisher disclaims all liability in connection with the use of information contained in this publication.

The Standard ISO 9001:2015. Changes and Challenges

Ioan C. BACIVAROV

EUROQUALROM Laboratory, Faculty of Electronics, Telecommunications and Information
Technology, Politehnica University Bucharest, Romania
bacivaro@euroqual.pub.ro

Abstract

ISO 9001 is undoubtedly the best known and most widely used of the many standards developed by the International Organization for Standardization (ISO). This paper analyzes – on the basis of documents elaborated by ISO/TC 176 – changes and updates proposed for the new ISO 9001:2015. As one of the key changes in the 2015 revision of ISO 9001 is to establish a systematic approach to risk, a special attention is given to the analysis of the concepts of risk and of risk-based thinking, introduced in this standard. A comparison between the “old standard” ISO 9001:2008 and the “new standard” ISO 9001:2015 is given too.

Keywords: quality, quality management, quality management system, ISO 9001, ISO 9001:2015, standard, International Organization for Standardization ISO, ISO/TC 176, changes, new standard revision, risk, risk-based thinking.

References:

- [1] http://www.iso.org/iso/home/standards/management-standards/iso_9000.htm (accessed January 10th, 2015).
- [2] Correlation matrices between ISO 9001:2008 and ISO/DIS 9001, ISO/TC 176/SC 2 Document N1224, July 2014.
- [3] „Risk” in the standard ISO 9001:2015, ISO/TC 176/SC2 Document N1222, 2014.
- [4] ISO 9001 Whitepaper: ISO Revisions, The history and future of ISO 9001, BSI, 2014.
- [5] Ioan Bacivarov, ISO 9000 Standards, Vector of Revolution in Quality Field”, in QUALITY and DEPENDABILITY – Proceedings of the 11th IEEE International Conference in Quality and Dependability, Sinaia, 2008, MEDIAREX, 2008, ISSN 1842-3566, pp. 38-47.
- [6] Vidosav Majstoroviæ, ISO 14001:2015 – Advanced ISO 9001:2015 and QMS and EMS versions, Asigurarea Calitatii - Quality Assurance, no. 79, vol. XIX (2014), pp. 18-25.
- [7] Renáta Kleinová a.o. Comparison of new drafts of ISO 9001:2015 and ISO 14001:2015 standards in term of integration, Transfer inovácií, no. 29, 2014, pp. 173-180.
- [8] Nigel Croft, ISO 9001:2015 – From CD to DIS, 2013.
- [9] Alexander Ezrakhovich, Valentin Dzedik, Julia Bannykh, ISO 9001:2015 – New Improvements, Asigurarea Calitatii – Quality Assurance, no. 80, vol. XX (2014), pp. 7-10.

Quality Management in Dental Health Care in the Republic of Serbia

Jasmina TEKIĆ¹, Vidosav MAJSTOROVIĆ²

¹ Belgrade University, Faculty of Dentistry, Belgrade, Serbia; ² Belgrade University, Mechanical Engineering Faculty, Belgrade, Serbia
vidosav.majstorovic@sbb.rs

Abstract

Standards ISO 9000 series, passed in 1987, were the driving force of development and implementation of quality management (QM) in various sectors, including health care. Today there are over one million certificates for QMS, so you could say that they were the main generator of quality improvement. In addition to quality management models of products / services today, in this area, using different models. The aim of this study was to present the methods and techniques to improve the quality of health services, with special emphasis on dental health care services and the aspect of improving quality of it in the Republic of Serbia.

Keywords: quality, health, quality management, health services, dental health care

References:

