Bibliography

[1] G. E. Moore. Progress in digital integrated electronics. In *IEEE International Electron Devices Meeting, Technical Digest*, pages 11–13, 1975.

[2] The international technology roadmap for semiconductors. Technical report, Semiconductor Industry Association, 2013.

[3] M. N. Baibich, J. M. Broto, A. Fert, F. Nguyen Van Dau, F. Petroff, P. Etienne, G. Creuzet, A. Friederich, and J. Chazelas. Giant magnetoresistance of (001)Fe/(001)Cr magnetic superlattices. *Phys. Rev. Lett.*, 61:2472–2475, 1988.

[4] G. Binasch, P. Grünberg, F. Saurenbach, and W. Zinn. Enhanced magnetoresistance in layered magnetic structures with antiferromagnetic interlayer exchange. *Phys. Rev. B*, 39:4828–4830, 1989.

[5] K. Bernstein, R. K. Cavin, W. Porod, A. Seabaugh, and J. Welser. Device and architecture outlook for beyond CMOS switches. *Proceedings of the IEEE*, 98(12):2169–2184, 2010.

[6] S. Datta and B. Das. Electronic analog of the electro-optic modulator. *Appl. Phys. Lett.*, 56(7):665–667, 1990.

[7] M. E. Flatté and G. Vignale. Unipolar spin diodes and transistors. *Appl. Phys. Lett.*, 78(9):1273–1275, 2001.

[8] K. C. Hall, W. H. Lau, K. Gündoğdu, M. E. Flatté, and T. F. Boggess. Nonmagnetic semiconductor spin transistor. *Appl. Phys. Lett.*, 83(14):2937–2939, 2003.

[9] J. C. Egues, G. Burkard, and D. Loss. Datta-Das transistor with enhanced spin control. *Appl. Phys. Lett.*, 82(16):2658–2660, 2003.

[10] J. Schliemann, J. C. Egues, and D. Loss. Nonballistic spin-field-effect transistor. *Phys. Rev. Lett.*, 90:146801/1, 2003.

[11] B. Behin-Aein, D. Datta, S. Salahuddin, and S. Datta. Proposal for an all-spin logic device with built-in memory. *Nature Nanotechnology*, 5:266, 2010.

[12] H. C. Koo, J. H. Kwon, J. Eom, J. Chang, S. H. Han, and M. Johnson. Control of spin precession in a spin-injected field effect transistor. *Science*, 325(5947):1515–1518, 2009.

[13] Yu. A. Bychkov and E. I. Rashba. Oscillatory effects and the magnetic susceptibility of carriers in inversion layers. *Journal of Physics C (Solid State Physics)*, 17(33):6039–6045, 1984.

[14] M. König, H. Buhmann, L. W. Molenkamp, T. Hughes, C.-X. Liu, X.-L. Qi, and S.-C. Zhang. The quantum spin Hall effect: Theory and experiment. *Journal of the Physical Society of Japan*, 77(3):031007, 2008.

[15] X.-L. Qi and S.-C. Zhang. Topological insulators and superconductors. *Rev. Mod. Phys.*, 83:1057–1110, 2011.

[16] Y. Ando. Topological insulator materials. *Journal of the Physical Society of Japan*, 82(10):102001, 2013.

[17] M. A. Nielsen and I. L. Chuang. *Quantum Computation and Quantum Information:*. Cambridge University Press, 2010.

[18] P. W. Shor. Algorithms for quantum computation: Discrete logarithms and factoring. In S. Goldwasser, editor, *Proc. 35th Annual Symposium on the foundations of Computer Science*, pages 124–134. IEEE Computer Society Press, Los Alamitos, CA, 1994.

[19] D. Loss and D. P. DiVincenzo. Quantum computation with quantum dots. *Phys. Rev. A*, 57:120, 1998.

[20] R. Hanson, L. P. Kouwenhoven, J. R. Petta, S. Tarucha, and L. M. K. Vandersypen. Spins in few-electron quantum dots. *Rev. Mod. Phys.*, 79:1217–1265, 2007.

[21] P. Yu and M. Cardona. *Fundamentals of Semiconductors*. Springer-Verlag Berlin Heidelberg, 2010.

[22] T. Heinzel. *Mesoscopic Electronics in Solid State Nanostructures*. Wiley-VCH, 2006.

[23] T. Ihn. *Semiconductor Nanostructures*. Oxford University Press, 2009.

[24] H. Ibach and H. Lüth. *Solid-State Physics*. Springer Berlin Heidelberg, 2009.

[25] S. Datta. *Electronic transport in mesoscopic systems*. Cambridge University Press, Cambridge, 1995.

[26] H. Lüth. *Surfaces and Interfaces of Solid Materials*. Springer-Verlag, Berlin, 1996.

[27] C. T. Foxon, J. J. Harris, D. Hilton, J. Hewitt, and C. Roberts. Optimisation of (Al,Ga)As/GaAs two-dimensional electron gas structures for low carrier densities and ultrahigh mobilities at low temperatures. *Semicond. Sci. Technol.*, 4:582–582, 1989.

[28] L. Pfeiffer, K. W. West, H. L. Störmer, and K. W. Baldwin. Electron mobilities exceeding 10^7 cm^2/Vs in modulation-doped GaAs. *Appl. Phys. Lett.*, 55:1888–1890, 1989.

[29] H. Hardtdegen, R. Meyer, H. Løken-Larsen, J. Appenzeller, Th. Schäpers, and H. Lüth. Extremely high mobilities in modulation doped InGaAs/InP heterostructures grown by LP MOVPE. *J. Crystal Growth*, 116:521–523, 1992.

