

# Table of Contents

## Preface, Committees, Sponsors

## Memorial

**The Science Enjoyed by Professor Alec T. Stewart**  
T. Hyodo

3

## Chapter 1: Positron and Positronium Physics

### Positron Manipulation and Positronium Laser Excitation in AEGIS

S. Mariazzi, R. Caravita, S. Aghion, C. Amsler, A. Ariga, T. Ariga, G. Bonomi, P. Bräunig, J. Bremer, R.S. Brusa, L. Cabaret, M. Caccia, F. Castelli, G. Cerchiari, K. Chlouba, S. Cialdi, D. Comparat, G. Consolati, A. Demetrio, L. di Noto, M. Doser, A. Dudarev, A. Ereditato, C. Evans, R. Ferragut, J. Fesel, A. Fontana, O.K. Forslund, S. Gerber, M. Giammarchi, A. Gligorova, S. Gninenko, F. Guatieri, S. Haider, H. Holmestad, T. Huse, I.L. Jernelv, E. Jordan, T. Kaltenbacher, A. Kellerbauer, M. Kimura, T. Koetting, D. Krasnický, V. Lagomarsino, P. Lansonneur, P. Lebrun, S. Lehner, J. Liberadzka, C. Malbrunot, L. Marx, V. Matveev, Z. Mazzotta, G. Nebbia, P. Nedelec, M. Oberthaler, N. Pacifico, D. Pagano, L. Penasa, V. Petrcek, C. Pistillo, F. Prelez, M. Prevedelli, L. Ravelli, L. Resch, B. Rienäcker, O.M. Röhne, S. Rosenberger, A. Rotondi, M. Sacerdoti, H. Sandaker, R. Santoro, P. Scampori, F. Sorrentino, M. Spacek, J. Storey, I.M. Strojek, G. Testera, I. Tietje, S. Vamasi, E. Widmann, P. Yzombard, S. Zavatarelli and J. Zmeskal

11

### Enegretics of the Ps Formation: Role of the Solvated Electron

S.V. Stepanov, V. Byakov, D. Zvezhinskiy and G. Duplâtre

17

### Low-Energy Ps-Xe Scattering Analyzed Using a Modified Effective Range Theory

K. Shibuya and H. Saito

23

## Chapter 2: Modeling and Computational Methods of Calculations

### Positron Lifetime Calculation for Plastic Deformed Nanocrystalline Copper

K. Zhou and T. Zhang

31

### Parameter-Free Gradient Correction for Positron States in Oxides

J. Kuriplach and B. Barbiellini

35

### First-Principles Calculation of Defect Formation and Positron Annihilation States in Bi<sub>2</sub>Te<sub>3</sub>

B. Zhao, B. Zhou, C.Y. Li, N. Qi and Z.Q. Chen

41

### First-Principles Study on Positron States at Li-Adsorbed Al(100) Surfaces: Effect of Electron-Positron Correlation

S. Hagiwara, Y. Suzuki and K. Watanabe

46

## Chapter 3: Recent Trends in Experimental Techniques

### Simulation Study of Positron Beam Generation via Irradiating an Ultra-Intense Laser on a Hollow Target

J.X. Liu, Y.Y. Ma, J. Zhao, T.P. Yu, X.H. Yang, W.Q. Wang and J. Jiang

53

### Project for a Source of Polarized Slow Positrons at ELI-NP

N. Djourelov, A. Oprisa and V. Leca

57

### Investigation of Non-Destructive Testing in Inner Cavity with Ant-Nest Structure Based on Positron Annihilation

J.T. Liu, M. Zhao, H. Xiao and M. Yao

61

### Spin-Polarized Positron Annihilation Study on Some Ferromagnets

H. Li, M. Maekawa, A. Miyashita and A. Kawasuso

65

### CDBTools - Evaluate Positron Annihilation Coincidence Doppler Broadening Spectrum

M. Petriska, V. Sabelová and V. Slugeň

71

|                                                                                                                                                                                               |    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| <b>New Precision Measurement of Hyperfine Splitting of Positronium</b><br>A. Ishida                                                                                                           | 75 |
| <b>Ionic Liquid Loaded Silica Gel Particles Studied by Spatially Resolved DBS Using a Scanning Positron Beam</b><br>M. Reiner, H. Ceeh, T. Gigl, M. Haumann, A. Schönweiz and C. Hugenschmidt | 80 |
| <b>Study of Position-Sensitive PMTs as Gamma Cameras for 2D-ACAR</b><br>H. Ceeh, R. Engels, C. Wesolek, J.A. Weber and C. Hugenschmidt                                                        | 84 |