- [1] Bilawka, E., Craing, B., QA in health care, *Int. Jour. Dental. Hygiene*, 1, pp. 159-68, 2005.
- [2] Donabedian, A., Models of QA, *Journal of Med. Systems*, 12, pp. 307-313.
- [3] Walton, M., *The Deming Management Methods*, New York, 1992.
- [4] Epstein, A., Performance report on quality, *Nat. Engl. Jour. Med.*, pp. 157-161, No. 16, 1999.
- [5] Tekic, J., Istrazivanje i razvoj modela izvrsnosti u stomatološkoj zdravstvenoj zaštiti, *Doktorska teza (u toku)*, Stomatološki fakultet, Beograd, 2010.
- [6] Minkman, M., et al, Performance improvement based on integrated quality management models: what evidence do we have? A systematic literature review, *International Journal for Quality in Health Care*, Volume 19, Number 2, pp. 90-104.
- [7] Walshe, K., Understanding what works and why in quality improvement: the need for theory-driven evaluation, *International Journal for Quality in Health Care*, Volume 19, Number 2, pp. 57-59.
- [8] McDowel, I., Newell, C., *Measuring Health – A Guide to Rating Scales and Questionnaires*, New York, 1996.
- [9] Lepier, R., Hill, R., *Evaluating QA – QUARTZ System*, London, 1998.
- [10] Ammentorp, J., Electronic questionnaires for measuring parent satisfaction and as a basis for quality improvement, *International Journal for Quality in Health Care*, Volume 19, Number 2, pp. 120-124.
- [11] Goldman, R., The reliability of peer assessment of quality care, *JAMA* 267, pp. 258-262.
- [12] Kane, R., The challenge of explaining why quality improvement has not done better, *International Journal for Quality in Health Care* 2007, Volume 19, Number 1, pp. 8-10
- [13] Arah, O., A conceptual framework for the OECD Health Care Quality Indicators Project, *International Journal for Quality in Health Care*, September 2006, pp. 5-13.
- [14] Fromberg, R., *The Joint Commission Guide to QA*, Chicago, 2001.

Detection of Mean Shifts by Statistical Approaches. Part 2: Context of Non-Gaussian or Autocorrelated Observations

Teodor TIPLICA

UNAM Université, Laboratoire Angevin de Recherche en Ingénierie de Systèmes (LARIS), EA
7315, France
teodor.tiplica@univ-angers.fr

Abstract

This article is the second part of a global overview of the research on the detection of mean shifts through statistical techniques. Various categories of control charts used in the field of Statistical Process Control (SPC) are reviewed in the particular context represented by autocorrelated observations or distributed under non-Gaussian distributions.

Keywords: SPC, APC, control charts, detection, autocorrelated observations, non-Gaussian distributions.

References:

- [1] B. Adams and I. Tseng, Robustness of Forecast-based Monitoring Systems. *Journal of Quality Technology*, 30, 328-339, 1998.
- [2] L. C. Alwan, Effects of Autocorrelation on Control Chart Performance. *Communications in Statistics: Theory and Methods*, 21, 1025–1049, 1992.
- [3] L. C. Alwan and D. Radson, Time-Series Investigation of Subsample Mean Charts. *IIE Transactions*, 24 (5), 66-80, 1992.
- [4] L. C. Alwan and H. V. Roberts, Time-Series Modeling for Statistical Process Control. *Journal of Business and Economic Statistics*, 6, 87-95, 1988.
- [5] R. W. Amin, M. R. Reynolds and S. Bakir, Non parametric Quality Control Charts Based on the Sign Test. *Communications in Statistics. Theory and Methods*, 24, 1597-1624, 1995.
- [6] D. Apley and H. Lee, Robustness Comparison of Exponentially Weighted Moving-Average Charts on Autocorrelated Data and on Residuals. *Journal of Quality Technology*, 40(4), 428-447, 2008.
- [7] D. Apley and J. J. Shi, The GLRT for Statistical Process Control of Autocorrelated Processes. *IIE transactions*, 31, 1123–1134, 1999.
- [8] D. Apley and F. Tsung, The Autoregressive T2 Chart for Monitoring Univariate Autocorrelated Processes. *Journal of Quality Technology*, 34(1), 80-96, 2002.
- [9] O. O. Atienza, L. L. Tang and B. W. Ang, A SPC Procedure for Detecting Level Shifts of Autocorrelated Processes. *Journal of Quality Technology*, 30, 340–351, 1998.
- [10] O. O. Atienza, L. L. Tang and B. W. Ang, A CUSUM scheme for autocorrelated observations, *Journal of Quality Technology*, 34 (2), 187–199, 2002.
- [11] F. Babus, Contrôle de processus industriels complexes et instables par le biais des techniques statistiques et automatiques. Thèse de doctorat à l’Institut des Sciences et Techniques de l’Ingénieur (ISTIA) – Université d’Angers, 2008.

