

References

1. H. Mette, H. Pick, Z. Phys. **134**, 566 (1953)
2. M. Pope, H.P. Kallmann, P. Magnante, Electroluminescence in organic crystals. J. Chem. Phys. **38**, 2042 (1963)
3. R.G. Kepler, Charge carrier production and mobility in anthracene crystals. Phys. Rev. **119**(4), 1226–1229 (1960)
4. C.K. Chiang, C.R. Fincher, J.Y.W. Park, A.J. Heeger, H. Shirakawa, E.J. Louis, S.C. Gau, A.G. MacDiarmid, Electrical conductivity in doped polyacetylene. Phys. Rev. Lett. **39**(17), 1098–1101 (1977)
5. J.C. Kotz, P. Treichel, *Chemistry and Chemical Reactivity* (Saunders College Publishing, Philadelphia, 1999)
6. C. Kittel, *Introduction to Solid State Physics*, 6th edn. (Wiley, New York, 1986), p. 185
7. S. Verlaak, Small-molecule organic thin-film transistors: growth, charge transport and some applications. PhD thesis, K. U. Leuven (2004)
8. V.I. Arkhipov, V.A. Kolesnikov, A.I. Rudenko, Dispersive transport of charge-carriers in polycrystalline pentacene layers. J. Phys. D **17**(6), 1241–1254 (1984)
9. M. Pope, C.S. Swenberg, *Electronic Processes in Organic Crystals and Polymers*, 2nd edn. (Oxford University Press, New York, 1999)
10. V. Arkhipov, I. Fishchuk, A. Kadashchuk, H. Bässler, *Photophysics of Molecular Materials: From Single Molecules to Single Crystals* (Wiley, New York, 2006). Chap. 6: Charge transport in disordered organic semiconductors
11. W. Warta, N. Karl, Hot holes in naphthalene: high, electric-field-dependent mobilities. Phys. Rev. B **32**(2), 1172–1182 (1985)
12. N. Karl, J. Marktanner, Electron and hole mobilities in high purity anthracene single crystals. Mol. Cryst. Liq. Cryst. **355**, 149–173 (2001)
13. V. Podzorov, É. Menard, J.A. Rogers, M.E. Gershenson, Hall effect in the accumulation layers on the surface of organic semiconductors. Phys. Rev. Lett. **95**, 26601 (2005)
14. O. Ostroverkhova, D.G. Cooke, F.A. Hegmann, J.E. Anthony, V. Podzorov, M.E. Gershenson, O.D. Jurchescu, T.T.M. Palstra, Ultrafast carrier dynamics in pentacene, functionalized pentacene, tetracene, and rubrene single crystals. Appl. Phys. Lett. **88**, 162101 (2006)
15. P.G.L. Comber, W.E. Spear, Electronic transport in amorphous silicon films. Phys. Rev. Lett. **25**(8), 509–511 (1970)
16. G. Horowitz, R. Hajlaoui, P. Delannoy, Temperature-dependence of the field-effect mobility of sexithiophene—determination of the density of traps. J. Phys. **5**(4), 355–371 (1995)
17. M. Mottaghi, G. Horowitz, Field-induced mobility degradation in pentacene thin-film transistors. Org. Electron. **7**, 528–536 (2006)
18. H. Bässler, Charge transport in disordered organic photoconductors: a Monte-Carlo simulation study. Phys. Status Solidi B **175**(1), 15–56 (1993)

19. M.C.J.M. Vissenberg, M. Matters, Theory of the field-effect mobility in amorphous organic transistors. *Phys. Rev. B* **57**(20), 12964–12967 (1998)
20. J.A. Barltrop, J.D. Coyle, *Excited States in Organic Chemistry* (Wiley-VCH, New York, 1975)
21. M.V. der Auweraer, Photophysics and photochemistry of molecular materials, B-KUL-G0I12A
22. Y. Shi, J. Liu, K. Han, Investigation of the internal conversion time of the chlorophyll a from S₃, S₂ to S₁. *Chem. Phys. Lett.* **410**(4–6), 260–263 (2005)
23. C.W. Tang, S.A. VanSlyke, Organic electroluminescent diodes. *Appl. Phys. Lett.* **51**(12), 913–915 (1987)
24. L.S. Hung, C.H. Chen, Recent progress of molecular organic electroluminescent materials and devices. *Mater. Sci. Eng. R.* **39**, 143–222 (2002)
25. A. Bernanose, M. Comte, P. Vouaux, A new method of light emission by certain organic compounds. *J. Chim. Phys.* **50**, 64 (1953)
26. A. Bernanose, P. Vouaux, Organic electroluminescence type of emission. *J. Chim. Phys.* **50**, 261 (1953)
27. J.H. Burroughes, D.D. Bradley, A.R. Brown, R.N. Marks, K. Mackay, R.H. Friend, P.L. Burnst, A.B. Holmes, Light-emitting diodes based on conjugated polymers. *Nature* **347**, 539 (1990)
28. R.H. Friend, R.W. Gymer, A.B. Holmes, J.H. Burroughes, R.N. Marks, C. Taliani, D.D.C. Bradley, D.A.D. Santos, J.L. Brédas, M. Lögdlund, W.R. Salaneck, Electroluminescence in conjugated polymers. *Nature* **397**, 121 (1999)
29. F. So, J. Kido, P. Burrows, Organic light-emitting devices for solid-state lighting. *Mater. Res. Soc. Bull.* **33**, 663–669 (2008)
30. S.A. VanSlyke, C.W. Tang, Organic electroluminescent devices having improved power conversion efficiencies. US patent 4,539,507
31. P.W.M. Blom, M.J.M. de Jong, Electrical characterization of polymer light-emitting diodes. *IEEE J. Sel. Top. Quantum Electron.* **4**(1), 105–112 (1998)
32. C. Hosokawa, H. Tokailin, H. Higashi, T. Kusumoto, Transient behavior of organic thin film electroluminescence. *Appl. Phys. Lett.* **60**(10), 1220–1222 (1992)
33. J. Kido, Y. Lizumi, Fabrication of highly efficient organic electroluminiscent devices. *Appl. Phys. Lett.* **73**(19), 2721–2723 (1998)
34. C. Adachi, M.A. Baldo, M.E. Thompson, S.R. Forrest, Nearly 100% internal phosphorescence efficiency in an organic light emitting device. *J. Appl. Phys.* **90**(10), 5048–5051 (2001)
35. N.K. Patel, S. Cina, J.H. Burroughes, High-efficiency organic light-emitting diodes. *IEEE J. Quantum Electron.* **8**(2), 346–361 (2002)
36. M.A. Baldo, D.F. O'Brien, M.E. Thompson, S.R. Forrest, Excitonic singlet-triplet ratio in a semiconducting organic thin film. *Phys. Rev. B* **60**(20), 14422–14428 (1999)
37. M.A. Baldo, D.F. O'Brien, Y. You, A. Shoustikov, S. Sibley, M.E. Thompson, S.R. Forrest, Highly efficient phosphorescent emission from organic electroluminescent devices. *Nature* **395**, 151–154 (1998)
38. D. Tanaka, H. Sasabe, Y. Li, S. Su, T. Takeda, J. Kido, Ultra high efficiency green organic light-emitting devices. *Jpn. J. Appl. Phys.* **46**(1), L10–L12 (2007)
39. D. Tanaka, Y. Agata, T. Takeda, S. Watanabe, J. Kido, High luminous efficiency blue organic light-emitting devices using high triplet excited energy materials. *Jpn. J. Appl. Phys.* **46**(5), L117–L119 (2007)
40. O. Inganäs, T. Granlund, M. Theander, M. Berggren, M.R. Andersson, A. Ruseckas, V. Sundström, Optical emission from confined poly(thiophene) chains. *Opt. Mater.* **9**, 104–108 (1998)
41. C.W. Tang, S.A. VanSlyke, C.H. Chen, Electroluminescence of doped organic thin films. *J. Appl. Phys.* **65**(9), 3610–3616 (1989)
42. Y. Lin, W. Chou, S. Lin, Enhanced efficiency in polymer light-emitting diodes due to the improvement of charge-injection balance. *Appl. Phys. Lett.* **88**, 071108 (2006)