[30] H. Hardtdegen, R. Meyer, M. Hollfelder, Th. Schäpers, J. Appenzeller, H. Løken-Larsen, Th. Klocke, Ch. Dieker, B. Lengeler, H. Lüth, and W. Jäger. Optimization of modulation doped InGaAs/InP heterostructures towards extremely high mobilities. *J. Appl. Phys.*, 73:4489–4493, 1993.

[31] S. P. Beaumont, P. G. Bower, T. Tamamara, and C. D. W. Wilkinson. Sub-20-nm-wide metal lines by electron-beam exposure of thin poly(methyl methacrylate) films and liftoff. *Appl. Phys. Lett.*, 38:436–439, 1981.

[32] C. Thelander, P. Agarwal, S. Brongersma, J. Eymery, L. F. Feiner, A. Forchel, M. Scheffler, W. Riess, B. J. Ohlsson, U. Gösele, and L. Samuelson. Nanowire-based one-dimensional electronics. *Materials Today*, 9:28–35, 2006.

[33] H. Lüth. *Solid Surfaces, Interfaces and Thin Films*. Springer-Verlag, Berlin, Heidelberg, New York, 2010.

[34] K. Tomioka, P. Mohan, J. Noborisaka, S. Hara, J. Motohisa, and T. Fukui. Growth of highly uniform InAs nanowire arrays by selective-area MOVPE. *J. Cryst. Growth*, 298:644, 2007.

[35] M. Akabori, K. Sladek, H. Hardtdegen, Th. Schäpers, and D. Grützmacher. Influence of growth temperature on the selective area MOVPE of InAs nanowires on GaAs (111) B using N_2 carrier gas. *Journal of Crystal Growth*, 311(15):3813–3816, 2009.

[36] B. J. van Wees, H. van Houten, C. W. J. Beenakker, J. G. Willamson, L. P. Kouwenhoven, D. van der Marel, and C. T. Foxon. Quantized conductance in point contacts in a two-dimensional electron gas. *Phys. Rev. Lett.*, 60:848–850, 1988.

[37] D. A. Wharam, T. J. Thornton, R. Newbury, M. Pepper, H. Ahmed, J. E. F. Frost, D. G. Hasko, D. C. Peacock, D. A. Ritchie, and G. A. C. Jones. One-dimensional transport and the quantisation of the ballistic resistance. *J. Phys. C*, 21:L209–214, 1988.

[38] R. Landauer. Spatial variations of currents and fields due to localized scatterers in metallic conduction. *IBM J. Res. Dev.*, 1:223–231, 1957.

[39] M. Büttiker. Absence of backscattering in the quantum Hall effect in multiprobe conductors. *Phys. Rev. B*, 38:9375–9389, 1988.

[40] M. Büttiker, Y. Imry, R. Landauer, and S. Pinhas. Generalized many-channel conductance formula with application to small rings. *Phys. Rev. B*, 31:6207–6215, 1985.

[41] K. von Klitzing, G. Dorda, and M. Pepper. New method for high-accuracy determination of the fine-structure constant based on quantized Hall resistance. *Phys. Rev. Lett.*, 45(6):494–497, 1980.

[42] M. A. Ruderman and C. Kittel. Indirect exchange coupling of nuclear magnetic moments by conduction electrons. *Phys. Rev.*, 96:99–102, 1954.