- [12] M. Basseville and I. Nikiforov, *Detection of Abrupt Changes: Theory and Applications*. Englewood Cliffs: NJ: Prentice-Hall, 1993.
- [13] P. M. Berthouex, W. G. Hunter and L. Pallesen, *Monitoring Sewage Treatment Plants: Some Quality Control Aspects*. *Journal of Quality Technology*, 10, 139–149, 1978.
- [14] C. M. Borrer, C. W. Champ and S. E. Rigdon, *Poisson EWMA Control Charts*. *Journal of Quality Technology*, 30, 352–361, 1998.
- [15] C. M. Borrer, D. C. Montgomery and G.C. Runger, *Robustness of the EWMA control chart to non-normality*. *Journal of Quality Technology*, 31, (3), 1999.
- [16] G. E. Box and D. R. Cox, *An Analysis of Transformations*. *Journal of the Royal Statistical Society*, B 26, 211–243, 1964.
- [17] G. E. Box and T. Kramer, *Statistical Process Monitoring and Feedback Adjustment – A Discussion*. *Technometrics*, 34, 251–285, 1992.
- [18] R. Boyles, *Phase I Analysis for Autocorrelated Processes*. *Journal of Quality Technology*, 32, 395–409, 2000.
- [19] P. Castagliola, C. Giovanni and S. Psarakis, *Monitoring the coefficient of variation using EWMA charts*. *Journal of Quality Technology*, 43(3), 249 – 265, 2011.
- [20] Y.-M. Chu, A. M. Polansky and R. L. Mason, *Transforming Non-Normal Data to Normality in Statistical Process Control*. *Journal of Quality Technology*, 30(2), 133-141, 1998.
- [21] J. N. Deyer, *Evaluation of Control Charting Techniques for Monitoring Autocorrelated Processes*. Ph.D. Dissertation, University of Alabama, Tuscaloosa, AL, 1997.
- [22] J. N. Deyer, B. Adams and M. Conerly, *The Reverse Moving Average Control Chart for Monitoring Autocorrelated Processes*. *Journal of Quality Technology*, 35(2), 139-152, 2003.
- [23] E. Duclos, *Contribution à la Maîtrise Statistique des Procédés. Cas des procédés non normaux*. Thèse de doctorat à l’Ecole Supérieure d’Ingénieurs d’Annecy (ESIA) – Université de Savoie, 1997.
- [24] J. R. Fricker, M. C. Knitt and C. X. Hu, *Comparing Directionally Sensitive MCUSUM and MEWMA Procedures with Application to Biosurveillance*. *Quality Engineering*, 20(4), 478 — 494, 2008.
- [25] F. W. Faltin, C. Mastrangelo, G. Runger and T. Ryan, *Considerations in the Monitoring of Autocorrelated and Independent Data*. *Journal of Quality Technology*, 29(2), 131-133, 1997.
- [26] F. W. Faltin and W. T. Tucker, *On-Line Quality Control for the Factory of the 1990’s and Beyond*. Dans J. Keats, & D. C. Montgomery, *Statistical Process Control In Manufacturing*. New York, NY.: Marcel-Dekker, 1991.
- [27] J. Fu, F. Spiring and H. Xie, *On the average run lengths of quality control schemes using a Markov chain approach*. *Statistics and Probability Letters*, 56(4), 369-380, 2002.
- [28] F. F. Gan, *Design of Optimal Exponential CUSUM Charts*. *Journal of Quality Technology*, 26, 109–124, 1994.
- [29] F. F. Gan, *Designs of One- and Two-Sided Exponential EWMA Charts*. *Journal of Quality Technology*, 30, 55–69, 1998.
- [30] F. F. Gan and K. P. Choi, *Computing Average Run Length for Exponential CUSUM Schemes*. *Journal of Quality Technology*, 26, 134–139, 1994.
- [31] F. A. Graybill, *The Theory and Applications of the Linear Model*. London: Duxbury Press, 1976.
- [32] W. Jiang, *Multivariate Control Charts for Monitoring Autocorrelated Processes*. *Journal of Quality Technology*, 36(4), 367-379, 2004.
- [33] W. Jiang and K.-L. Tsui, *SPC Monitoring of MMSE- and PI-Controlled Processes*. *Journal of Quality Technology*, 34(4), 384-398, 2002.
- [34] W. Jiang, K.-L. Tsui and W. H. Woodall *A New SPC Monitoring Method: the ARMA Chart*. *Technometrics*, 42, 399–410, 2000.
- [35] J. A. John and N. R. Draper, *An alternative family of transformations*. *Applied Statistics*, 29, 190-197, 1980.