43. T. Yamasaki, K. Sumioka, T. Tsutsui, Organic light-emitting device with an ordered monolayer of silica microspheres as a scattering medium. *Appl. Phys. Lett.* **76**(10), 1243–1245 (2000)
44. G. Parthasarathy, P.E. Burrows, V. Khalfin, V.G. Kozlov, S.R. Forrest, A metal-free cathode for organic semiconductor devices. *Appl. Phys. Lett.* **72**(17), 2138–2140 (1998)
45. F. Dinelli, M. Mugia, P. Levy, M. Cavallini, F. Biscarini, Spatially correlated charge transport in organic thin film transistors. *Phys. Rev. Lett.* **92**(11), 116802 (2004)
46. C. Tanase, E.J. Meijer, P.W.M. Blom, D.M. de Leeuw, Unification of the hole transport in polymeric field-effect transistors and light-emitting diodes. *Phys. Rev. Lett.* **91**, 216601 (2003)
47. A. Dodabalapur, H.E. Katz, L. Torsi, Molecular orbital energy level engineering in organic transistors. *Adv. Mater.* **8**(10), 853–855 (1996)
48. A. Hepp, H. Heil, W. Weise, M. Ahles, R. Schmeichel, H. von Seggern, Light-emitting field-effect transistor based on a tetracene thin film. *Phys. Rev. Lett.* **91**(15), 157406 (2003)
49. M. Muccini, A bright future for organic field-effect transistors. *Nat. Mater.* **5**, 605–613 (2006)
50. S. Verlaak, D. Cheyns, M. Debucquoy, V. Arkhipov, P. Heremans, Numerical simulation of tetracene light-emitting transistors: a detailed balance of exciton processes. *Appl. Phys. Lett.* **85**(12), 2405–2407 (2004)
51. J. Reynaert, D. Cheyns, D. Janssen, R. Müller, V.I. Arkhipov, J. Genoe, G. Borghs, P. Heremans, Ambipolar injection in a submicron-channel light-emitting tetracene transistor with distinct source and drain contacts. *J. Appl. Phys.* **97**, 114501 (2005)
52. C. Santato, R. Capelli, M.A. Loi, M. Murgia, F. Cicoria, V.A.L. Roy, P. Stallinga, R. Zamboni, C. Rost, S.F. Karg, M. Muccini, Tetracene-based organic light-emitting transistors: optoelectronic properties and electron injection mechanism. *Synth. Met.* **146**, 329–334 (2004)
53. T. Sakanoue, E. Fujiwara, R. Yamada, H. Tada, Visible light emission from polymer-based field-effect transistors. *Appl. Phys. Lett.* **84**(16), 3037–3039 (2004)
54. M. Ahles, A. Hepp, R. Schmeichel, H. von Seggern, Light emission from a polymer transistor. *Appl. Phys. Lett.* **84**(3), 428–430 (2004)
55. J. Swensen, D. Moses, A.J. Heeger, Light emission in the channel region of a polymer thin-film transistor fabricated with gold and aluminum for the source and drain electrodes. *Synth. Met.* **153**, 53–56 (2005)
56. H. Nakanotani, S. Akiyama, D. Ohnishi, M. Moriwake, M. Yahiro, T. Yoshihara, S. Tōbita, C. Adachi, Extremely low-threshold amplified spontaneous emission of 9,9'-spirobifluorene derivates and electroluminescence from field-effect transistor structure. *Adv. Funct. Mater.* **17**, 2328–2335 (2007)
57. T. Oyamada, H. Uchiuzou, S. Akiyama, Y. Oku, N. Shimoji, K. Matsushige, H. Sasabe, C. Adachi, Lateral organic light-emitting diode with field-effect transistor characteristics. *J. Appl. Phys.* **98**, 074506 (2005)
58. C. Rost, S. Karg, W. Riess, M.A. Loi, M. Murgia, M. Muccini, Ambipolar light-emitting organic field-effect transistor. *Appl. Phys. Lett.* **85**(9), 1613–1615 (2004)
59. M.A. Loi, C. Rost, M. Murgia, S. Karg, W. Riess, M. Muccini, Tuning optoelectronic properties of ambipolar organic light-emitting transistor using a bulk-heterojunction approach. *Adv. Funct. Mater.* **16**, 41–47 (2006)
60. C. Rost, S. Karg, W. Riess, M.A. Loi, M. Murgia, M. Muccini, Light-emitting ambipolar organic heterostructure field-effect transistor. *Synth. Met.* **146**, 237–241 (2004)
61. R. Capelli, F. Dinelli, M.A. Loi, M. Murgia, R. Zamboni, M. Muccini, Ambipolar organic light-emitting transistors employing heterojunctions of n-type and p-type materials as the active layer. *J. Phys., Condens. Matter* **18**, S2127–S2138 (2006)
62. F. Dinelli, R. Capelli, M.A. Loi, M. Murgia, M. Muccini, A. Facchetti, T.J. Marks, High-mobility ambipolar transport in organic light-emitting transistors. *Adv. Mater.* **18**, 1416–1420 (2006)
63. E.B. Namdas, P. Ledochowitsch, J.D. Yuen, D. Moses, A.J. Heeger, High performance light emitting transistors. *Appl. Phys. Lett.* **92**, 183304 (2008)

64. S.D. Vusser, S. Steudel, S. Schols, S. Verlaak, J. Genoe, W.D. Oosterbaan, L. Lutsen, D. Vandezande, P. Heremans, A light-emitting organic field-effect transistor using an organic heterostructure inside the transistor channel. *Appl. Phys. Lett.* **89**, 223504 (2006)
65. J. Zaumseil, R. Friend, H. Sirringhaus, Spatial control of the recombination zone in an ambipolar light-emitting organic transistor. *Nat. Mater.* **5**(1), 69–74 (2006)
66. J.S. Swensen, C. Soci, A.J. Heeger, Light emission from an ambipolar semiconducting polymer field-effect transistor. *Appl. Phys. Lett.* **87**, 253511 (2005)
67. J. Zaumseil, C.L. Donley, J. Kim, R.H. Friend, H. Sirringhaus, Efficient top-gate, ambipolar, light-emitting field-effect transistors based on a green-light-emitting polyfluorene. *Adv. Mater.* **18**, 2708–2712 (2006)
68. J.S. Swensen, J. Yuen, D. Gargas, S.K. Buratto, A.J. Heeger, Light emission from an ambipolar semiconducting polymer field effect transistor: Analysis of the device physics. *J. Appl. Phys.* **102**, 013103 (2007)
69. R.C.G. Naber, M. Bird, H. Sirringhaus, A gate dielectric that enables high ambipolar mobilities in polymer light-emitting field-effect transistors. *Appl. Phys. Lett.* **93**, 023301 (2008)
70. T. Sakanoue, M. Yahiro, C. Adachi, H. Uchiuzou, T. Takahashi, A. Toshimitsu, Ambipolar light-emitting organic field-effect transistors using a wide-band-gap blue-emitting small molecule. *Appl. Phys. Lett.* **90**, 171118 (2007)
71. E.C.P. Smits, S. Setayesh, T.D. Anthopoulos, M. Buechel, W. Nijssen, R. Coehoorn, P.W.M. Blom, B. de Boer, D.M. de Leeuw, Near-infrared light-emitting ambipolar organic field-effect transistors. *Adv. Mater.* **19**, 734–738 (2007)
72. D.L. Smith, P.P. Ruden, Analytic device model for light-emitting ambipolar organic semiconductor field-effect transistors. *Appl. Phys. Lett.* **89**, 233519 (2006)
73. M. Kemerink, D.S.H. Charrier, E.C.P. Smits, S.G.J. Mathijssen, D.M. de Leeuw, R.A.J. Janssen, On the width of the recombination zone in ambipolar organic field effect transistors. *Appl. Phys. Lett.* **93**, 033312 (2008)
74. T. Takahashi, T. Takenobu, J. Takeya, Y. Iwasa, Ambipolar light-emitting transistors of a tetracene single crystal. *Adv. Funct. Mater.* **17**, 1623–1628 (2007)
75. T. Takenobu, S.Z. Bisri, T. Takahashi, M. Yahiro, C. Adachi, Y. Iwasa, High current density in light-emitting transistors of organic single crystals. *Phys. Rev. Lett.* **100**, 066601 (2008)
76. H. Nakatani, R. Kabe, M. Yahiro, T. Takenobu, Y. Iwasa, C. Adachi, Blue-light-emitting ambipolar field-effect transistors using an organic single crystal of 1,4-bis(4-methylstyryl)benzene. *Appl. Phys. Express* **1**, 091801 (2008)
77. J. Zaumseil, H. Sirringhaus, Electron and ambipolar transport in organic field-effect transistors. *Chem. Rev.* **107**, 1296–1323 (2007)
78. F. Ciciora, C. Santato, Organic light emitting field effect transistors: advances and perspectives. *Adv. Funct. Mater.* **17**, 3421–3434 (2007)
79. T.P.I. Saragi, R. Pudzich, T. Fuhrmann, J. Salbecka, Organic phototransistor based on intramolecular charge transfer in a bifunctional spiro compound. *Appl. Phys. Lett.* **84**(13), 2334–2336 (2004)
80. M. Debucquoy, S. Verlaak, S. Steudel, K. Myny, J. Genoe, P. Heremans, Correlation between bias stress instability and phototransistor operation of pentacene thin-film transistors. *Appl. Phys. Lett.* **91**, 103508 (2007)
81. T.N. Ng, W.S. Wong, M.L. Chabinyc, S. Sambandan, R.A. Street, Flexible image sensor array with bulk heterojunction organic photodiode. *Appl. Phys. Lett.* **92**, 213303 (2008)
82. C.J. Brabec, N.S. Sariciftci, J.C. Hummelen, Plastic solar cells. *Adv. Funct. Mater.* **11**(1), 15–26 (2001)
83. H. Sirringhaus, N. Tessler, R.H. Friend, Integrated optoelectronic devices based on conjugated polymers. *Science* **280**, 1741–1744 (1998)
84. N. Tessler, Laser based on semiconducting organic materials. *Adv. Mater.* **11**(5), 363–370 (1999)
85. M.D. McGehee, A.J. Heeger, Semiconducting (conjugated) polymers as material for solid-state lasers. *Adv. Mater.* **12**(22), 1655–1668 (2000)
86. I.D.W. Samuel, G.A. Turnbull, Organic semiconductor lasers. *Chem. Rev.* **107**, 1272–1295 (2007)