## Chapter 4: Metals and Alloys

|                                                                                                                                                                                                                                                                                                                                                      |     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| <b>Temperature Dependence of Radiation Damage in ODS Steel Studied by Triple Beam Irradiation and Positron Annihilation Techniques</b><br>D.Q. Yuan, Q.L. Zhang, P. Fan, X.P. Wang, B. Long, H.L. Ma, Y. Zuo, A. Wen, Y.N. Zheng, X.S. Kong, Z. Zhuang, W. Feng, J.C. Liang, W.J. Xiong, E.Y. Lu, X.Z. Cao, P. Zhang, B.Y. Wang, L. Wei and S.Y. Zhu | 91  |
| <b>PALS and TEM Study on Irradiation Defects of 12Cr-ODS Steels Induced by He/H Ions</b><br>L.H. Han, T. Fa and Y.W. Zhao                                                                                                                                                                                                                            | 96  |
| <b>Study on the Evolution of Defects in Helium-Implanted Tungsten</b><br>K. Wang, A.H. Deng, L. Wang, Y. Wang, X.B. Lu and M. Gong                                                                                                                                                                                                                   | 100 |
| <b>The Evolution Behavior of Defects in the Nanofilms of W/Cu and W Probed by Doppler Broadening Positron Annihilation Spectroscopy</b><br>L. Wang, A.H. Deng, K. Wang, Y. Wang, X.B. Lu, Y. Wang and R. Li                                                                                                                                          | 104 |
| <b>Evolution of the Helium-Related Defect in Polycrystalline Tungsten</b><br>X.B. Lu, A.H. Deng, Y. Wang, K. Wang and L. Wang                                                                                                                                                                                                                        | 108 |
| <b>Fe<sup>+</sup> Implantation Induced Damage in Oxide Dispersion Strengthened Steels Investigated by Doppler Broadening Spectroscopy</b><br>W. Anwand, T. Leguey, M. Scepanovic, F.J. Sanchez, I. García-Cortés and A. Wagner                                                                                                                       | 113 |
| <b>Synergistic Effect on Formation of Radiation Damage in CLAM Steel Studied by Triple Beam Irradiation</b><br>D.Q. Yuan, H.L. Ma, P. Fan, Y.N. Zheng, Y. Zuo, Q.L. Zhang, A. Wen, W. Feng, J.C. Liang, W.J. Xiong, X.Q. Ma, B.Q. Cui, L.H. Chen, W.S. Jiang, Q.Y. Huang, Y.C. Wu, P. Lei, X.Z. Cao, B.Y. Wang, L. Wei, H.H. Xia and S.Y. Zhu        | 117 |
| <b>Hydrogen-Induced Defects in Titanium</b><br>P. Hruška, J. Čížek, F. Lukáč, J. Knapp, S. Mašková, J. Drahokoupil, O. Melikhova and I. Procházka                                                                                                                                                                                                    | 122 |
| <b>Study of Defects Introduced by 2 and 9 MeV Electron Irradiation in B2 Type Fe-Al Alloy</b><br>Y. Ueno, A. Iwase, K. Ohsawa, Q. Xu, K. Sato, Y. Saitoh and F. Hori                                                                                                                                                                                 | 126 |
| <b>Structural Relaxation of Open Volume in Hyper-Eutectic Zr-Cu-Al Bulk Amorphous Alloys Measured by Positron Annihilation</b><br>T. Ishiyama, K. Kobayashi, Y. Yokoyama, T.J. Konno, A. Iwase and F. Hori                                                                                                                                           | 130 |
| <b>A Preliminary Study of Oxidation Behavior of Mo-50Re Alloy at Different Temperature Using Positron Annihilation Lifetime Spectroscopy</b><br>Z.J. Zhu, W. Yang, J.J. Shi, T.G. Zhai and Y.C. Wu                                                                                                                                                   | 134 |
| <b>Positron Spectroscopy of Defects in Hydrogen-Saturated Zirconium</b><br>Y. Bordulev, K. Lee, R.S. Laptev, V.N. Kudiiarov and A.M. Lider                                                                                                                                                                                                           | 138 |
| <b>Study the Effect of Plastic Deformation in 8006 Al-Alloys by Positron Lifetime Spectroscopy, Vickers Hardness and X-Ray Diffraction</b><br>E.A. Badawi, M.A. Abdel-Rahman, M. Salah and M. Abdel-Rahman                                                                                                                                           | 142 |
| <b>Studies of Microdefects, Thermal Expansion and Magnetic Properties of Fe-Ni-Co Invar Alloys</b><br>W. Deng, L.X. Li, S.L. Xu, W.C. Zhang, Y.Y. Huang and D.K. Xiong                                                                                                                                                                               | 146 |
| <b>Positron Annihilation and TEM Characterization of Cu-Enriched Clusters in the Ferritic Steels Containing Copper</b><br>Z.L. Chen, X.B. Liu, Y.C. Wu, R.S. Wang, F. Xue, P. Huang, C.L. Xu and W.J. Qian                                                                                                                                           | 150 |
| <b>Irradiation Induced Defects by Fe-Ion in 316L Stainless Steel Studied by Positron Annihilation Spectroscopy</b><br>X.Z. Cao, E.Y. Lu, S.X. Jin, Y.H. Gong, Y.C. Hu, T. Zhu, P. Zhang, L. Wei and B.Y. Wang                                                                                                                                        | 155 |