[43] T. Kasuya. A theory of metallic ferro- and antiferromagnetism on Zener's model. *Prog. Theor. Phys.*, 16:45, 1956.
[44] K. Yosida. Magnetic properties of Cu-Mn alloys. *Phys. Rev.*, 106:893–898, 1957.
[45] J. F. Janak. Uniform susceptibilities of metallic elements. *Phys. Rev. B*, 16:255–262, 1977.
[46] V. L. Moruzzi, J. F. Janak, and A. R. Williams. *Calculated Electronic Properties of Metals*. Pergamon Press, NY, 1978.
[47] J. K. Furdyna. Diluted magnetic semiconductors. *J. Appl. Phys.*, 64(4):R29–R64, 1988.
[48] R. L. Aggarwal, S. N. Jasperson, P. Becla, and J. K. Furdyna. Optical determination of the antiferromagnetic exchange constant between nearest-neighbor Mn^{2+} ions in $Zn_{0.95}Mn_{0.05}Te$. *Phys. Rev. B*, 34:5894–5896, 1986.
[49] H. Munekata, H. Ohno, S. von Molnar, A. Segmüller, L. L. Chang, and L. Esaki. Diluted magnetic III-V semiconductors. *Phys. Rev. Lett.*, 63:1849–1852, 1989.
[50] H. Ohno. Making nonmagnetic semiconductors ferromagnetic. *Science*, 281:951–956, 1998.
[51] H. Ohno, A. Shen, F. Matsukura, A. Oiwa, A. Endo, S. Katsumoto, and Y. Iye. (Ga,Mn)As: A new diluted magnetic semiconductor based on GaAs. *Appl. Phys. Lett.*, 69(3):363–365, 1996.
[52] T. Dietl, H. Ohno, F. Matsukura, J. Cibert, and D. Ferrand. Zener model description of ferromagnetism in zinc-blende magnetic semiconductors. *Science*, 287(5455):1019–22, 2000.
[53] H. Ohno. *Semiconductor Spintronics and Quantum Computation*, chapter Ferromagnetic I-V Semiconductors and Their Heterostructures, page 1. Springer, 2002.
[54] T. Dietl and H. Ohno. Dilute ferromagnetic semiconductors: Physics and spintronic structures. *Rev. Mod. Phys.*, 86:187–251, 2014.
[55] T. Jungwirth, K. Y. Wang, J. Mašek, K. W. Edmonds, J. König, J. Sinova, M. Polini, N. A. Goncharuk, A. H. MacDonald, M. Sawicki, A. W. Rushforth, R. P. Campion, L. X. Zhao, C. T. Foxon, and B. L. Gallagher. Prospects for high temperature ferromagnetism in (Ga,Mn)As semiconductors. *Phys. Rev. B*, 72:165–204, 2005.
[56] K. Sato, L. Bergqvist, J. Kudrnovský, P. H. Dederichs, O. Eriksson, I. Turek, B. Sanyal, G. Bouzerar, H. Katayama-Yoshida, V. A. Dinh, T. Fukushima, H. Kizaki, and R. Zeller. First-principles theory of dilute magnetic semiconductors. *Rev. Mod. Phys.*, 82:1633–1690, 2010.
[57] Y. Ohno, D. K. Young, B. Beschoten, F. Matsukara, H. Ohno, and D. D. Awschalom. Electrical spin injection in a ferromagnetic semiconductor heterostructure. *Nature*, 402:790–792, 1999.
[58] D. Chiba, F. Matsukura, and H. Ohno. Electric-field control of ferromagnetism in (Ga,Mn)As. *Appl. Phys. Lett.*, 89(16):162505, 2006.
[59] H. Ohno, F. Matsukura, T. Omiya, and N. Akiba. Spin-dependent tunneling and properties of ferromagnetic (Ga,Mn)As (invited). *J. Appl. Phys.*, 85(8):4277–4282, 1999.
[60] H. Ohno, D. Chiba, F. Matsukura, T. Omiya, E. Abe, T. Dietl, Y. Ohno, and K. Ohtani. Electric-feld control of ferromagnetism. *Nature*, 408:944, 2000.
[61] A. Yamaguchi, T. Ono, S. Nasu, K. Miyake, K. Mibu, and T. Shinjo. Real-space observation of current-driven domain wall motion in submicron magnetic wires. *Phys. Rev. Lett.*, 92:077205, 2004.
[62] D. A. Allwood, G. Xiong, C. C. Faulkner, D. Atkinson, D. Petit, and R. P. Cowburn. Magnetic domain-wall logic. *Science*, 309(5741):1688–1692, 2005.
[63] S. S. P. Parkin, M. Hayashi, and L. Thomas. Magnetic domain-wall racetrack memory. *Science*, 320:190, 2008.
[64] J. Nitta, Th. Schäpers, H. B. Heersche, T. Koga, Y. Sato, and H. Takayanagi. Investigation of ferromagnetic microstructures by local Hall effect and magnetic force microscopy. volume 41, pages 2497–500, 2002.
[65] M. Johnson, B. R. Bennett, M. J. Yang, M. M. Miller, and B. V. Shanabrook. Hybrid Hall effect device. *Appl. Phys. Lett.*, 71(7):974–976, 1997.

[66] F. G. Monzon, M. Johnson, and M. L. Roukes. Strong Hall voltage modulation in hybrid ferromagnet/semiconductor microstructures. *Appl. Phys. Lett.*, 71(21):3087–3089, 1997.

[67] S. Heedt, C. Morgan, K. Weis, D. E. Bürgler, R. Calarco, H. Hardtdegen, D. Grützmacher, and Th. Schäpers. Electrical spin injection into InN semiconductor nanowires. *Nano Letters*, 12(9):4437–4443, 2012.

[68] M. J. Donahue and D. G. Porter. Oommf user's guide, version 1.0, interagency report NISTIR 6376. Technical report, National Institute of Standards and Technology, Gaithersburg, MD (Sept 1999), 1999.

[69] M. Hayashi, L. Thomas, R. Moriya, C. Rettner, and S. S. P. Parkin. Current-controlled magnetic domain-wall nanowire shift register. *Science*, 320:209, 2008.

[70] G. Schmidt and L. W. Molenkamp. Spin injection into semiconductors, physics and experiments. *Semiconductor Science and Technology*, 17(4):310, 2002.

[71] G. Schmidt, D. Ferrand, L. W. Molenkamp, A. T. Filip, and B. J. van Wees. Fundamental obstacle for electrical spin injection from a ferromagnetic metal into a diffusive semiconductor. *Phys. Rev. B*, 62:R4790–4793, 2000.

[72] C. Weisbuch and B. Vinter. *Quantum Semiconductor Structures: Fundamentals and Applications*. Academic, Boston, 1991.

[73] R. Fiederling, M. Keim, G. Reuscher, W. Ossau, G. Schmidt, A. Waag, and L. W. Molenkamp. Injection and detection of a spin-polarized current by a light emitting diode. *Nature*, 402:787–790, 1999.

[74] E. I. Rashba. Theory of electrical spin injection: Tunnel contacts as a solution of the conductivity mismatch problem. *Phys. Rev. B*, 62:R16267–R16270, 2000.

[75] H. B. Heersche, Th. Schäpers, J. Nitta, and H. Takayanagi. Enhancement of spin injection from ferromagnetic metal into a two-dimensional electron gas using a tunnel barrier. *Phys. Rev. B*, 64(16):161307/1–4, 2001.

[76] A. Fert and H. Jaffrès. Conditions for efficient spin injection from a ferromagnetic metal into a semiconductor. *Phys. Rev. B*, 64(18):184420, 2001.