87. T.H. Maiman, Stimulated optical radiation in ruby. *Nature* **187**(4736), 493–494 (1960)
88. D. Meschede, *Optics, Light and Lasers: The Practical Approach to Modern Aspects of Photonics and Laser Physics* (Wiley-VCH, Weinheim, 2004)
89. J. Engelen, Optische communicatie h245 & h806, k.u.leuven, ir.elektronica: ict-telecommunicatie en telematica (2003)
90. V.G. Kozlov, V. Bulovic, P.E. Burrows, S.R. Forrest, Laser action in organic semiconductor waveguide and double-heterostructure devices. *Nature* **389**, 362–364 (1997)
91. G. Kranzelbinder, G. Leising, Organic solid-state lasers. *Rep. Prog. Phys.* **63**(5), 729–762 (2000)
92. B. Schweitzer, G. Wegmann, H. Giessen, D. Hertel, H. Bässler, R.F. Mahrt, U. Scherf, K. Müllen, The optical gain mechanism in solid conjugated polymers. *Appl. Phys. Lett.* **72**, 2933–2935 (1998)
93. A.R. Brown, A. Pomp, C.M. Hart, D.M. de Leeuw, Logic gates made from polymer transistors and their use in ring oscillators. *Science* **270**(5238), 972–974 (1995)
94. Z. Bao, A. Bodabalapur, A.J. Lovinger, Soluble and processable regioregular poly(3-hexylthiophene) for thin film field-effect transistor applications with high mobility. *Appl. Phys. Lett.* **69**(26), 4108–4110 (1996)
95. C.D. Dimitrakopoulos, P.R.L. Malenfant, Organic thin film transistors for large area electronics. *Adv. Mater.* **14**(2), 99–117 (2002)
96. V.G. Kozlov, V. Bulovic, P.E. Burrows, M. Baldo, V.B. Khalfin, G. Parthasarathy, S.R. Forrest, Study of lasing action based on Förster energy transfer in optically pumped organic semiconductor thin films. *J. Appl. Phys.* **84**(8), 4096–4108 (1998)
97. D. Schneider, T. Rabe, T. Riedl, T. Dobbertin, M. Kröger, E. Becker, H. Johannes, W. Kowalsky, T. Weimann, J. Wang, P. Hinze, Ultrawide tuning range in doped organic solid-state lasers. *Appl. Phys. Lett.* **85**(11), 1886–1888 (2004)
98. D. Schneider, T. Rabe, T. Riedl, T. Dobbertin, O. Werner, M. Kröger, E. Becker, H. Johannes, W. Kowalsky, T. Weimann, J. Wang, P. Hinze, A. Gerhard, P. Stössel, H. Vestweber, Deep blue widely tunable organic solid-state laser based on a spirobifluorene derivative. *Appl. Phys. Lett.* **84**(23), 4693–4695 (2004)
99. T. Riedl, T. Rabe, H.-H. Johannes, W. Kowalsky, J. Wang, T. Weimann, R. Hinze, B. Nehls, T. Farrell, U. Scherf, Tunable organic thin-film laser pumped by an inorganic violet diode laser. *Appl. Phys. Lett.* **88**, 241116 (2006)
100. G. Wegmann, H. Giessen, A. Greiner, R.F. Mahrt, Laser emission from a solid conjugated polymer: gain, tunability and coherence. *Phys. Rev. B* **57**(8), R4218–R4221 (1998)
101. A.K. Sheridan, G.A. Turnbull, A.N. Safonov, I.D.W. Samuel, Tuneability of amplified spontaneous emission through control of the waveguide-mode structure in conjugated polymer films. *Phys. Rev. B* **62**(18), R11929–R11932 (2000)
102. G.A. Turnbull, T.F. Krauss, W.L. Barnes, I.D.W. Samuel, Tuneable distributed feedback lasing in MEH-PPV films. *Synth. Met.* **121**, 1757–1758 (2001)
103. S. Riechel, U. Lemmer, J. Feldmann, S. Berleb, A.G. Mückl, W. Brüttling, Very compact tunable solid-state laser utilizing a thin-film organic semiconductor. *Opt. Lett.* **26**(9), 593–595 (2001)
104. B. Schütte, H. Gothe, S.I. Hintschich, M. Sudzius, H. Fröb, V.G. Lyssenko, K. Leo, Continuously tunable laser emission from a wedge-shaped organic microcavity. *Appl. Phys. Lett.* **92**, 163309 (2008)
105. D. Amarasinghe, A. Ruseckas, A.E. Vasdekis, M. Goossens, G.A. Turnbull, I.D.W. Samuel, Broadband solid state optical amplifier based on a semiconducting polymer. *Appl. Phys. Lett.* **89**, 201119 (2006)
106. J.R. Lawrence, G.A. Turnbull, I.D.W. Samuel, Broadband optical amplifier based on a conjugated polymer. *Appl. Phys. Lett.* **80**(17), 3036–3038 (2002)
107. I.D.W. Samuel, G.A. Turnbull, Polymer lasers: recent advances. *Mater. Today* 28–35 (2004)
108. U. Rauscher, H. Bässler, D.D.C. Bradley, M. Hennecke, Exciton versus band description of the absorption and luminescence spectra in poly(p-phenylenevinylene). *Phys. Rev. B* **42**(16), 9830–9836 (1990)

109. R. Kersing, U. Lemmer, R.F. Mahrt, K. Leo, H. Kurz, H. Bässler, E.O. Böbel, Femtosecond energy relaxation in π -conjugated polymers. *Phys. Rev. B* **70**(24), 3820–3823 (1993)
110. M. Andersson, G. Yub, A. Heeger, Photoluminescence and electroluminescence of films from soluble PPV-polymers. *Synth. Met.* **85**, 1275–1276 (1997)
111. S. Tasch, A. Niko, G. Leising, U. Scherf, Highly efficient electroluminescence of new wide band gap ladder-type poly(para-phenylenes). *Appl. Phys. Lett.* **68**(8), 1090–1092 (1996)
112. B.R. Hsieh, Y. Yu, E.W. Forsythe, G.M. Schaaf, W.A. Feld, A new family of high emissive soluble poly(*p*-phenylene vinylene) derivatives. A step toward fully conjugated blue-emitting poly(*p*-phenylene vinylenes). *J. Am. Chem. Soc.* **120**, 231–232 (1998)
113. L. Chan, Y. Lee, C. Chen, Synthesis and characterization of 3,4-diphenylmaleimide copolymers that exhibit organic to red photoluminescence and electroluminescence. *Macromolecules* **39**, 3262–3269 (2006)
114. M. Berggren, A. Dodabalapur, R.E. Slusher, Stimulated emission and lasing in dye-doped organic thin films with Förster transfer. *Appl. Phys. Lett.* **71**, 2230 (1997)
115. A. Tsumara, H. Koezuka, T. Ando, Macromolecular electronic device: field-effect transistor with a polythiophene thin film. *Appl. Phys. Lett.* **49**(18), 1210–1212 (1986)
116. V.L. Broude, V.S. Mashkevich, A.F. Prikhot'ko, N.F. Prokopyuk, M.S. Soskin, On the possibility of stimulated emission in systems with electronic vibrational levels. *Fiz. Tverd. Tela* **4**, 2976 (1962)
117. P.P. Sorokin, J.R. Lankard, Stimulated emission observed from an organic dye chloro-aluminum phthalocyanine. *IBM J. Res. Dev.* **10**, 162–163 (1966)
118. M. Maeda, *Laser Dyes: Properties of Organic Compounds for Dye Lasers* (OHM, Tokyo, 1984)
119. B.H. Soffer, B.B. McFarland, Continuously tunable, narrow-band organic dye lasers. *Appl. Phys. Lett.* **10**(10), 266–267 (1967)
120. N. Karl, Laser emission from an organic molecular crystal. *Phys. Status Solidi A* **13**, 651 (1972)
121. O.S. Avanesjan, V.A. Benderskii, V.K. Brikenstein, V.L. Broude, L.I. Korshunov, A.G. Lavrushko, I.I. Tartakovskii, Anthracene crystals under intensive optical pumping. *Mol. Cryst. Liq. Cryst.* **29**, 165–174 (1974)
122. H. Kogelnik, C.V. Shank, Stimulated emission in a periodic structure. *Appl. Phys. Lett.* **18**(4), 152–154 (1971)
123. T.W. Hänsch, M. Pernier, A.L. Schawlow, Laser action of dyes in gelatin. *IEEE J. Quantum Electron.* **7**(1), 45–46 (1971)
124. F.P. Schäfer, K.H. Drexhage, *Dye Lasers*, vol. 1, 2nd rev. edn. (Springer, Berlin, 1977)
125. D. Zhang, Y. Wang, D. Ma, Random lasing emission from a red fluorescent dye doped polystyrene film containing dispersed polystyrene nanoparticles. *Appl. Phys. Lett.* **91**, 091115 (2007)
126. D. Moses, High quantum efficiency luminescence from a conducting polymer in solution: A novel polymer laser dye. *Appl. Phys. Lett.* **60**(26), 3215–3216 (1992)
127. L.J. Rothberg, M. Yan, F. Papadimitrakopoulos, M.E. Galvin, E.W. Kwock, T.M. Miller, Photophysics of phenylenevinylene polymers. *Synth. Met.* **80**, 41–58 (1996)
128. L.J. Rothberg, M. Yan, S. Son, M.E. Galvin, E.W. Kwock, T.M. Miller, H.E. Katz, R.C. Haddon, F. Papadimitrakopoulos, Intrinsic and extrinsic constraints on phenylenevinylene polymer electroluminescence. *Synth. Met.* **78**, 213–236 (1996)
129. G.J. Denton, N. Tessler, N.T. Harrison, R.H. Friend, Factors influencing stimulated emission from poly(*p*-phenylenevinylene). *Phys. Rev. Lett.* **78**(4), 733–736 (1997)
130. F. Hide, B.J. Schwartz, M.A. Diaz-Garcia, A.J. Heeger, Laser emission from solutions and films containing semiconducting polymer and titanium dioxide nanocrystals. *Chem. Phys. Lett.* **256**, 424–430 (1996)
131. W. Graupner, G. Leising, G. Lanzani, M. Nisoli, S.D. Silvestri, U. Scherf, Femtosecond relaxation of photoexcitations in a poly(para-phenylene)-type ladder polymer. *Phys. Rev. Lett.* **76**(5), 847–850 (1996)
132. N. Tessler, G.J. Denton, R.H. Friend, Lasing from conjugated polymer microcavities. *Nature* **382**, 695–697 (1996)