- [36] T. J. Harris and W. H. Ross, Statistical Process Control Procedures for Correlated Observations. *The Canadian Journal of Chemical Engineering*, 69, 48-57, 1991.
- [37] E. Hong, C. Kang, J. W. Baek and H. Kang, Development of CV Control Chart Using EWMA Technique. *Journal of the Society of Korea Industrial and Systems Engineering*, 31(4), 114-120, 2008.
- [38] N. L. Johnson, Systems of Frequency Curves Generated by Methods of Translation. *Biometrika*, 36, 149-176, 1949.
- [39] C. W. Kang, M. S. Lee, Y. J. Seong and D. M. Hawkins, A control chart for the coefficient of variation. *Journal of Quality Technology*, 39(2), 151-158, 2007.
- [40] B. Kim and G. S. May, An Optimal Neural Network Model for Plasma Etching. *IEEE Transactions on Semiconductor Manufacturing*, 7, 12–21, 1994.
- [41] H. Kramer and W. Schmid, Ewma charts for multivariate time series. *Sequential Analysis: Design Methods and Applications*, 16 (2), 131-154, 1997.
- [42] H. Kramer and W. Schmid, The Influence of Parameter Estimation on the ARL of Shewhart-Type Charts for Time Series. *Statistical Papers*, 41, 173-196, 2000.
- [43] Y. C. Lin and C. Y. Chou, On the design of variable sample size and sampling intervals X-bar charts under non-normality. *International Journal of Production Economics* 96: 249–261, 2005.
- [44] W. S. W. Lin and B. M. Adams, Combined Control Charts for Forecast-Based Monitoring Schemes. *Journal of Quality Technology* 28, pp. 289–302, 1996.
- [45] M. T. Longnecker and R. T. Rayan, Charting Correlated Process Data. Technical Report No. 166, Department of Statistics, Texas A & M University, College Station, TX, 1992.
- [46] C.-H. Lu and M. J. Raynolds, EWMA Control Charts for Monitoring the Mean of Autocorrelated Processes. *Journal of Quality Technology*, 31(2), 166-188, 1999.a.
- [47] C.-H. Lu and M. J. Raynolds, Control Charts for Monitoring the Mean and Variance of Autocorrelated Processes. *Journal of Quality Technology*, 31(3), 259-274, 1999.b.
- [48] C.-H. Lu and M. J. Raynolds, Cusum Charts For Monitoring An Autocorrelated Process. *Journal of Quality Technology*, 33(3), 316-334, 2011.
- [49] J. M. Lucas, Counted Data CUSUM's. *Technometrics*, 27, 129-144, 1985.
- [50] B. F. Manly, Exponential data transformation. *The Statistician*, 25, 37-42, 1976.
- [51] R. L. Mason and J. C. Young, The effect of dependent observations on process control. *Quality Progress* (4), 70-72, 2008.
- [52] D. C. Montgomery, *Introduction to Statistical Quality Control* (5th Edition). New York: John Wiley & Sons Ltd., 2005.
- [53] D. C. Montgomery and C. M. Mastrangelo, Some Statistical Process Control Methods for Autocorrelated Data. *Journal of Quality Technology*, 23, 179-193, 1991.
- [54] R.R. Mortel and G.C. Runge, Statistical Process Control of Multiple Stream Process. *Journal of Quality Technology*, 27 (1), 1995.
- [55] L. S. Nelson, A Control Chart for Parts-per-Million Nonconforming Items. *Journal of Quality Technology*(26), 239–240, 1994.
- [56] B. D. Notohardjono and D. S. Ermer, Time Series Control Charts for Correlated and Contaminated Data. *Journal of Engineering for Industry*, 108, 219–226, 1986.
- [57] C. S. Padgett, L. A. Thombs and W. J. Padgett, On the a-risks for Shewhart Control Charts. *Communications in Statistics-Simulation and Computation*, 21, 1125-1147, 1992.
- [58] A. M. Polansky, Y.-M. Chu and R. L. Mason, An Algorithm for Fitting Johnson Transformations to Non-normal Data. *Journal of Quality Technology*, 31(3), 345-350, 1999.
- [59] M. R. Reynolds, J. C. Arnold and J. W. Baik, Variable Sampling Interval X Charts in the Presence of Correlation. *Journal of Quality Technology*, 28, 12-30, 1996.
- [60] G. C. Runger, T. Willemain and S. Prabhu, Average Run Lengths for CUSUM Control Charts Applied to Residuals. *Communications in Statistics- Theory and Methods*, 24, 273-282, 1995.
- [61] E. Sachs, A. Hu and A. Ingolfsson, Run by run process control: combining SPC and feedback control. *Semiconductor Manufacturing, IEEE Transactions* 8 (1), 26-43, 1995.