[77] G. E. Blonder, M. Tinkham, and T. M. Klapwijk. Transition from metallic to tunneling regimes in superconducting microconstrictions: Excess current, charge imbalance, and supercurrent conversion. *Phys. Rev. B*, 25:4515–4532, 1982.

[78] T. Valet and A. Fert. Theory of the perpendicular magnetoresistance in magnetic multilayers. *Phys. Rev. B*, 48:7099–7113, 1993.

[79] T. Manago and H. Akinaga. Spin-polarized light-emitting diode using metal/insulator/semiconductor structures. *Appl. Phys. Lett.*, 81:694–696, 2002.

[80] A. T. Hanbicki, B. T. Jonker, G. Itskos, G. Kioseoglou, and A. Petrou. Efficient electrical spin injection from a magnetic metal/tunnel barrier contact into a semiconductor. *Appl. Phys. Lett.*, 80(7):1240–2, 2002.

[81] A. T. Hanbicki, O. M. J. van 't Erve, R. Magno, G. Kioseoglou, C. H. Li, B. T. Jonker, G. Itskos, R. Mallory, M. Yasar, and A. Petrou. Analysis of the transport process providing spin injection through an Fe/AlGaAs Schottky barrier. *Appl. Phys. Lett.*, 82(23):4092–4, 2003.

[82] F. G. Monzon and M. L. Roukes. Spin injection and the local Hall effect in InAs quantum wells. *Journal of Magnetism and Magnetic Materials*, 198–199(0):632–635, 1999.

[83] N. Tombros, S. J. van der Molen, and B. J. van Wees. Separating spin and charge transport in single-wall carbon nanotubes. *Phys. Rev. B*, 73:233–403, 2006.

[84] M. Johnson and R. H. Silsbee. Interfacial charge-spin coupling: Injection and detection of spin magnetization in metals. *Phys. Rev. Lett.*, 55:1790–1793, 1985.

[85] K. Schmalbuch, S. Göbbels, Ph. Schäfers, Ch. Rodenbücher, P. Schlammes, Th. Schäpers, M. Lepsa, G. Güntherodt, and B. Beschoten. Two-dimensional optical control of electron spin orientation by linearly polarized light in InGaAs. *Phys. Rev. Lett.*, 105:246603, 2010.

[86] S. Bandyopadhyay and M. Cahay. Alternate spintronic analog of the electro-optic modulator. *Appl. Phys. Lett.*, 85:1814, 2004.

[87] J. Nitta, T. Akazaki, H. Takayanagi, and T. Enoki. Gate control of spin-orbit interaction in an inverted $In_{0.53}Ga_{0.47}As/In_{0.52}Al_{0.48}As$ heterostructure. *Phys. Rev. Lett.*, 78:1335–1338, 1997.

[88] R. Winkler. *Spin orbit coupling effects in two-dimensional electron and hole systems.* Springer-Verlag, Berlin, Heidelberg, New York, 2003.

[89] R. Winkler. Spin orientation and spin precession in inversion-asymmetric quasi-two-dimensional electron systems. *Phys. Rev. B*, 69(4):45317–1–9, 2004.

[90] E. O. Kane. Energy band theory. In T. S. Moss, editor, *Handbook on Semiconductors*, pages 193–217. North-Holland, Amsterdam, 1982.

[91] P.-O. Löwdin. A note on the quantum-mechanical perturbation theory. *The Journal of Chemical Physics*, 19(11):1396–1401, 1951.

[92] R. Lassnig. $k \cdot p$ theory, effective-mass approach, and spin splitting for two-dimensional electrons in GaAs-GaAlAs heterostructures. *Phys. Rev. B*, 31(12):8076–8086, 1985.

[93] Th. Schäpers, G. Engels, J. Lange, Th. Klocke, M. Hollfelder, and H. Lüth. Effect of the heterointerface on the spin splitting in modulation doped $In_xGa_{1-x}As/InP$ quantum wells for $B \rightarrow 0$. *J. Appl. Phys.*, 83(8):4324–4333, 1998.

[94] Landolt-Börnstein. *Group III Condensed Matter*, volume III/41. Springer Verlag, 2002.

[95] R. Winkler. Rashba spin splitting and Ehrenfest's theorem. *Physica E*, 22:450–454, 2004.

[96] G. Engels, J. Lange, Th. Schäpers, and H. Lüth. Experimental and theoretical approach to spin splitting in modulation-doped $In_xGa_{1-x}As/InP$ quantum wells for $B \rightarrow 0$. *Phys. Rev. B*, 55:R1958–R1961, 1997.

[97] D. Grundler. Large Rashba splitting in InAs quantum wells due to electron wave function penetration into the barrier layers. *Phys. Rev. Lett.*, 84:6074–6077, 2000.

[98] G. Dresselhaus. Spin-orbit coupling effects in zinc-blende structures. *Phys. Rev.*, 100:580, 1955.

[99] B. A. Bernevig, T. L. Hughes, and S. C. Zhang. Quantum spin Hall effect and topological phase transition in HgTe quantum wells. *Science*, 314:1757–1761, 2006.

[100] J. D. Koralek, C. P. Weber, J. Orenstein, B. A. Bernevig, S.-C. Zhang, S. Mack, and D. D. Awschalom. Emergence of the persistent spin helix in semiconductor quantum wells. *Nature*, 458:610–613, 2009.

[101] M. P. Walser, C. Reichl, W. Wegscheider, and G. Salis. Direct mapping of the formation of a persistent spin helix. *Nature Physics*, 8:757–762, 2012.