133. F. Hide, M.A. Diaz-Garcia, B.J. Schwartz, M.R. Andersson, Q. Pei, A.J. Heeger, Semiconducting polymers: a new class of solid-state laser materials. *Science* **273**, 1833–1836 (1996)
134. S.V. Frolov, M. Ozaki, W. Gellermann, Z.V. Vareeny, K. Yoshino, Mirrorless lasing in conducting polymer poly(2,5-diethoxy-p-phenylenevinylene) films. *J. Appl. Phys.* **35**(10B), 1371–1373 (1996)
135. M. Berggren, A. Dodabalapur, R.E. Slusher, Z. Bao, Light amplification in organic thin films using cascade energy transfer. *Nature* **389**, 466–469 (1997)
136. V.G. Kozlov, G. Parthasarathy, P.E. Burrows, S.R. Forrest, Y. You, M.E. Thompson, Optically pumped blue organic semiconductor lasers. *Appl. Phys. Lett.* **72**(2), 144–146 (1998)
137. T. Aimono, Y. Kawamura, K. Goushi, H. Yamamoto, H. Sasebae, C. Adachi, 100% fluorescence efficiency of 4,4'-bis[(n-carbazole)styryl]biphenyl in a solid film and the very low amplified spontaneous emission threshold. *Appl. Phys. Lett.* **86**(7), 071110 (2005)
138. M.D. McGehee, R. Gupta, S. Veenstra, E.K. Miller, M.A. Diaz-Garcia, A.J. Heeger, Amplified spontaneous emission from photopumped films of a conjugated polymer. *Phys. Rev. B* **58**(11), 7035–7039 (1998)
139. A. Andreev, F. Quochi, F. Cordella, A. Mura, G. Bongiovanni, H. Sitter, G. Hlawacek, C. Teichert, N.S. Sariciftci, Coherent random lasing in the deep blue from self-assembled organic nanofibers. *J. Appl. Phys.* **99**, 034305 (2006)
140. D. Schneider, T. Rabe, T. Riedl, T. Dobbertin, M. Kröger, E. Becker, H. Johannes, W. Kowalsky, T. Weimann, J. Wang, P. Hinze, Laser threshold reduction in an all-spiro guest-host system. *Appl. Phys. Lett.* **85**(10), 1659–1661 (2004)
141. T. Rabe, M. Hoping, D. Schneider, E. Becker, H. Johannes, W. Kowalsky, T. Weimann, J. Wang, P. Hinze, B.S. Nehls, U. Scherf, T. Farrell, T. Riedl, Threshold reduction in polymer lasers based on poly(9,9-diethylfluorene) with statistical binaphthyl units. *Adv. Funct. Mater.* **12**, 1188–1192 (2005)
142. C. Zenz, W. Graupner, S. Tasch, G. Leising, K. Müllen, U. Scherf, Blue green stimulated emission from a high gain conjugated polymer. *Appl. Phys. Lett.* **71**(18), 2566–2568 (1997)
143. A. Dodabalapur, M. Berggren, R.E. Slusher, Z. Bao, A. Timko, P. Schiortino, E. Laskowsk, H.E. Katz, O. Nalamasu, Resonators and materials for organic lasers based on energy transfer. *IEEE J. Quantum Electron.* **4**(1), 67–74 (1998)
144. G. Heliotis, R. Xia, D.D.C. Bradley, G.A. Turnbull, I.D.W. Samuel, P. Andrew, W.L. Barnes, Two-dimensional distributed feedback lasers using a broadband, red polyfluorene gain medium. *J. Appl. Phys.* **96**(12), 6959–6965 (2004)
145. C. Bauer, H. Giessen, B. Schnabel, E. Kley, C. Schmitt, U. Scherf, R.F. Mahrt, A surface-emitting circular grating polymer laser. *Adv. Mater.* **13**(15), 1161–1164 (2001)
146. C. Karnutsch, C. Gärtner, V. Haug, U. Lemmer, T. Farrell, B.S. Nehls, U. Scherf, J. Wang, T. Weimann, G. Heliotis, C. Pfleum, J.C. deMello, D.D.C. Bradley, Low threshold blue conjugated polymer lasers with first-and second-order distributed feedback. *Appl. Phys. Lett.* **89**, 201108 (2006)
147. K. Baumann, T. Stöferle, N. Moll, R. Mahrt, T. Wahlbrink, J. Bolten, T. Mollenhauser, C. Moormann, U. Scherf, Organic mixed-order photonic crystal lasers with ultrasmall footprint. *Appl. Phys. Lett.* **91**, 171108 (2007)
148. C. Karnutsch, C. Pfleum, G. Heliotis, J.C. deMello, D.D.C. Bradley, Improved organic semiconductor lasers based on a mixed-order distributed feedback resonator design. *Appl. Phys. Lett.* **90**, 131104 (2007)
149. U. Scherf, S. Riechel, U. Lemmer, R.F. Mahrt, Conjugated polymers: lasing and stimulated emission. *Curr. Opin. Solid State Mater. Sci.* **5**, 143–154 (2001)
150. A. Haugeneder, M. Neges, C. Kallinger, W. Spirkl, U. Lemmer, J. Feldmann, M.-C. Amann, U. Scherf, Nonlinear emission and recombination in conjugated polymer waveguides. *Appl. Phys. Lett.* **85**(2), 1124–1130 (1999)
151. W. Holzer, A. Penzkofer, S. Gong, A. Bleyer, D.D.C. Bradley, Laser action in poly(*m*-phenylenevinylene-*co*-2,5-diethoxy-*p*-phenylenevinylene). *Adv. Mater.* **8**(12), 974–978 (1996)

152. M. Yan, L.J. Rothberg, F. Papadimitrakopoulos, L.E. Galvin, T.M. Miller, Spatially indirect excitons as primary photoexcitations in conjugated polymers. *Phys. Rev. Lett.* **72**(7), 1104–1107 (1994)
153. S.V. Frolov, Z.V. Vardeny, K. Yoshina, Cooperative and stimulated emission in poly(*p*-phenylene-vinylene) thin films and solutions. *Phys. Rev. B* **57**(15), 9141–9147 (1998)
154. T. Granlund, M. Theander, M. Berggren, M. Andersson, A. Ruzeckas, V. Sundström, G. Björk, M. Granström, O. Inganäs, A polythiophene microcavity laser. *Chem. Phys. Lett.* **288**, 879–884 (1998)
155. F. Laquai, A.K. Mishra, K. Müllen, R.H. Friend, Amplified spontaneous emission of poly(ladder-type phenylene)s—the influence of photophysical properties on ASE thresholds. *Adv. Funct. Mater.* **18**, 3265–3275 (2008)
156. B.K. Yap, R. Xia, M. Campoy-Quiles, M.N. Stavrinou, D.D.C. Bradley, Simultaneous optimization of charge-carrier mobility and optical gain in semiconducting polymer films. *Nat. Mater.* **7**, 376–380 (2008)
157. G. Wegmann, B. Schweitzer, D. Hertel, H. Giessen, M. Oestreich, U. Scherf, K. Müllen, R.F. Mahrt, The dynamics of gain-narrowing in a ladder-type π -conjugated polymer. *Chem. Phys. Lett.* **312**, 376–384 (1999)
158. G. Cerullo, S. Stagira, M. Nisoli, S.D. Silvestri, G. Lanzani, G. Kranzelbinder, W. Graupner, G. Leising, Excited-state dynamics of poly(para-phenylene)-type ladder polymers at high photoexcitation density. *Phys. Rev. B* **57**(20), 12806–12811 (1998)
159. H. Tanaka, Y. Yoshida, T. Nakao, N. Tsujimoto, A. Fujii, M. Ozaki, Photopumped laser oscillation and charge carrier mobility of composite films based on poly(3-haxylthiophene)s with different stereoregularity. *Jpn. J. Appl. Phys.* **45**(40), L1077–L1079 (2006)
160. T. Nguyen, I.B. Martini, J. Liu, B.J. Schwartz, Controlling interchain interactions in conjugated polymers: the effects of chain morphology on exciton-exciton annihilation and aggregation in meh-ppv films. *J. Phys. Chem. B* **104**, 237–255 (2000)
161. T. Nguyen, V. Doan, B.J. Schwartz, Conjugated polymer aggregates in solution: control of interchain interactions. *J. Chem. Phys.* **110**(8), 4068–4078 (1999)
162. M. Anni, G. Gigli, R. Cingolan, M. Zavelani-Rossi, C. Gadermaier, G. Lanzani, G. Barbarella, L. Favaretto, Amplified spontaneous emission from a soluble thiophene-based oligomer. *Appl. Phys. Lett.* **78**(18), 2679–2681 (2001)
163. F. Laquai, P.E. Keivanidis, S. Baluschev, J. Jacob, K. Müllen, G. Wegner, Low threshold amplified spontaneous emission in thin films of poly(tetraarylindenofluorene). *Appl. Phys. Lett.* **87**, 261917 (2005)
164. H. Nakanotani, N. Matsumoto, H. Uchiuzou, M. Nishiyama, M. Yahiro, C. Adachi, Very low amplified spontaneous emission threshold and electroluminescence characteristics of 1,1'-diphenyl substituted fluorene derivatives. *Opt. Mater.* **30**, 630–636 (2007)
165. K.L. Shaklee, R.F. Leheny, Direct determination of optical gain in semiconductor crystals. *Appl. Phys. Lett.* **18**(11), 475–477 (1971)
166. Y. Sorek, R. Reisfeld, I. Finkelstein, S. Ruschin, Light amplification in dye-doped glass planar waveguide. *Appl. Phys. Lett.* **66**(10), 1169–1171 (1995)
167. G. Jordan, M. Flämmich, M. Rüther, T. Kobayashi, W.J. Blau, Y. Suzuki, T. Kaino, Light amplification at 501 nm and large nanosecond optical gain in organic dye-doped polymeric waveguides. *Appl. Phys. Lett.* **88**, 161114 (2006)
168. G. Heliotis, D.C. Bradley, G.A. Turnbull, I.D.W. Samuel, Light amplification and gain in polyfluorene waveguides. *Appl. Phys. Lett.* **81**(3), 415–417 (2002)
169. S.V. Frolov, W. Gellermann, M. Ozaki, K. Yoshino, Z.V. Vardeny, Cooperative emission in π -conjugated polymer thin films. *Phys. Rev. Lett.* **78**(4), 729–732 (1997)
170. G.H. Gelinck, J.M. Warman, M. Remmers, D. Neher, Narrow-band emissions from conjugated-polymer films. *Chem. Phys. Lett.* **265**, 320–326 (1997)
171. T. Virgili, D.G. Lidzey, M. Grell, D.D.C. Bradley, S. Stagira, M. Zavelani-Rossi, S.D. Silvestri, Influence of the orientation of liquid crystalline poly(9,9-diptylfluorene) on its lasing properties in a planar microcavity. *Appl. Phys. Lett.* **80**(22), 4088–4090 (2002)
172. M. Koschorreck, R. Gehlhaar, V.G. Lyssenko, M. Swoboda, M. Hoffmann, K. Leo, Dynamics of a high-Q vertical-cavity organic laser. *Appl. Phys. Lett.* **87**, 181108 (2005)