|                                                                                                                               |     |
|-------------------------------------------------------------------------------------------------------------------------------|-----|
| <b>Estimation of Dislocation Concentration in Plastically Deformed FeCrNi Alloy by Positron Annihilation Lifetime</b>         |     |
| E.Y. Lu, X.Z. Cao, S.X. Jin, Y.H. Gong, P. Zhang, R.S. Yu and B.Y. Wang                                                       | 162 |
| <b>The Microdefects, Magnetic Properties and Electron Characters of Fe-Ga Alloys</b>                                          |     |
| D.K. Xiong, H.Q. Wei, W.T. Liu, Y.Y. Huang and W. Deng                                                                        | 167 |
| <b>Strain-Rate Dependence of Vacancy Cluster Size in Hydrogen-Charged Martensitic Steel AISI410 under Tensile Deformation</b> |     |
| K. Sugita, Y. Mutou and Y. Shirai                                                                                             | 171 |

## Chapter 5: Semiconductors, Ceramics and Compound Materials

|                                                                                                                                         |     |
|-----------------------------------------------------------------------------------------------------------------------------------------|-----|
| <b>Study of Defects in Croconic Acid Single Crystals Using Positron Annihilation Lifetime Spectroscopy</b>                              |     |
| F. Guzman, J. Tran, K. Cousins, P.K. Dixon, D. Smith, T.D. Usher and R.W. Zhang                                                         | 179 |
| <b>Vacancy-Type Defects in GaN for Power Devices Probed by Positron Annihilation</b>                                                    |     |
| A. Uedono, S. Ishibashi, N. Oshima and R. Suzuki                                                                                        | 183 |
| <b>Effect of FLiBe Infiltration Pressure on Microstructure of Matrix for TMSR Fuel Elements (FEs)</b>                                   |     |
| H.X. Xu, J. Lin, Y. Chen, B.C. Gu, B.J. Ye, Z.Y. Zhu, H.T. Jiang, Y.J. Zhong and B. Liu                                                 | 189 |
| <b>Study of Defects in High Energy Ion Implanted ZnO Crystals</b>                                                                       |     |
| O. Melikhova, J. Čížek, I. Procházka, P. Hruška, W. Anwand, V. Havránek, V.A. Skuratov and T.S. Strukova                                | 193 |
| <b>Effect of TiO<sub>2</sub> Doping on Microdefects and Electrical Properties of ZnO-Based Varistors</b>                                |     |
| Z.Y. Chen, M.Y. Li, Y. Wan, L.F. Han, Y.Y. Huang and W. Deng                                                                            | 197 |
| <b>1-xSr<sub>x</sub>MnO<sub>3</sub> Manganites</b>                                                                                      |     |
| Y.Y. Huang, Y. Meng, W.H. Huang, S.L. Xu, D.K. Xiong and W. Deng                                                                        | 201 |