[102] A. Sasaki, S. Nonaka, Y. Kunihashi, M. Kohda, T. Bauernfeind, T. Dollinger, K. Richter, and J. Nitta. Direct determination of spin-orbit interaction coefficients and realization of the persistent spin helix symmetry. *Nature Nanotechnology*, 9:703, 2014.

[103] M. Governale and U. Zülicke. Spin accumulation in quantum wires with strong Rashba spin-orbit coupling. *Phys. Rev. B*, 66(7):073311/1–4, 2002.

[104] J. Knobbe and Th. Schäpers. Magnetosubbands of semiconductor quantum wires with Rashba spin-orbit coupling. *Phys. Rev. B*, 71(3):35311–1–6, 2005.

[105] T. Richter, Ch. Blömers, H. Lüth, R. Calarco, M. Indlekofer, M. Marso, and Th. Schäpers. Flux quantization effects in InN nanowires. *Nano Letters*, 8:2834–2838, 2008.

[106] Ö. Gül, N. Demarina, C. Blömers, T. Rieger, H. Lüth, M. I. Lepsa, D. Grützmacher, and Th. Schäpers. Flux periodic magnetoconductance oscillations in GaAs/InAs core/shell nanowires. *Phys. Rev. B*, 89:045417, 2014.

[107] A. Bringer and Th. Schäpers. Spin precession and modulation in ballistic cylindrical nanowires due to the Rashba effect. *Phys. Rev. B*, 83(11):115305, 2011.

[108] Y. Aharonov and D. Bohm. Significance of electromangnetic potentials in the quantum theory. *Phys. Rev.*, 115:485–491, 1959.

[109] R. G. Chambers. Shift of an electron interference pattern by enclosed magnetic flux. *Phys. Rev. Lett.*, 5(1):3–5, 1960.

[110] A. Tonomura, T. Matsuda, R. Suzuki, A. Fukuhara, N. Osakabe, H. Umezaki, J. Endo, K. Shinagawa, Y. Sugita, and H. Fujiwara. Observation of Aharonov-Bohm effect by electron holography. *Phys. Rev. Lett.*, 48(21):1443–1446, 1982.

[111] R. A. Webb, S. Washburn, C. P. Umbach, and R. B. Laibowitz. Observation of h/e Aharonov-Bohm oscillations in normal-metal rings. *Phys. Rev. Lett.*, 54(25):2696–2699, 1985.

[112] B. Krafft, A. Förster, A. van der Hart, and Th. Schäpers. Control of Aharonov–Bohm oscillations in an AlGaAs/GaAs ring by asymmetric and symmetric gate biasing. *Physica E*, 9(4):635–641, 2001.

[113] J. Appenzeller, Th. Schäpers, H. Hardtdegen, B. Lengeler, and H. Lüth. Aharonov-Bohm effect in quasi-one-dimensional $In_{0.77}Ga_{0.23}As$/InP rings. *Phys. Rev. B*, 51:4336–4342, 1995.

[114] B. L. Al'tshuler, A. G. Aronov, and B. Z. Spivak. Aharonov-Bohm effect in disordered conductors. *Pis'ma Zh. Eksp. Teo. Fiz. [JETP Lett. **33**, 94 (1981)]*, 33:101–103, 1981.

[115] D. Yu. Sharvin and Yu. V. Sharvin. Quantisation of the magnetic flow in a normal metal cylindrical film. *Pis'ma Zh. Eksp. Teor. Fiz. [JETP Lett. **34**, 272 (1981)]*, 34:285–288, 1981.

[116] G. J. Dolan, J. C. Licini, and D. J. Bishop. Quantum interfernce effects in lithium ring arrays. *Phys. Rev. Lett.*, 56(14):1493–1496, 1986.

[117] S. Chakravarty and A. Schmid. Weak localization: the quasiclassical theory of electrons in a random potential. *Physics Reports*, (140):193–236, 1986.

[118] C. W. J. Beenakker and H. van Houten. Semiconductor heterostructures and nanostructures (see also: http://de.arxiv.org/abs/cond-mat/0412664v1). In H. Ehrenreich and D. Turnbull, editors, *Solid State Physics*, volume 44, page 1. Academic, New York, 1991.

[119] C. W. J. Beenakker and H. van Houten. Boundary scattering and weak localization of electrons in a magnetic field. *Phys. Rev. B*, 38(5):3232–3240, 1988.

[120] B. L. Altshuler, D. Khmel'nitzkii, A. I. Larkin, and P. A. Lee. Magnetoresistance and Hall effect in a disordered two-dimensional electron gas. *Phys. Rev. B*, 22:5142–5153, 1980.

[121] S. Hikami, A. I. Larkin, and Y. Nagaoka. Spin-orbit interaction and magnetoresistance in the two dimensional random system. *Progress of Theoretical Physics*, 63(2):707–10, 1980.

[122] R. J. Elliott. Theory of the effect of spin-orbit coupling on magnetic resonance in some semiconductors. *Phys. Rev.*, 96:266–279, 1954.

[123] G. Bergmann. Weak anti-localization-an experimental proof for the destructive interference of rotated spin 1/2. *Solid State Communications*, 42:815–817, 1982.

[124] W. Knap, C. Skierbiszewski, A. Zduniak, E. Litwin-Staszewska, D. Bertho, F. Kobbi, J. L. Robert, G. E. Pikus, F. G. Pikus, S. V. Iordanskii, V. Mosser, K. Zekentes, and Yu. B. Lyanda-Geller. Weak antilocalization and spin precession in quantum wells. *Phys. Rev. B*, 53(7):3912–24, 1996.