173. L. Persano, P.D. Carro, E. Mele, R. Cingolani, D. Pisignano, M. Zavelani-Rossi, S. Longhi, G. Lanzani, Monolithic polymer microcavity lasers with on-top evaporated dielectric mirrors. *Appl. Phys. Lett.* **88**, 121110 (2006)
174. M.A. Díaz-García, F. Hide, B.J. Schwartz, M.D. McGehee, M.R. Andersson, A.J. Heeger, Plastic lasers: comparison of gain narrowing with a soluble semiconducting polymer in waveguides and microcavities. *Appl. Phys. Lett.* **70**(24), 3191–3193 (1997)
175. A. Schülzgen, C. Spiegelberg, M.M. Morrell, S.B. Mendes, B. Kippelen, N. Peyghambarian, Near diffraction-limited laser emission from a polymer in a high finesse planar cavity. *Appl. Phys. Lett.* **72**(3), 269–271 (1998)
176. X. Liu, H. Li, C. Song, Y. Liao, M. Tian, Microcavity organic laser device under electrically pumping. *Opt. Lett.* **34**(4), 503–505 (2009)
177. H. Kogelnik, C.V. Shank, Stimulated emission in a periodic structure. *Appl. Phys. Lett.* **18**(4), 152–154 (1971)
178. H. Kogelnik, C.V. Shank, Coupled-wave theory of distributed feedback lasers. *J. Appl. Phys.* **43**(5), 2327–2335 (1972)
179. M.D. McGehee, M.A. Diaz-Garcia, F. Hide, R. Gupta, E.K. Miller, D. Moses, A.J. Heeger, Semiconducting polymer distributed feedback lasers. *Appl. Phys. Lett.* **72**(13), 1536–1538 (1998)
180. G.A. Turnbull, P. Andrew, M.J. Jory, W.L. Barnes, I.D.W. Samuel, Relationship between photonic band structure and emission characteristics of a polymer distributed feedback laser. *Phys. Rev. B* **64**, 125122 (2001)
181. G. Heliotis, R. Xia, G.A. Turnbull, P. Andrew, W.L. Barnes, I.D.W. Samuel, D.D.C. Bradley, Emission characteristics and performance comparison of polyfluorene lasers with one- and two-dimensional distributed feedback. *Adv. Funct. Mater.* **14**(1), 91–97 (2004)
182. M. Reufer, S. Riechel, J.M. Lupton, J. Feldmann, U. Lemmer, D. Schneider, T. Benstem, T. Dobbertin, W. Kowalsky, A. Gombert, K. Forberich, V. Wittwer, U. Scherf, Low-threshold polymeric distributed feedback lasers with metallic contacts. *Appl. Phys. Lett.* **84**(17), 3262–3264 (2004)
183. C. Kallinger, M. Hilmer, A. Haugeneder, M. Perner, W. Spirkl, U. Lemmer, J. Feldmann, U. Scherf, K. Mullen, A. Gombert, V. Wittwer, A flexible conjugated polymer laser. *Adv. Mater.* **10**(12), 920–923 (1998)
184. V.G. Kozlov, G. Parthasarathy, P.E. Burrows, V.B. Khalfin, J. Wang, S.Y. Chou, S.R. Forrest, Structures for organic diode lasers and optical properties of organic semiconductors under intense optical and electrical excitations. *IEEE J. Quantum Electron.* **36**(1), 18–26 (2000)
185. T. Spehr, A. Siebert, T. Fuhrmann-Lieker, J. Salbeck, T. Rabe, T. Riedl, H.H. Johannes, W. Kowalsky, J. Wang, T. Weimann, P. Hinze, Organic solid-state ultraviolet-laser based on spiro-terphenyl. *Appl. Phys. Lett.* **87**, 161103 (2005)
186. D. Pisignano, L. Persano, P. Visconti, R. Cingolani, G. Gigli, G. Barbarella, L. Favaretto, Oligomer-based organic distributed feedback lasers by room-temperature nanoimprint lithography. *Appl. Phys. Lett.* **83**(13), 2545–2547 (2003)
187. A. Rose, Z. Zhu, C.F. Madigan, T.M. Swager, V. Bulovic, Sensitivity gains in chemosensing by lasing action in organic polymers. *Nature* **434**, 876–879 (2005)
188. D. Schneider, S. Hartmann, T. Benstem, T. Dobbertin, D. Heithecker, D. Metzdorf, E. Becker, T. Riedl, H. Johannes, W. Kowalsky, T. Weimann, J. Wang, P. Hinze, Wavelength-tunable organic solid-state distributed-feedback laser. *Appl. Phys. B* **77**, 399–402 (2003)
189. R. Xia, G. Heliotis, P.N. Stavrinou, D.D.C. Bradley, Polyfluorene distributed feedback lasers operating in the green-yellow spectral region. *Appl. Phys. Lett.* **87**, 031104 (2005)
190. S. Riechel, C. Kallinger, U. Lemmer, J. Feldmann, A. Gombert, V. Wittwer, U. Scherf, A nearly diffraction limited surface emitting conjugated polymer laser utilizing a two-dimensional photonic band structure. *Appl. Phys. Lett.* **77**(15), 2310–2312 (2000)
191. A.E. Vasdekis, G.A. Turnbull, I.D.W. Samuel, P. Andrew, W.L. Barnes, Low threshold edge emitting polymer distributed feedback laser based on a square lattice. *Appl. Phys. Lett.* **86**, 161102 (2005)

192. J. Stehr, J. Crewett, F. Schindler, R. Sperling, G. von Plessen, U. Lemmer, J.M. Lupton, T.A. Klar, J. Feldmann, A.W. Holleitner, M. Forster, U. Scherf, A low threshold polymer laser based on metallic nanoparticle gratings. *Adv. Mater.* **15**(20), 1726–1729 (2003)
193. G.A. Turnbull, P. Andrew, W.L. Barnes, I.D.W. Samuel, Operating characteristics of a semi-conducting polymer laser pumped by a microchip laser. *Appl. Phys. Lett.* **82**(3), 313–315 (2003)
194. M. Notomi, H. Suzuki, T. Tamamura, Directional lasing oscillation of two-dimensional organic photonic crystal lasers at several photonic band gaps. *Appl. Phys. Lett.* **78**(10), 1325–1327 (2001)
195. N. Moll, R.F. Mahrt, C. Bauer, H. Giessen, B. Schnabel, E.B. Kley, U. Scherf, Evidence for bandedge lasing in a two-dimensional photonic bandgap polymer laser. *Appl. Phys. Lett.* **80**(5), 734–736 (2002)
196. G.A. Turnbull, A. Carleton, G.F. Barlow, A. Tahraoui, T.F. Krauss, K.A. Shore, I.D.W. Samuel, Influence of grating characteristics on the operation of circular-grating distributed-feedback polymer lasers. *J. Appl. Phys.* **98**, 023105 (2005)
197. G. Ramos-Ortiz, C. Spiegelberg, N. Peyghambarian, B. Kippelen, Temperature dependence of the threshold for laser emission in polymer microlasers. *Appl. Phys. Lett.* **77**(18), 2783–2785 (2000)
198. S.V. Frolov, M. Shkunov, Z.V. Vardeny, Ring microlasers from conducting polymers. *Phys. Rev. B* **56**(8), 4363–4366 (1997)
199. S.V. Frolov, M. Shkunov, A. Fujii, K. Yoshino, Z.V. Vardeny, Lasing and stimulated emission in π -conjugated polymers. *IEEE J. Quantum Electron.* **36**(1), 2–11 (2000)
200. Y. Kawabe, C. Spiegelberg, A. Schülzgen, M.F. Nabor, B. Kippelen, E.A. Mash, P.M. Allemand, M. Kuwata-Gonokami, K. Takeda, N. Peyghambarian, Whispering-gallery-mode microring laser using a conjugated polymer. *Appl. Phys. Lett.* **72**(2), 141–143 (1998)
201. S.V. Frolov, A. Fujii, D. Chinn, Z.V. Vardeny, Cylindrical microlasers and light emitting devices from conducting polymers. *Appl. Phys. Lett.* **72**(22), 2811–2813 (1998)
202. M. Berggren, A. Dodabalapur, Z. Bao, R.E. Slusher, Solid-state droplet laser made from an organic blend with a conjugated polymer emitter. *Adv. Mater.* **9**(12), 968–971 (1997)
203. S.V. Frolov, A. Fujii, D. Chinn, M. Hirohata, R. Hidayat, M. Taraguchi, T. Masuda, K. Yoshino, Z.V. Vardeny, Microlasers and micro-leds from disubstituted polyacetylene. *Adv. Mater.* **10**(11), 869–872 (1998)
204. M. Berggren, A. Dodabalapur, R.E. Slusher, Z. Bao, Organic lasers based on Förster transfer. *Synth. Met.* **91**, 65–68 (1997)
205. R. Gupta, M. Stevenson, A. Dogariu, M.D. McGehee, J.Y. Park, V. Srdanov, A.J. Heeger, H. Wang, Low-threshold amplified spontaneous emission in blends of conjugated polymers. *Appl. Phys. Lett.* **73**(24), 3492–3494 (1998)
206. M.A. Baldo, M.E. Thompson, S.R. Forrest, Phosphorescent materials for application to organic light emitting devices. *Pure Appl. Chem.* **71**(11), 2095–2106 (1999)
207. V.G. Kozlov, P.E. Burrows, G. Parthasarathy, S.R. Forrest, Optical properties of molecular organic semiconductor thin films under intense electrical excitation. *Appl. Phys. Lett.* **74**, 1057 (1999)
208. L. Ma, J. Ouyang, Y. Yang, High-speed and high-current density C₆₀ diodes. *Appl. Phys. Lett.* **84**(23), 4786–4788 (2004)
209. N. Tessler, N.T. Harrison, R.H. Friend, High brightness polymer light-emitting diodes. *Adv. Mater.* **10**(1), 64–68 (1998)
210. H. Yamamoto, H. Kasajima, W. Yokayama, H. Sasabe, C. Adachi, Extremely-high-density carrier injection and transport over 12000 A/cm² into organic thin films. *Appl. Phys. Lett.* **86**(8), 083502 (2005)
211. T. Matsushima, H. Sasabe, C. Adachi, Carrier injection and transport characteristics of copper phthalocyanine thin films under low to extremely high current densities. *Appl. Phys. Lett.* **88**, 033508 (2006)
212. M.A. Baldo, R.J. Holmes, S.R. Forrest, Prospects for electrically pumped organic lasers. *Phys. Rev. B* **66**, 35321 (2002)