- [62] R. M. Sakia, The Box-Cox transformation technique: a review. *The Statistician*, 41, 169-178, 1992.
- [63] E. G. Schilling and P. R. Nelson, The Effect of Non-Normality on the Control Limits of Charts. *Journal of Quality Technology*, 8, 183-188, 1976.
- [64] W. Schmid, CUSUM Control Schemes for Gaussian Processes. *Statistical Papers*, 38, 191-217, 1997.a.
- [65] W. Schmid, On EWMA Charts for Time Series. Vol. *Frontiers of Statistical Quality Control*, H. H. J. Lenz and P.-Th. Wilrich. Physica-Verlag, Ed., 1997.b.
- [66] W. Schmid and A. Schone, Some Properties of the EWMA Control Chart in the Presence of Autocorrelation. *Annals of Statistics*, 25, 1277-1283, 1997.
- [67] L. Shu, W. Jiang and K.-L. Tsui, A Weighted Cusum Chart for Detecting Patterned Mean Shifts. *Journal of Quality Technology*, 40, 194–213, 2008.
- [68] L. Shu, W. Jiang and K.-L. Tsui, A Comparison of Weighted CUSUM Procedures that Account for Monotone Changes in Population Size. *Statistics in Medicine*, 2011.
- [69] A. E. Smith, Predicting Product Quality with Back-propagation: A Thermoplastic Injection Molding Case Study. *International Journal of Advanced Manufacturing Technology*, 8, 252–257, 1993.
- [70] R. S. Sparks, CUSUM Charts for Signaling Varying Location Shifts. *Journal of Quality Technology*, 32, 157–171, 2000.
- [71] C. Superville and B. Adams, An Evaluation of Forecast-Based Quality Control Schemes. *Communications in Statistics: Simulation and Computation*, 23, 645–661, 1994.
- [72] D. Timmer, J. Pignatiello and M. Longnecker, The Development and Evaluation of CUSUM-Based Control Charts for an AR(l) Process. *IIE Transactions*, 30, 525-534, 1998.
- [73] F. Tsung, J. Shi and C. F. Wu, Joint Monitoring of PID-Controlled Processes. *Journal of Quality Technology*, 31, 275–285, 1999.
- [74] F. Tsung and K.-L. Tsui, A Mean Shift Pattern Study on Integration of SPC and APC for Process Monitoring. *IIE Transactions*, 2001.
- [75] F. Tsung and K.-L. Tsui, A Mean Shift Pattern Study on Integration of SPC and APC for Process Monitoring. *IIE Transactions*, 35, 231-242, 2003.
- [76] L. N. Vanbrackle and M. R. Reynolds, EWMA and CUSUM Control Charts in the Presence of Correlation. *Communications in Statistics-Simulation and Computation*, 26, 979-1008, 1997.b.
- [77] S. A. Vander Weil, Modeling Processes That Wander Using Moving Average Models. *Technometrics*, 38, 139- 151, 1996.
- [78] S. Vardeman and D. Ray, Average Run Lengths for CUSUM Schemes when Observations are Exponentially Distributed. *Technometrics*, 27, 145-150, 1985.
- [79] D. G. Wardell, H. Moskowitz and R. D. Plante, Control Charts in the Presence of Data Correlation. *Management Science*, 38, 1084-1105, 1992.
- [80] D. G. Wardell, H. Moskowitz and R. D. Plante, Run Length Distributions of Special-Cause Control Charts for Correlated Processes. *Technometrics*, 36, 3-17, 1994.
- [81] Q. Xia, M. Rao, X. Shan and H. Shu, Adaptive Control of a Paperboard Machine. *Pulp and Paper Canada*, 95, 51–55, 1994.
- [82] M. Xie, T. Goh and V. Kuralmani, *Statistical Models and Control Charts for High Quality Processes*. Boston: MA: Kluwer Academic Publisher, 2002.
- [83] Y. Xie, M. Xie and T. N. Goh, Two MEWMA Charts for Gumbel's Bivariate Exponential Distribution. *Journal of Quality Technology*, 43(1), 50-65, 2011.
- [84] E. Yashchin, Performance of CUSUM Control Schemes for Serially Correlated Observations. *Technometrics*, 35, pp. 37-52, 1993.
- [85] N. F. Zhang, Detection Capability of Residual Control Chart for Stationary Process Data. *Journal of Applied Statistics*, 24, 363-380, 1997.