[125] M. I. D'yakonov and V. I. Perel'. Spin relaxation of conduction electrons in noncentrosymmetric semiconductors. *Fiz. Tverd. Tela [Sov. Phys. Solid State **13**, 3023 (1971)]*, 13:3581, 1971.

[126] Y. Yafet. g factors and spin-lattice relaxation of conduction electrons. Volume 14 of *Solid State Physics*, pages 1–98. Academic Press, 1963.

[127] J. N. Chazalviel. Spin relaxation of conduction electrons in *n*-type indium antimonide at low temperature. *Phys. Rev. B*, 11:1555–1562, 1975.

[128] G. L. Bir, A. G. Aronov, and G. E. Pikus. Spin relaxation of electrons due to scattering by holes. *Sov. Phys. JETP*, 42:705, 1976.

[129] N. Thillosen, S. Cabañas, N. Kaluza, V. A. Guzenko, H. Hardtdegen, and Th. Schäpers. Weak antilocalization in gate-controlled $Al_xGa_{1-x}N$/GaN two-dimensional electron gases. *Phys. Rev. B*, 73(24):241311, 2006.

[130] S. V. Iordanskii, Yu. B. Lyanda-Geller, and G. E. Pikus. Weak localization in quantum wells with spin-orbit interaction. *JETP Letters*, 60(3):206–11, 1994.

[131] Vitaliy A. Guzenko, Thomas Schäpers, and H. Hardtdegen. Weak antilocalization in high mobility $Ga_xIn_{1-x}As/InP$ two-dimensional electron gases with strong spin-orbit coupling. *Phys. Rev. B*, 76(16):165301, 2007.

[132] L. E. Golub. Weak antilocalization in high-mobility two-dimensional systems. *Phys. Rev. B*, 71:235310, 2005.

[133] Ç. Kurdak, A. M. Chang, A. Chin, and T. Y. Chang. Quantum interference effects and spin-orbit interaction in quasi-one-dimensional wires and rings. *Phys. Rev. B*, 46:6846–6856, 1992.

[134] Th. Schäpers, V. A. Guzenko, M. G. Pala, U. Zülicke, M. Governale, J. Knobbe, and H. Hardtdegen. Suppression of weak antilocalization in $Ga_xIn_{1-x}As/InP$ narrow quantum wires. *Phys. Rev. B*, 74(8):081301, 2006.

[135] V. A. Guzenko, J. Knobbe, H. Hardtdegen, Th. Schäpers, and A. Bringer. Rashba effect in parallel InGaAs/InP quantum wires. *Appl. Phys. Lett.*, 88:032102, 2006.

[136] I. L. Aleiner and V. I. Fal'ko. Spin-orbit coupling effects on quantum transport in lateral semiconductor dots. *Phys. Rev. Lett.*, 87(25):256801/1–4, 2001.

[137] J. B. Miller, D. M. Zumbühl, C. M. Marcus, Y. B. Lyanda-Geller, D. Goldhaber-Gordon, K. Campman, and A. C. Gossard. Gate-controlled spin-orbit quantum interference effects in lateral transport. *Phys. Rev. Lett.*, 90:076807, 2003.

[138] S. Kettemann. Dimensional control of antilocalization and spin relaxation in quantum wires. *Phys. Rev. Lett.*, 98(17):176808/1, 2007.

[139] M. V. Berry. Quantal phase factors accompanying adiabatic changes. *Proc. R. Soc. London Ser. A*, 392:45, 1984.

[140] J. Nitta, F. E. Meijer, and H. Takayanagi. Spin-interference device. *Appl. Phys. Lett.*, 75:695–697, 1999.

[141] F. E. Meijer, A. F. Morpurgo, and T. M. Klapwijk. One-dimensional ring in the presence of Rashba spin-orbit interaction: Derivation of the correct Hamiltonian. *Phys. Rev. B*, 66:033107, 2002.

[142] D. Frustaglia and K. Richter. Spin interference effects in ring conductors subject to Rashba coupling. *Phys. Rev. B*, 69(23):235310, 2004.

[143] Y. Aharonov and J. Anandan. Phase change during a cyclic quantum evolution. *Phys. Rev. Lett.*, 58:1593–1596, 1987.

[144] T. Koga, Y. Sekine, and J. Nitta. Experimental realization of a ballistic spin interferometer based on the Rashba effect using a nanolithographically defined square loop array. *Phys. Rev. B*, 74(4):041302, 2006.

[145] M. I. D'yakonov and V. I. Perel'. Possibility of orienting electron spins with current. *JETP Lett.*, 13:46, 1971.

[146] J. E. Hirsch. Spin Hall effect. *Phys. Rev. Lett.*, 83:1834–1837, 1999.

[147] H.-A. Engel, B. I. Halperin, and E. I. Rashba. Theory of spin Hall conductivity in *n*-doped GaAs. *Phys. Rev. Lett.*, 95:166605, 2005.

[148] J. Sinova, D. Culcer, Q. Niu, N. A. Sinitsyn, T. Jungwirth, and A. H. MacDonald. Universal intrinsic spin Hall effect. *Phys. Rev. Lett.*, 92:126603, 2004.

[149] J. Smit. The spontaneous Hall effect in ferromagnetics-II. *Physica*, 24:39, 1958.

[150] N. F. Mott and H. S. W. Massey. *The Theory of Atomic Collisions*. Oxford University Press, London, 1965.

[151] L. Berger. Side-jump mechanism for the Hall effect of ferromagnets. *Phys. Rev. B*, 2:4559–4566, 1970.

[152] G. Vignale. Ten years of spin Hall effect. *Journal of Superconductivity and Novel Magnetism*, 23(1):3–10, 2010.