213. P. Andrew, G.A. Turnbull, I.D.W. Samuel, W.L. Barnes, Photonic band structure and emission characteristics of a metal-backed polymeric distributed feedback laser. *Appl. Phys. Lett.* **81**(6), 954–956 (2002)
214. J. Stehr, J. Crewett, F. Schindler, R. Sperling, G. von Plessen, U. Lemmer, J.M. Lupton, T.A. Klar, J. Feldmann, A.W. Holleitner, M. Forster, U. Scherf, A low threshold polymer laser based on metallic nanoparticle gratings. *Adv. Mater.* **15**(20), 1426–1729 (2003)
215. C. Gärtner, C. Karnutsch, U. Lemmer, C. Pflumm, The influence of annihilation processes on the threshold current density of organic laser diodes. *J. Appl. Phys.* **101**, 023107 (2007)
216. H. Kim, C.M. Gilmore, J.S. Horwitz, A. Piqué, H. Murata, G.P. Kushto, R. Schlaf, Z.H. Kafafi, D.B. Chrisey, Transparent conducting aluminum-doped zinc oxide thin films for organic light-emitting devices. *Appl. Phys. Lett.* **76**(3), 259–261 (2000)
217. H. Yamamoto, T. Oyamada, H. Sasabe, C. Adachi, Amplified spontaneous emission under optical pumping from an organic semiconductor laser structure equipped with transparent carrier injection electrodes. *Appl. Phys. Lett.* **84**(8), 1401–1403 (2004)
218. P. Görnn, T. Rabe, T. Riedl, W. Kowalsky, F. Galbrecht, U. Scherf, Low loss contacts for organic semiconductor lasers. *Appl. Phys. Lett.* **89**, 161113 (2006)
219. P. Görnn, T. Riedl, W. Kowalsky, Loss reduction in fully contacted organic laser waveguides using TE₂ modes. *Appl. Phys. Lett.* **91**, 041113 (2007)
220. M. Reufer, J. Feldmann, P. Rudati, A. Ruhl, D. Müller, K. Meerholz, C. Karnutsch, M. Gerken, U. Lemmer, Amplified spontaneous emission in an organic semiconductor multi-layer waveguide structure including a highly conductive transparent electrode. *Appl. Phys. Lett.* **86**, 221102 (2005)
221. E.B. Namdas, T. Minghong, P. Ledochowitsch, S.R. Mednick, J.D. Yuen, D. Moses, A.J. Heeger, Low thresholds in polymer lasers on conductive substrates by distributed feedback nanoimprinting: progress towards electrically pumped plastic lasers. *Adv. Mater.* **20**, 1–4 (2008)
222. M.C. Gwinner, S. Khodabakhsh, M.H. Song, H. Schweizer, H. Giessen, H. Sirringhaus, Integration of a rib waveguide distributed feedback structure into a light-emitting polymer field-effect transistor. *Adv. Funct. Mater.* **19**(9), 1360–1370 (2009)
223. C. Gärtner, C. Karnutsch, C. Pflumm, U. Lemmer, Numerical device simulation of double-heterostructure organic laser diodes including current-induced absorption processes. *IEEE J. Quantum Electron.* **43**(11), 1006–1017 (2007)
224. V.G. Kozlov, S.R. Forrest, Lasing action in organic semiconductor thin films. *Curr. Opin. Solid State Mater. Sci.* **4**, 203–208 (1999)
225. N. Tessler, D.J. Pinner, V. Cleave, D.S. Thomas, G. Yahioglu, P.L. Barny, R.H. Friend, Pulsed excitation of low-mobility light-emitting diodes: implication for organic lasers. *Appl. Phys. Lett.* **74**, 2764–2766 (1999)
226. N. Tessler, D.J. Pinner, V. Cleave, P.K.H. Ho, R.H. Friend, G. Yahioglu, P.L. Barney, J. Gray, M. de Souza, G. Rumbles, Properties of light emitting organic materials within the context of future electrically pumped lasers. *Synth. Met.* **115**, 57–62 (2000)
227. N. Tessler, N.T. Harrison, D.S. Thomas, R.H. Friend, Current heating in polymer light emitting diodes. *Appl. Phys. Lett.* **73**(6), 732–734 (1998)
228. C. Gärtner, C. Karnutsch, J. Brückner, N. Christ, S. Uebe, U. Lemmer, P. Görnn, T. Rabe, T. Riedl, W. Kowalsky, Loss processes in organic double-heterostructure laser diodes. *Proc. SPIE* **6655**, 665525 (2007)
229. J.M. Lupton, Over the rainbow. *Nature* **453**, 459–460 (2008)
230. D. Hertel, S. Setayesh, H. Nothofer, U. Scherf, K. Müllen, H. Bässler, Phosphorescence in conjugated poly(para-phenylene)-derivatives. *Adv. Mater.* **13**(1), 65–70 (2001)
231. Y. Yang, G.A. Turnbull, I. Samuel, Hybrid optoelectronics: a polymer laser pumped by a nitride light-emitting diode. *Appl. Phys. Lett.* **92**, 163306 (2008)
232. C. Karnutsch, M. Stroisch, M. Punke, U. Lemmer, J. Wang, T. Weimann, Laser diode-pumped organic semiconductor lasers utilizing two-dimensional photonic crystal resonators. *IEEE Photonics Technol. Lett.* **19**(10), 741–743 (2007)

233. D. Yokoyama, M. Moriwake, C. Adachi, Spectrally narrow emissions at cutoff wavelength from edges of optically and electrically pumped anisotropic organic films. *J. Appl. Phys.* **103**, 123104 (2008)
234. Y. Tian, Z. Gan, Z. Zhou, D.W. Lynch, J. Shinar, J. Kang, Q. Park, Spectrally narrowed edge emission from organic light-emitting diodes. *Appl. Phys. Lett.* **91**, 143504 (2007)
235. Y. Hamada, H. Kanno, T. Tsuyoshi, H. Takahashi, Red organic light-emitting diodes using an emitting assist dopant. *Appl. Phys. Lett.* **75**(12), 1682–1684 (1999)
236. C. Rost, D.J. Gundlach, S. Karg, W. Riess, Ambipolar organic field-effect transistor based on an organic heterostructure. *J. Appl. Phys.* **95**(10), 5782–5787 (2004)
237. M. Yoon, S.A. DiBenedetto, A. Facchetti, T.J. Marks, Organic thin-film transistors based on carbonyl-functionalized quaterthiophenes: high mobility n-channel semiconductors and ambipolar transport. *J. Am. Chem. Soc.* **127**, 1348–1349 (2005)
238. H. Yersin, *Highly Efficient Oleds with Phosphorescent Materials* (Wiley-VCH, Weinheim, 2007)
239. Y.D. Jin, Role of excitons and interfaces on optimization of electroluminescence efficiencies in organic light-emitting diodes. PhD thesis, K.U.Leuven (May 2003)
240. B.W. D'Andrade, S. Datta, S.R. Forrest, P. Djurovich, E. Polikarpov, M.E. Thompson, Relationship between the ionization and oxidation potentials of molecular organic semiconductors. *Org. Electron.* **6**, 11–20 (2005)
241. M. Schott, Introduction to the physics of organic electroluminescence. *Acad. Sci.* **1**, 381 (2000)
242. A. Kadashchuk, Y. Skryshevskii, A. Vakhnin, N. Ostapenko, V.I. Arkhipov, E.V. Emelianova, H. Bässler, Thermally stimulated photoluminescence in disordered organic materials. *Phys. Rev. B* **63**, 115205 (2001)
243. A. Kadashchuk, Y. Skryshevski, Y. Piryatinski, A. Vakhnin, E.V. Emelianova, V.I. Arkhipov, H. Bässler, J. Shinar, Thermally stimulated photoluminescence in poly(2,5-diethoxy p-phenylene vinylene). *J. Appl. Phys.* **91**(8), 5016–5023 (2002)
244. I.D. Parker, Carrier tunneling and device characteristics in polymer light-emitting diodes. *J. Appl. Phys.* **75**(3), 1656–1666 (1994)
245. D.J. Gundlach, Y.Y. Lin, T.N. Jackson, S.F. Nelson, D.G. Schlom, Pentacene organic thin-film transistors—molecular ordering and mobility. *IEEE Electron Device Lett.* **18**, 87 (1997)
246. H. Sirringhaus, P.J. Brown, R.H. Friend, M.M. Nielsen, K. Bechgaard, B.M.W. Langeveld-Voss, A.J.H. Spiering, R.A.J. Janssen, E.W. Meijer, P. Herwig, D.M. de Leeuw, Two-dimensional charge transport in self-organized, high-mobility conjugated polymers. *Nature* **40**, 685–688 (1999)
247. I.D.W. Samuel, G. Rumbles, C.J. Collison, R.H. Friend, S.C. Moratti, A.B. Holmes, Picosecond time-resolved photoluminescence of ppv derivatives. *Synth. Met.* **84**, 497–500 (1997)
248. M. Muratsubaki, Y. Furukawa, T. Noguchi, T. Ohnishi, E. Fujiwara, H. Tada, Field-effect transistors based on poly(p-phenylenevinylene) derivatives. *Chem. Lett.* **33**(11), 1480–1481 (2004)
249. C. Adachi, S. Tokito, T. Tsutsui, S. Saito, Electroluminescence in organic films with three-layer structure. *Jpn. J. Appl. Phys.* **27**(2), L269–L271 (1988)
250. S. Schols, S. Verlaak, C. Rolin, D. Cheyns, J. Genoe, P. Heremans, An organic light-emitting diode with field-effect electron transport. *Adv. Funct. Mater.* **18**, 136–144 (2008)
251. S. Schols, C. McClatchey, C. Rolin, D. Bode, J. Genoe, P. Heremans, A. Facchetti, Organic light-emitting diodes with field-effect-assisted electron transport based on α,ω -diperfluorohexyl-quaterthiophene. *Adv. Funct. Mater.* **18**, 3645–3652 (2008)
252. S.D. Vusser, S. Stoedel, K. Myny, D. Janssen, S.D. Jonge, J. Genoe, P. Heremans, An integrated shadowmask technique for patterning small molecule organic semiconductors. *Appl. Phys. Lett.* **88**, 103501 (2006)
253. J. Veres, S. Ogier, S. Leeming, B. Brown, D. Cupertino, Air stable, amorphous organic films and their applications to solution processable flexible electronics. *Mater. Res. Soc. Symp. Proc.* **708**, BB8.7.1 (2002)