| <b>Studies of Microstructure and Electro-Magnetic Transport Property of La<sub>0.67</sub>Ca<sub>0.33</sub>MnO<sub>3</sub> Ceramic</b>   |     |
| S.L. Xu, E.J. Xie, X.Q. Cao, Y.Y. Huang, D.K. Xiong and W. Deng                                                                         | 205 |
| <b>Radiation-Induced Defects in Si after High Dose Proton Irradiation</b>                                                               |     |
| Y.V. Funtikov, L.Y. Dubov, Y.V. Shtotsky and S.V. Stepanov                                                                              | 209 |
| <b>Modulation of the Dielectric Properties of CaCu<sub>3</sub>Ti<sub>4</sub>O<sub>12</sub> System with Gd-Substitution</b>              |     |
| Z.P. Chen, H.F. He, T. Li, H.Y. Dai and Z.Q. Chen                                                                                       | 213 |
| <b>Effect of Annealing Process on the Photoelectric Properties and Microstructure of Sulfur-Hyperdoped Silicon</b>                      |     |
| D.W. Liu, T. Li, H.Y. Dai, R.Z. Xue, Z.P. Chen, X.Z. Cao and B.Y. Wang                                                                  | 217 |
| <b>Asymmetric Positron Interactions with Chiral Quartz Crystals?</b>                                                                    |     |
| J.D. van Horn, F. Wu, G. Corsiglia and Y.C. Jean                                                                                        | 221 |
| <b>Zn-Vacancy Related Defects Identified in ZnO Films Grown by Pulsed Laser Deposition</b>                                              |     |
| F.C.C. Ling, Z.L. Wang, C.Q. Luo, W. Anwand and A. Wagner                                                                               | 227 |
| <b>Positron Annihilation Spectroscopic Studies of Cu<sub>2</sub>Te Thermoelectric Material</b>                                          |     |
| W.N. Ge, J.P. Xu, R. Ye, J.D. Liu and B.J. Ye                                                                                           | 231 |
| <b>Positron Annihilation in TaN Thin Sputtering Films Prepared with Various N<sub>2</sub> Partial Pressures</b>                         |     |
| J.D. Liu, B.C. Gu, J.J. Fang and B.J. Ye                                                                                                | 237 |
| <b>Effect of La Doping on the Microstructure and Nonlinear Characteristics of CaCu<sub>3</sub>Ti<sub>4</sub>O<sub>12</sub> Ceramics</b> |     |
| J. Chen, T. Li, H.Y. Dai and Z.P. Chen                                                                                                  | 241 |
| <b>Defect Characterization in Thermoelectric Zn-Sb Systems by Positron Annihilation</b>                                                 |     |
| T. Zhang, K. Zhou and Z.Q. Chen                                                                                                         | 245 |
| <b>Microstructure and Defects of MgO/ZrO<sub>2</sub> Nanocrystals Investigated by Positron Annihilation Spectroscopy</b>                |     |
| J.H. Wang, J.J. Shi, W. Yang, Z.J. Zhu and Y.C. Wu                                                                                      | 249 |