[153] E. M. Hankiewicz and G. Vignale. Coulomb corrections to the extrinsic spin-Hall effect of a two-dimensional electron gas. *Phys. Rev. B*, 73:115339, 2006.

[154] Y. K. Kato, R. C. Myers, A. C. Gossard, and D. D. Awschalom. Observation of the spin Hall effect in semiconductors. *Science*, 306:1910–1913, 2004.

[155] J. Wunderlich, B. Kaestner, J. Sinova, and T. Jungwirth. Experimental observation of the spin-Hall effect in a two-dimensional spin-orbit coupled semiconductor system. *Phys. Rev. Lett.*, 94:047204, 2005.

[156] B. Yan and S.-C. Zhang. Topological materials. *Reports on Progress in Physics*, 75(9):096501, 2012.

[157] M. König, S. Wiedmann, C. Brüne, A. Roth, H. Buhmann, L. W. Molenkamp, X.-L. Qi, and S.-C. Zhang. Quantum spin Hall insulator state in HgTe quantum wells. *Science*, 318(5851):766–770, 2007.

[158] C. Brüne, A. Roth, H. Buhmann, E. M. Hankiewicz, L. W. Molenkamp, J. Maciejko, X.-L. Qi, and S.-C. Zhang. Spin polarization of the quantum spin Hall edge states. *Nature Physics*, 8:485, 2012.

[159] H. Zhang, C.-X. Liu, X.-L. Qi, X. Dai, Z. Fang, and S.-C. Zhang. Topological insulators in Bi_2Se_3, Bi_2Te_3 and Sb_2Te_3 with a single Dirac cone on the surface. *Nature Physics*, 5:438–442, 2009.

[160] J. Krumrain, G. Mussler, S. Borisova, T. Stoica, L. Plucinski, C. M. Schneider, and D. Grützmacher. MBE growth optimization of topological insulator Bi_2Te_3 films. *Journal of Crystal Growth*, 324(1):115–118, 2011.

[161] C.-X. Liu, X.-L. Qi, H. Zhang, X. Dai, Z. Fang, and S.-C. Zhang. Model Hamiltonian for topological insulators. *Phys. Rev. B*, 82:045122, 2010.

[162] A. Herdt, L. Plucinski, G. Bihlmayer, G. Mussler, S. Döring, J. Krumrain, D. Grützmacher, S. Blügel, and C. M. Schneider. Spin-polarization limit in Bi_2Te_3 dirac cone studied by angle- and spin-resolved photoemission experiments and *ab initio* calculations. *Phys. Rev. B*, 87:035127, 2013.

[163] I. A. Nechaev, R. C. Hatch, M. Bianchi, D. Guan, C. Friedrich, I. Aguilera, J. L. Mi, B. B. Iversen, S. Blügel, Ph. Hofmann, and E. V. Chulkov. Evidence for a direct band gap in the topological insulator Bi_2Se_3 from theory and experiment. *Phys. Rev. B*, 87:121111, 2013.

[164] M. Michiardi, I. Aguilera, M. Bianchi, V. E. de Carvalho, L. O. Ladeira, N. G. Teixeira, E. A. Soares, C. Friedrich, S. Blügel, and P. Hofmann. Bulk band structure of Bi_2Te_3. *Phys. Rev. B*, 90:075105, 2014.

[165] L. Fu and C. L. Kane. Topological insulators with inversion symmetry. *Phys. Rev. B*, 76:045302, 2007.

[166] L. Plucinski, G. Mussler, J. Krumrain, A. Herdt, S. Suga, D. Grützmacher, and C. M. Schneider. Robust surface electronic properties of topological insulators: Bi_2Te_3 films grown by molecular beam epitaxy. *Appl. Phys. Lett.*, 98(22):222503, 2011.

[167] J. Kampmeier, S. Borisova, L. Plucinski, M. Luysberg, G. Mussler, and D. Grützmacher. Suppressing twin domains in molecular beam epitaxy grown Bi_2Te_3 topological insulator thin films. *Crystal Growth and Design*, 15(1):390–394, 2015.

[168] Y. L. Chen, J. G. Analytis, J. H. Chu, Z. K. Liu, S. K. Mo, X. L. Qi, H. J. Zhang, D. H. Lu, X. Dai, Z. Fang, S. C. Zhang, I. R. Fisher, Z. Hussain, and Z. X. Shen. Experimental realization of a three-dimensional topological insulator, Bi_2Te_3. *Science*, 325:178, 2009.

[169] D. Hsieh, Y. Xia, D. Qian, L. Wray, J. H. Dil, F. Meier, J. Osterwalder, L. Patthey, J. G. Checkelsky, N. P. Ong, A. V. Fedorov, H. Lin, A. Bansil, D. Grauer, Y. S. Hor, R. J. Cava, and M. Z. Hasan. A tunable topological insulator in the spin helical Dirac transport regime. *Nature*, 460:1101, 2009.

[170] J. Zhang, C.-Z. Chang, Z. Zhang, J. Wen, X. Feng, K. Li, M. Liu, K. He, L. Wang, X. Chen, Q.-K. Xue, X. Ma, and Y. Wang. Band structure engineering in $(Bi_{1-x}Sb_x)_2Te_3$ ternary topological insulators. *Nature Communications*, 2:574, 2011.

[171] D. Kong, Y. Chen, J. J. Cha, Q. Zhang, J. G. Analytis, K. Lai, Z. Liu, S. S. Hong, K. J. Koski, S.-K. Mo, Z. Hussain, I. R. Fisher, Z.-X. Shen, and Y. Cui. Ambipolar field effect in the ternary topological insulator $(Bi_xSb_{1-x})_2Te_3$ by composition tuning. *Nature Nanotechnology*, 6:705–709, 2011.