[86] N. F. Zhang, A Statistical Control Chart for Stationary Process Data. *Technometrics* 40 (1), 24-38, 1998.

High-Power LEDs Lighting Systems Reliability - Understanding of Degradation Processes

Titu-Marius I. BĂJENESCU

C.F.C., La Conversion, Switzerland
tmbajenesco@bluewin.ch

Abstract

With the progress of LED lighting technologies, their application is spreading in sign and display devices, spot lighting, base lighting, and security lighting, and new applications that cannot be realized with conventional light sources are expected. The reliability of LED is key to its application system.

Keywords: degradation mechanisms, failure modes, packaging, phosphors, ESD, EOS, thermal management

References:

- [1] Krames, M. R., et al., “High-Brightness AlGaInN Light-Emitting Diodes”, Light-Emitting Diodes – Research, Manufacturing and Applications IV, Proc. of SPIE, vol. 3938(2000), pp. 2-12, 26-27 January 2000, San Jose, CA.
- [2] Niu, G., et al., “Health Monitoring of Electronic Products Based on Mahalanobis Distance and Weibull Decision Metrics. *Microelectr. Reliab.*, 51(2011), pp. 279-284.
- [3] Dupuis, R. D., and Krames, M. R., “History, Development, and Applications of High-Brightness Visible Light-Emitting Diodes”, *Journal of Lightwave Technology*, Vol. 26, Issue 9, p. 1154.
- [4] Kim, M. H., “Origin of Efficiency Droop in GaN-Based Light-Emitting Diodes”, *Applied Physics Letters* 91, 183507 (2007); doi:10.1063/1.2800290.
- [5] Yanagisawa, T., and T. Kojima, “Degradation of InGaN Blue Light-Emitting Diodes under Continuous and Low-Speed Pulse Operations”, *Microelectron. Reliab.*, vol. 43, no. 6, pp. 977-980.
- [6] Yanagisawa, T., “Estimation of the Degradation of InGaN/AlGaIn Blue Light-Emitting Diodes”, *Microelectron. Reliab.*, vol. 37, no. 8, pp. 1239-1241.
- [7] Cao, X. A., et al., “Defect Generation in InGaN/GaN Light-Emitting Diodes under Forward and Reverse Electrical Stresses”, *Microelectron. Reliab.*, vol. 43(2003), no. 12, pp. 1987-1991.
- [8] Uddin, A., et al., “Study of Degradation Mechanism of Blue Light Emitting Diodes”, *Thin Solid Films*, vol. 483, no. 1/2, pp. 378-381.
- [9] Manyakhin, F., et al., “Aging Mechanisms of InGaN/AlGaIn/GaN Light-Emitting Diodes Operating at High Currents”, *MRS Internet J. Nitride Semicond. Res.*, vol. 3, p. 53.
- [10] Chen, Z. Z., et al., “Study on the stability of the high-brightness white LED”, *Phys. Stat. Sol. (B)*, vol. 241, no. 12, pp. 2664-2667, Oct. 2004.
- [11] Meneghini, M., et al., “A Review on the Reliability of GaN-Based LEDs”, *IEEE Trans. Device Mater. Rel.*, vol. 8, no. 2, pp. 323-331.