254. V. Bulovic, A. Shoustikov, M.A. Baldo, E. Bose, V.G. Kozlov, M.E. Thompson, S.R. Forrest, Bright, saturated, red-to-yellow organic light-emitting devices based on polarization-induced spectral shifts. *Chem. Phys. Lett.* **287**, 455–460 (1998)
255. D.J. Gundlach, K.P. Pernstich, G. Wilckens, M. Grüter, S. Haas, B. Batlogg, High mobility n-channel organic thin-film transistors and complementary inverters. *J. Appl. Phys.* **98**, 064502 (2005)
256. S. Tatemichi, M. Ichikawa, T. Koyama, Y. Taniguchi, High mobility n-type thin-film transistors based on N,N'-ditridecyl perylene diimide with thermal treatments. *Appl. Phys. Lett.* **89**, 112108 (2006)
257. T. van Woudenbergh, P.W.M. Blom, J.N. Huiberts, Electro-optical properties of a polymer light-emitting diode with an injection-limited hole contact. *Appl. Phys. Lett.* **82**(6), 985–987 (2003)
258. T.W. Kelley, D.V. Muyres, P.F. Baude, T.P. Smith, T.D. Jones, High performance organic thin film transistors. *Mater. Res. Soc. Symp. Proc.* **771**, L6.5.2 (2003)
259. L.-L. Chua, J. Zaumseil, J.-F. Chang, E.C.-W. Ou, P.K.-H. Ho, H. Sirringhaus, R.H. Friend, General observation of n-type field-effect behaviour in organic semiconductors. *Nature* **434**, 194–199 (2005)
260. S. Lamansky, P. Djurovich, D. Murphy, F. Abdel-Razzaq, H. Lee, C. Adachi, P.E. Burrows, S.R. Forrest, M.E. Thompson, Highly phosphorescent bis-cyclometalated iridium complexes: synthesis, photophysical characterization and use in organic light emitting diodes. *J. Am. Chem. Soc.* **123**(18), 4304–4312 (2001)
261. I. Sokolik, R. Priestley, A.D. Walser, R. Dorsinville, Bimolecular reactions of singlet excitons in tris(8-hydroxyquinoline) aluminum. *Appl. Phys. Lett.* **69**(27), 4168–4170 (1996)
262. G.E. Jabbour, Y. Kawabe, S.E. Shaheen, J.F. Wang, M.M. Morrell, B. Kippelen, N. Peyghambarian, Highly efficient and bright organic electroluminescent devices with an aluminum cathode. *Appl. Phys. Lett.* **71**(13), 1762–1764 (1997)
263. C. Chiang, M. Wu, D. Dai, Y. Wen, J. Wang, C. Chen, Red-emitting fluorenes as efficient emitting hosts for non-doped organic red-light-emitting diodes. *Adv. Funct. Mater.* **15**(2), 231–238 (2005)
264. M.A. Wolak, J. Delcamp, C.A. Landis, P.A. Lane, J. Anthony, Z. Kafafi, High-performance organic light-emitting diodes based on dioxolane-substituted pentacene derivatives. *Adv. Funct. Mater.* **16**, 1943–1949 (2006)
265. J.-P. Duan, P.-P. Sun, C.-H. Cheng, New iridium complexes as highly efficient orange-red emitters in organic light-emitting diodes. *Adv. Mater.* **15**(3), 224–228 (2003)
266. M.A. Baldo, C. Adachi, S.R. Forrest, Transient analysis of organic electrophosphorescence, II. transient analysis of triplet-triplet annihilation. *Phys. Rev. B* **62**(16), 10967–10977 (2000)
267. R.H. Young, C.W. Tang, A.P. Marchetti, Current-induced fluorescence quenching in organic light-emitting diodes. *Appl. Phys. Lett.* **80**(5), 874–876 (2002)
268. N. Nakanotani, H. Sasabe, C. Adachi, Singlet-singlet and singlet-heat annihilations in fluorescence-based organic light-emitting diodes under steady-state high current density. *Appl. Phys. Lett.* **86**, 213506 (2005)
269. A. Facchetti, M. Mushrush, H.E. Katz, T.J. Marks, N-type building blocks for organic electronics: a homologous family of fluorocarbon-substituted thiophene oligomers with high carrier mobility. *Adv. Mater.* **15**(1), 33–38 (2003)
270. S. Schols, L.V. Willigenburg, R. Müller, D. Bode, M. Debucquo, S.D. Jonge, J. Genoe, P. Heremans, S. Lu, A. Facchetti, Influence of the contact metal on the performance of n-type carbonyl-functionalized quaterthiophene organic thin-film transistors. *Appl. Phys. Lett.* **93**, 263303 (2008)
271. J.A. Venables, G.D.T. Spiller, M. Hanbucken, Nucleation and growth of thin-films. *Rep. Prog. Phys.* **47**, 399 (1984)
272. M. Yoon, C. Kim, A. Facchetti, T.J. Marks, Gate dielectric chemical structure—organic field-effect transistor performance correlations for electron, hole, and ambipolar organic semiconductors. *J. Am. Chem. Soc.* **128**, 12851–12869 (2006)

273. M. Yoon, S.A. DiBenedetto, M.T. Russell, A. Facchetti, T.J. Marks, High-performance n-channel carbonyl-functionalized quaterthiophene semiconductors: thin-film transistor response and majority carrier type inversion via simple chemical protection/deprotection. *Chem. Mater.* **19**, 4864–4881 (2007)
274. S. Soeren, D. Janssen, S. Verlaak, J. Genoe, P. Heremans, Patterned growth of pentacene. *Appl. Phys. Lett.* **85**(23), 5550–5552 (2004)
275. S. Verlaak, S. Steudel, D. Janssen, P. Heremans, M.S. Deleuze, Nucleation of organic semiconductors on inert substrates. *Phys. Rev. B* **68**, 195409 (2003)
276. A. Dodabalapur, L. Torsi, H.E. Katz, Organic transistors: two-dimensional transport and improved electrical characteristics. *Science* **268**, 270–271 (1995)
277. R. Ruiz, A. Papadimitratos, A.C. Mayer, G.G. Malliaras, Thickness dependence of mobility in pentacene thin-film transistors. *Adv. Mater.* **17**, 1795–1798 (2005)
278. T. Muck, V. Wagner, U. Bass, M. Leufgen, J. Geurts, L.W. Molenkamp, In situ electrical characterization of DFH-4T field-effect transistors. *Synth. Met.* **146**, 317–320 (2004)
279. J. Grimshaw, *Organic Electrochemistry: An Introduction and a Guide*, 4th edn. (Dekker, New York, 2000). Chap. 10, Carbonyl Compounds, pp. 411–434
280. H.G.O. Becker, R. Beckert, G. Domschke, E. Fanghänel, W.D. Habicher, P. Metz, D. Pave, K. Schwetlick, *Organikum*, 21st edn. (Wiley-VCH, Weinheim, 2001). Chap. D.7 Reaktionen von Carbonylverbindungen, pp. 586–587
281. M. Hulce, T. Lavaute, Selective cycloalkanone reduction using aluminum amalgam. *Tetrahedron Lett.* **29**, 525–528 (1988)
282. J.C. Kotz, K.F. Purcell, *Chemistry & Chemical Reactivity*, 2nd edn. (Saunders College Publishing, Philadelphia, 1991). Chap. 21 Electrochemistry: The Chemistry of Oxidation-Reduction Reactions, pp. 851–899
283. D.R. Lide (ed.), *CRC Handbook of Chemistry and Physics*, 85th edn. (CRC Press, Boca Raton, 2004–2005), pp. 8.23–8.33
284. A.J. Bard, L.R. Faulkner, *Electrochemical Methods: Fundamentals and Applications*, 2nd edn. (Wiley, New York, 2001), p. 809
285. M.G. Mason, C.W. Tang, L.S. Hung, P. Raychaudhuri, J. Madathil, D.J. Giesen, L. Yan, Q.T. Le, Y. Gao, S.T. Lee, L.S. Liao, L.F. Cheng, W.R. Salaneck, D.A. dos Santos, J.L. Brédas, Interfacial chemistry of Alq₃ and LiF with reactive metals. *J. Appl. Phys.* **89**(5), 2756–2766 (2001)
286. C. Wu, G. Lee, T. Pi, Energy structures and chemical reactions at the Al/LiF/Alq₃ interfaces studied by synchrotron-radiation photoemission spectroscopy. *Appl. Phys. Lett.* **87**, 212108 (2005)
287. Q.T. Le, L. Yan, Y. Gao, M.G. Mason, D.J. Giesen, C.W. Tang, Photoemission study of aluminum/tris-(8-hydroxyquinoline) aluminum and aluminum/LiF/tris-(8-hydroxyquinoline) aluminum interfaces. *J. Appl. Phys.* **87**(1), 375–379 (2000)
288. C. Shen, A. Kahn, J. Schwartz, Chemical and electrical properties of interfaces between magnesium and aluminum and tris-(8-hydroxyquinoline) aluminum. *J. Appl. Phys.* **89**, 449 (2001)
289. C. Cheng, A. Kahn, J. Schwartz, Role of metal-molecule chemistry and interdiffusion on the electrical properties of an organic interface: the Al-F₁₆CuPc case. *J. Appl. Phys.* **90**, 6236 (2001)
290. Y. Hirose, A. Kahn, V. Aristov, P. Soukiassian, V. Bulovic, S.R. Forrest, Chemistry and electronic properties of metal-organic semiconductor interfaces: Al, Ti, In, Sn, Ag and Au on PTCDA. *Phys. Rev. B* **54**(19), 13748–13758 (1996)
291. M.S. Corbillon, M.A. Olazabal, M. Madariaga, Potentiometric study of aluminium-fluoride complexation equilibria and definition of the thermodynamic model. *J. Sol. Chem.* **37**, 567 (2008)
292. T.D. Anthopoulos, B. Singh, N. Marjanovic, N.S. Sariciftci, A.M. Ramil, H. Sitter, M. Cölle, D.M. de Leeuw, High performance n-channel organic field-effect transistors and ring oscillators based on c60 fullerene films. *Appl. Phys. Lett.* **89**, 213504 (2006)
293. S. Schols, A. Kadashchuk, P. Heremans, A. Helfer, U. Scherf, Triplet excitation scavenging in films of conjugated polymers. *ChemPhysChem* **10**, 1071–1076 (2009)