## Chapter 6: Polymers, Composites and Porous Materials

|                                                                                                                                                                                                                                                                                   |     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| <b>Characterization of Polysulfone/TiO<sub>2</sub> Composite Membrane Modified by Plasma</b><br>Z. Chen, C. Yin, S. Wang, K. Ito, Q.M. Fu, Q.R. Deng, Z.D. Lin, P. Fu, Y. Zhang and Z.T. Liu                                                                                      | 257 |
| <b>On the Limits of Sensitivity of PALS to Incorporated Free Volume Holes in Polymeric Membranes and Sorbents: Effect of <i>sc</i>-CO<sub>2</sub> in Polyhexafluoropropylene</b><br>V.P. Shantarovich, V. Bekeshev, N. Belov, I. Kevdina, M. Filimonov, I. Ronova and A. Nikolaev | 261 |
| <b>A Microstructural Study of Acrylic-Modified Chitosan by Means of PALS and SAXS</b><br>P. Anbinder, C. Macchi, J. Amalvy and A. Somoza                                                                                                                                          | 265 |
| <b>Influence of the Crosslinking Content on the Structural Properties of Polybutadiene Rubbers with Different Isomeric Composition</b><br>A. Rodriguez Garraza, M. Mansilla, C. Macchi, S. Cervený, A. Marzocca and A. Somoza                                                     | 269 |
| <b>Study of Gamma Irradiation Effect on Unplasticized PVC by Positron Annihilation</b><br>B.Y. Wang, J. Yang, X.Z. Cao, L. Wei and R.S. Yu                                                                                                                                        | 274 |
| <b>Positron Lifetime Annihilation Study of Porous Composites and Silicas Synthesized Using Polymer Templates</b><br>M. Gorgol, A. Kierys and R. Zaleski                                                                                                                           | 280 |
| <b>Investigation of Micro-Sized Capsules at High Pressure by PALS Method</b><br>B. Zgardzińska, M. Tydda and J. Wawryszczuk                                                                                                                                                       | 284 |
| <b>Positron Annihilation Lifetime Spectroscopy Application to <i>In Situ</i> Monitoring of <i>n</i>-Heptane Sorption in Mesopores</b><br>R. Zaleski, M. Gorgol and A. Kierys                                                                                                      | 288 |
| <b>Characterisation of Porosity in Zirconia-Based Nanopowders</b><br>I. Procházka, J. Čížek, O. Melikhova, P. Hruška, W. Anwand, T.E. Konstantinova and I.A. Danilenko                                                                                                            | 295 |
| <b>Positron Annihilation Study of Porous ZnO Synthesized with Soft Template</b><br>B. Zhou, C.Y. Li, N. Qi and Z.Q. Chen                                                                                                                                                          | 299 |
| <b>Application and Evaluation of 3D Printed Materials with PALS</b><br>M.D. Paul, J.S. Davis, Y.C. Jean and J.D. van Horn                                                                                                                                                         | 303 |

## Chapter 7: Surfaces and Interfaces

|                                                                                                                                                                                                                                                                    |     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| <b>Observation of a Low Energy Component of Positronium Emitted from Alkali-Metal Coated Polycrystalline Tungsten Surfaces</b><br>S. Iida, H. Terabe, T. Tachibana, K. Wada, I. Mochizuki, A. Yagishita, T. Hyodo and Y. Nagashima                                 | 309 |
| <b>Comparative Study of Time-Dependent PAES and XPS on a Ni/Pd Surface</b><br>S. Zimnik, C. Piochacz, S. Vohburger and C. Hugenschmidt                                                                                                                             | 313 |
| <b>Investigation of Hydrogen Sorption-Desorption Processes at Gas-Phase Hydrogenation and Defects Formation in Titanium by Means of Electron-Positron Annihilation Techniques</b><br>T. Murashkina, R.S. Laptev, V.N. Kudiyarov, D.V. Gvozdyakov and M.N. Babihina | 317 |
| <b>Ion Desorption from TiO<sub>2</sub>(110) by Low Energy Positron Impact</b><br>T. Tachibana, L. Chiari, M. Nagira, T. Hirayama and Y. Nagashima                                                                                                                  | 324 |