- [12] Rossi, F., et al., “Influence of Short-Term Low Current DC Aging on the Electrical and Optical Properties of InGaN Blue Light- Emitting Diodes”, *J. Appl. Phys.*, vol. 99, no. 5, pp. 053 104-1–053 104-7.
- [13] Hu,, J., L. Yang, and M. W. Shin, “Electrical, Optical and Thermal Degradation of High Power GaN/InGaN Light-Emitting Diodes”, *J. Phys. D, Appl. Phys.*, vol. 41, no. 3, p. 035 107.
- [14] Buso, S., et al., “Performance Degradation of High Brightness Light Emitting Diodes under DC and Pulsed Bias”, *IEEE Trans. Device Mater. Rel.*, vol. 8, no. 2, pp. 312-322.
- [15] Yu, T., et al., “Luminescence Degradation of InGaN/GaN Violet LEDs”, *J. Lumin.*, vol. 122/123, pp. 696-699.
- [16] Bychikhin, S., et al., “Low-Frequency Noise Sources in As-Prepared and AQged GaN-Based Light-Emitting Diodes”, *J. Appl. Phys.*, vol. 97, no. 12, pp. 123 714- 1–123 714-7.
- [17] Meneghini, M., et al., “High-Temperature Degradation of GaN LEDs Related to Passivation”, *IEEE Trans. Electron Devices*, vol. 53, no. 12, pp. 2981-2987.
- [18] Meneghini, M., et al., “Reversible Degradation of Ohmic Contacts on p-GaN for Application in High Brightness LEDs”, *IEEE Trans. Electron Devices*, vol. 54, no. 12, pp. 3245-3251.
- [19] Meneghini, M., et al., “A Model for the Thermal Degradation of Metal/(p-GaN) Interface in GaN-Based LEDs”, *J. Appl. Phys.*, vol.103, no. 6, pp. 063 703-1–063 703-7.
- [20] Polyakov, A. Y., et al., “Enhanced Tunneling in GaN/InGaN Multi-Quantum-Well Heterojunction Diodes after Short-Term Injection Annealing”, *J. Appl. Phys.*, vol. 91, no. 8, pp. 5203-5207.
- [21] Meneghesso, G., et al., “Electrostatic Discharge and Electrical Overstress on GaN/InGaN Light Emitting Diodes”, in *Proc. 23rd EOS/ESD Symp.*, Portland, OR, Sep. 11–13, 2001, pp. 249-254.
- [22] Jeon, S.-K., et al., “The Effect of the Internal Capacitance of InGaN-Light Emitting Diode on the Electrostatic Discharge Properties”, *Appl. Phys. Lett.*, vol. 94, no. 13, p. 131 106.
- [23] Narendran, N., et al., “Solid-State Lighting: Failure Analysis of White LEDs”, *J. Cryst. Growth*, vol. 268, no. 3/4, pp. 449-456.
- [24] Mueller-Mach, R., et al., “High-Power Phosphor-Converted Light-Emitting Diodes Based on III-Nitrides”, *IEEE J. Sel. Topics Quantum Electron.*, vol. 8, no. 2, pp. 339-345.
- [25] Trevisanello, L.-R., et al., “Thermal Stability Analysis of High Brightness LED During High Temperature and Electrical Aging”, *Proc. SPIE*, vol. 6669, p. 666 913.
- [26] Meneghini, M., et al., “A Review on the Physical Mechanisms that Limit the Reliability of GaN-Based LEDs”, *IEEE Trans. on Electron Devices*, Vol. 57, No. 1, pp. 108-118.
- [27] Krames, M. R., and H. Amano, *IEEE J. Sel. Top. Quantum Electron.*, vol. 8, no. 2, p. 185.
- [28] Delbecke, D., et al., *IEEE J. Sel. Top. Quantum Electron.*, vol. 8, no. 2, p. 189.
- [29] Windisch, R., et al., *IEEE Electron. Lett.*, vol. 36, no. 4, p. 351.
- [30] Zehnder U, et al., “Industrial Production of GaNand InGaN-Light Emitting Diodes on SiC-Substrates, *Journal of Crystal Growth*, no. 230, pp. 497-502.
- [31] Rigutti L., et al., “Redistribution of Multi-Quantum Well States Induced by Current Stress in InGaN/GaN Light- Emitting Diodes”, *Semicond. Sci. Technol.* no. 24, 055015.
- [32] Lee S. N., et al., “Effects of Mg Dopant on the Degradation of InGaN Multiple Quantum Wells in AlInGaN-Based Light Emitting Devices, *Journal of Electroceramics*, DOI 10.1007/s10832-008-9478-2.
- [33] Meneghesso, G., et al., “Recent Results on the Degradation of White LEDs for Lighting”, *Journal of Physics D: Applied Physics*, vol. 43, no. 35, p. 7.
- [34] Narendran, N., et al., “Solid-State Lighting: Failure Analysis of White LEDs”, *J. of Crystal Growth*, Vol. 268, no. 3-4, pp. 449-456.
- [35] Meneghini M, et al., “Reversible Degradation of GaN LEDs Related to Passivation”, *IEEE Proc. International Reliability Physics Symposium, IRPS 2007*, pp. 457-461.
- [36] Meneghini M, et al., “Extensive Analysis of the Degradation of Phosphor-Converted LEDs”, *Proc. SPIE 7422, 74220H*.