294. S. Schols, L.V. Willigenburg, S. Steudel, J. Genoe, P. Heremans, Pulsed excitation of oleds with field-effect electron transport. *IEEE J. Quantum Electron.* **46**(1), 62–67 (2010)
295. S. Barth, P. Müller, H. Riel, P.F. Seidler, W. Riess, H. Vestweber, H. Bässler, Electron mobility in tris(8-hydroxyquinoline)aluminum thin films determined via transient electroluminescence from single- and multilayer organic light-emitting diodes. *J. Appl. Phys.* **89**(7), 3711–3719 (2001)
296. T.G. Pavlopoulos, Scaling of dye lasers with improved laser dyes. *Prog. Quantum Electron.* **26**, 193–224 (2002)
297. J.B. Marling, D.W. Gregg, L. Wood, Chemical quenching of the triplet state in flashlamp-excited liquid organic lasers. *Appl. Phys. Lett.* **17**(12), 527–530 (1970)
298. H.S.R. Pappalardo, A. Lempicki, Long pulse laser emission from rhodamine 6G using cyclooctatetraene. *Appl. Phys. Lett.* **16**(7), 267–269 (1970)
299. H.S.R. Pappalardo, A. Lempicki, Long-pulse laser emission from rhodamine 6G. *IEEE J. Quantum Electron.* **6**(11), 716–725 (1970)
300. C. Rothe, S. King, A. Monkman, Long-range resonantly enhanced triplet formation in luminescent polymers doped with iridium complexes. *Nat. Mater.* **5**, 463–466 (2006)
301. L. Frutos, O. Castaño, M. Merchán, Theoretical determination of the singlet → singlet and singlet → triplet electronic spectra, lowest ionization potentials, and electron affinity of cyclooctatetraene. *J. Phys. Chem. A* **107**, 5472–5478 (2003)
302. L.M. Frutos, O. Castaño, J.L. Andrés, M. Merchán, A.U. Acuna, A theory of nonvertical triplet energy transfer in terms of accurate potential energy surfaces: the transfer reaction from π , π^* triplet donors to 1,3,5,7-cyclooctatetraene. *J. Chem. Phys.* **120**(3), 1208–1216 (2004)
303. L. Frutos, O. Castaño, A new algorithm for predicting triplet-triplet energy-transfer activated complex coordinate in terms of accurate potential-energy surfaces. *J. Chem. Phys.* **123**, 104108 (2005)
304. J. Saltiel, G.S. Hammond, Mechanisms of photochemical reactions in solution. XVII. cis-trans isomerization of the stilbenes by excitation transfer from low energy sensitizers. *J. Am. Chem. Soc.* **85**(16), 2515–2516 (1963)
305. A.A. Corman, I. Hamblett, M. Irvine, P. Raby, M.C. Standen, S. Yeates, Pulse radiolysis study of the cycloheptatriene triplet state: lifetime, relaxation, and nonvertical excitation. *J. Am. Chem. Soc.* **107**, 4404–4411 (1985)
306. A.P. Monkman, H.D. Burrows, L.J. Hartwell, L.E. Horsburgh, I. Hamblett, S. Navaratnam, Triplet energies of π -conjugated polymers. *Phys. Rev. Lett.* **86**(7), 1358–1361 (2001)
307. S.A. Bagnich, C. Im, H. Bässler, D. Neher, U. Scherf, Energy transfer in a ladder-type methyl-poly(para-phenylene) doped by pt(II)octaethylporphyrin. *Chem. Phys.* **299**, 11–16 (2004)
308. D. Hertel, H. Bässler, R. Guentner, U. Scherf, Triplet-triplet annihilation in a poly(fluorene)-derivative. *J. Chem. Phys.* **115**(21), 10007 (2001)
309. A. Kadašchuk, A. Vakhnin, Y. Skryshevski, V.I. Arkhipov, E.V. Emelianova, H. Bässler, Thermally stimulated luminescence in π -conjugated polymers containing fluorene and spirobifluorene units. *Chem. Phys.* **291**, 243–250 (2003)
310. S.A. Bagnich, H. Bässler, Origin of delayed fluorescence of a ladder-type methyl-poly(para-phenylene) doped with pt(II)octaethylporphyrin. *Chem. Phys. Lett.* **381**, 464–470 (2003)
311. A. Kadašchuk, S. Schols, A. Vakhnin, J. Genoe, P. Heremans, Triplet dynamics and charge carrier trapping in triplet-emitter doped conjugated polymers. *Chem. Phys.* **358**, 147–155 (2009)
312. M. Thompson, The evolution of organometallic complexes in organic light-emitting devices. *Mater. Res. Soc. Bull.* **32**, 694–701 (2007)
313. V. Cleave, G. Yahioglu, P.L. Barny, R.H. Friend, N. Tessler, Harvesting singlet and triplet energy in polymer LEDs. *Adv. Mater.* **11**(4), 285–288 (1999)
314. V. Cleave, G. Yahioglu, P.L. Barny, D. Hwang, A.B. Holmes, R.H. Friend, N. Tessler, Transfer processes in semiconducting polymer-porphyrin blends. *Adv. Mater.* **13**(1), 44–47 (2001)
315. S.A. Bagnich, H. Bässler, D. Neher, Sensitized phosphorescence of benzil-doped ladder-type methyl-poly(para-phenylene). *J. Chem. Phys.* **121**(18), 9178–9183 (2004)

316. F. Laquai, C. Im, A. Kadashchuk, H. Bässler, Sensitized intrinsic phosphorescence from a poly(phenylene-vinylene) derivative. *Chem. Phys. Lett.* **375**, 286–291 (2003)
317. Y.V. Romanovskii, H. Bässler, Phosphorescence from a ladder-type conjugated polymer in solid solutions at low temperature. *Chem. Phys. Lett.* **326**, 51–57 (2000)
318. A.P. Monkman, H.D. Burrows, I. Hamblett, S. Navaratnam, U. Scherf, C. Schmitt, The triplet state of the ladder-type methyl-poly(p-phenylene) as seen by pulse radiolysis-energy transfer. *Chem. Phys. Lett.* **327**, 111–116 (2000)
319. R.W.T. Higgins, A.P. Monkman, H. Nothofer, U. Scherf, Energy transfer to porphyrin derivative dopants in polymer light-emitting diodes. *J. Appl. Phys.* **91**(1), 99–105 (2002)
320. I. Tanaka, Y. Tabata, S. Tokito, Comparison of phosphorescence properties of green-emitting Ir(ppy)₃ and red-emitting Btp₂Ir(acac). *Jpn. J. Appl. Phys.* **43**(12B), L1601–L1603 (2004)
321. C. Adachi, M.A. Baldo, S.R. Forrest, High-efficiency red electrophosphorescence devices. *Appl. Phys. Lett.* **78**(11), 1622–1624 (2001)
322. Y.V. Romanovskii, A. Gerhard, B. Schweitzer, U. Scherf, R.I. Personov, H. Bässler, Phosphorescence of π -conjugated oligomers and polymers. *Phys. Rev. Lett.* **84**(5), 1027–1030 (2000)
323. Y.V. Romanovskii, H. Bässler, Phosphorescence from a ladder-type conjugated polymer in solid solutions at low temperature. *Chem. Phys. Lett.* **326**, 51–57 (2000)
324. S.A. Patil, U. Scherf, A. Kadashchuk, New conjugated ladder polymer containing carbazole moieties. *Adv. Funct. Mater.* **13**(8), 609–614 (2003)
325. Y. Kawamura, J. Brooks, J.J. Brown, H. Sasabe, C. Adachi, Intermolecular interaction and a concentration-quenching mechanism of phosphorescent Ir(III) complexes in a solid film. *Phys. Rev. Lett.* **96**, 017404 (2006)
326. P.M. Borsenberger, D.S. Weiss, *Organic Photoreceptors for Imaging Systems* (Dekker, New York, 1993)
327. H. Kuhn, Classical aspects of energy transfer in molecular systems. *J. Chem. Phys.* **53**, 101–108 (1970)
328. W. Zhu, Y. Mo, M. Yuan, Y. Cao, Highly efficient electrophosphorescent devices based on conjugated polymers doped with iridium complexes. *Appl. Phys. Lett.* **80**(12), 2045–2047 (2002)
329. H. Liu, J. He, P. Wang, H. Xie, X. Zhang, C. Lee, B. Sun, Y. Xia, High-efficiency polymer electrophosphorescent diodes based on an Ir (III) complex. *Appl. Phys. Lett.* **87**, 221103 (2005)
330. V.R. Nikitenko, D. Hertel, H. Bässler, Dispersive geminate recombination in a conjugated polymer. *Chem. Phys. Lett.* **348**, 889–94 (2001)
331. J. Yoon, W. Lee, E.L. Thomas, Optically pumped surface-emitting lasing using self-assembled block-copolymer-distributed Bragg reflectors. *Nano Lett.* **6**(10), 2211–2214 (2006)
332. C. Adachi, H. Nakanotani, T. Matsushima, S. Akiyama, Y. Kawamura, Amplified spontaneous emission characteristics and low-threshold mechanism in organic solid state thin film based on styrylbenzene derivatives. Presentation at SPIE Optics and Photonics West 2006, San Diego, USA, 2006
333. M.A. Baldo, M.E. Thompson, S.R. Forrest, High-efficiency fluorescent organic light-emitting devices using a phosphorescent sensitizer. *Nature* **403**, 750–753 (2000)
334. J. Nagle, S. Hersee, M. Krakowski, T. Weil, C. Weisbuch, Threshold current of single quantum well lasers: the role of the confining layers. *Appl. Phys. Lett.* **49**(20), 1325–1327 (1986)
335. P.L. Derry, A. Yariv, K.Y. Lau, N. Bar-Chaim, K. Lee, J. Rosenberg, Ultralow-threshold graded-index separate-confinement single quantum well buried heterostructure (Al,Ga)As lasers with high reflectivity coatings. *Appl. Phys. Lett.* **50**(25), 1773–1775 (1987)