- [37] Narendran, N., and Yimin, Gu, “Life of LED-Based White Light Sources”, IEEE/OSA Journal of Display Technology, vol. 1, no. 1, pp. 167-171.
- [38] Yimin, Gu, et al., “Spectral and Luminous Efficacy Change of High-Power LEDs under Different Dimming Methods”. SPIE Proceedings vol. 6337, Sixth Internat. Conf. on Solid State Lighting; DOI: 10.1117/12.680531.
- [39] Cao, X. A., et al., “Investigation of Radiative Tunneling in GaN/InGaN Single Quantum Well Light-Emitting Diodes”, Solid State Electron., vol. 46(2002), no. 12, pp. 2291-2294.
- [40] Meneghesso, G., et al., “Reliability of Visible GaN LEDs in Plastic Package”, Microelectronics Reliability, vol. 43(2003), pp. 1737-1742.
- [41] Arik, M., and Stanton Weaver, “Effect of Chip and Bonding Defects on the Junction Temperatures of High-Brightness Light-Emitting Diodes”, Opt. Eng. 44(11), 111305 (November 18, 2005); <http://dx.doi.org/10.1117/1.2130127>.
- [42] Lu, G., et al., “Analysis on Failure Modes and Mechanisms of LED”, Proc. of 8th Internat. Conf. on Reliability, Maintainability and Safety, 20-24 July 2009. ICRMS 2009, pp. 1237-1241.
- [43] Chen, N., “Numerical Simulation and Experimental Researches on the LED Reliability under Temperature Loading”, Applied Mathematics & Information Sciences, Vol. 6(2012), no. 3, pp. 775-779.
- [44] Yung, K. C., et al., “Degradation Mechanism Beyond Device Self-Heating in High Power Light-Emitting Diodes”, Journal of Applied Physics 109(2011), 094509, doi:10.1063/1.3580264.
- [45] Fan, J. et al., “Physics-of-Failure-Based Prognostics and Health Management for High-Power White Light-Emitting Diode Lighting”, IEEE Transactions on Device and Materials Reliability, vol. 11(2011), no. 3, pp. 407-416.
- [46] Yang, Sh.-Ch., et al., “Failure and Degradation Mechanisms of High-Power White Light Emitting Diodes”, Microelectronics Reliability, vol. 50(2010), no. 7, pp. 959-964.
- [47] Zhaohui, Chen, et al., “Reliability Test and Failure Analysis of High-Power LED Packages”, Journal of Semiconductors, vol. 32(2011), no. 1, pp. 014007-1 to 014007-4.
- [48] Li, Z. L., P. T. Lai, and H. W. Choi, “A Reliability Study on Green InGaN–GaN Light-Emitting Diodes”, IEEE Photonics Technology Letters, vol. 21(2009), no. 19, pp. 1429-1431.
- [49] Murakami, K., et al., “White Illumination Characteristics of ZnS-based Phosphor Materials Excited by InGaN-base Ultra Violet Light Emitting Diode”, Defense Technical Information Center, Compilation Part Notice ADP 011310.