[172] J. G. Analytis, R. D. McDonald, S. C. Riggs, J.-H. Chu, G. S. Boebinger, and I. R. Fisher. Two-dimensional surface state in the quantum limit of a topological insulator. *Nature Physics*, 6:960–964, 2010.

[173] D.-X. Qu, Y. S. Hor, J. Xiong, R. J. Cava, and N. P. Ong. Quantum oscillations and Hall anomaly of surface states in the topological insulator Bi_2Te_3. *Science*, 329:821–824, 2010.

[174] Z. Ren, A. A. Taskin, S. Sasaki, K. Segawa, and Y. Ando. Large bulk resistivity and surface quantum oscillations in the topological insulator Bi_2Te_2Se. *Phys. Rev. B*, 82:241306, 2010.

[175] Y. Xu, I. Miotkowski, C. Liu, J. Tian, H. Nam, N. Alidoust, J. Hu, C.-K. Shih, M. Z. Hasan, and Y. P. Chen. Observation of topological surface state quantum Hall effect in an intrinsic three-dimensional topological insulator. *Nature Physics*, 10:956–963, 2014.

[176] H. Peng, K. Lai, D. Kong, S. Meister, Y. Chen, X.-L. Qi, S.-C. Zhang, Z.-X. Shen, and Y. Cui. Aharonov-Bohm interference in topological insulator nanoribbons. *Nat Mater*, 9:225–229, 2010.

[177] F. Xiu, L. H. Wang, L. Cheng, L.-T. Chang, M. Lang, G. Huang, X. Kou, Y. Zhou, X. Jiang, Z. Chen, J. Zou, A. Shailos, and K. L. Wang. Manipulating surface states in topological insulator nanoribbons. *Nature Nanotechnology*, 6:216–221, 2011.

[178] P. M. Ostrovsky, I. V. Gornyi, and A. D. Mirlin. Interaction-induced criticality in Z_2 topological insulators. *Phys. Rev. Lett.*, 105:036803, 2010.

[179] G. Rosenberg, H.-M. Guo, and M. Franz. Wormhole effect in a strong topological insulator. *Phys. Rev. B*, 82:041104, 2010.

[180] J. H. Bardarson, P. W. Brouwer, and J. E. Moore. Aharonov-Bohm oscillations in disordered topological insulator nanowires. *Phys. Rev. Lett.*, 105:156803, 2010.

[181] R. Jackiw and C. Rebbi. Solitons with fermion number ½. *Phys. Rev. D*, 13:3398–3409, 1976.

[182] H. Häffner, C. F. Roos, and R. Blatt. Quantum computing with trapped ions. *Physics Reports*, 469(4):155–203, 2008.

[183] J. Clarke and F. K. Wilhelm. Superconducting quantum bits. *Nature*, 453:1031, 2008.

[184] D. P. DiVincenzo. The physical implementation of quantum computation. *Fortschr. Phys.*, 48(9–11):771–83, 2000.

[185] C. Monroe, D. M. Meekhof, B. E. King, W. M. Itano, and D. J.Wineland. Demonstration of a fundamental quantum logic gate. *Phys. Rev. Lett.*, 75(25):4714–4717, 1995.

[186] R. Vrijen, E. Yablonovitch, K. Wang, H. W. Jiang, A. Balandin, V. Roychowdhury, T. Mor, and D. DiVincenzo. Electron-spin-resonance transistors for quantum computing in silicon-germanium heterostructures. *Phys. Rev. A*, 62:012306/1, 2000.

[187] L. K. Grover. Quantum mechanics helps in searching for a needle in a haystack. *Phys. Rev. Lett.*, 79(2):325–8, 14 1997.

[188] D. Deutsch. Quantum theory, the Church-Turing principle and the universal quantum computer. *Proc. R. Soc. Lond. A*, 400:97, 1985.

[189] D. Deutsch. Quantum computational networks. *Proc. R. Soc. Lond. A*, 425:73, 1989.

[190] D. Deutsch and R. Jozsa. Rapid solution of problems by quantum computation. *Proc. R. Soc. Lond. A.*, 439(1907):553–558, 1992.

[191] J. M. Elzerman, R. Hanson, W. van Beveren, B. Witkamp, L. M. K. Vandersypen, and L. P. Kouwenhoven. Single-shot read-out of an individual electron spin in a quantum dot. *Nature*, 430:431, 2004.

[192] R. Hanson, L. H. Willems van Beveren, I. T. Vink, J. M. Elzerman, W. J. M. Naber, F. H. L. Koppens, L. P. Kouwenhoven, and L. M. K. Vandersypen. Single-shot readout of electron spin states in a quantum dot using spin-dependent tunnel rates. *Phys. Rev. Lett.*, 94(19):196802, 2005.

[193] F. H. L. Koppens, C. Buizert, K. J. Tielrooij, I. T. Vink, K. C. Nowack, T. Meunier, L. P. Kouwenhoven, and L. M. K. Vandersypen. Driven coherent oscillations of a single electron spin in a quantum dot. *Nature*, 442:766, 2006.

[194] V. N. Golovach, M. Borhani, and D. Loss. Electric-dipole-induced spin resonance in quantum dots. *Phys. Rev. B*, 74:165319, 2006.

[195] K. C. Nowack, F. H. L. Koppens, Yu. V. Nazarov, and L. M. K. Vandersypen. Coherent control of a single electron spin with electric fields. *Science*, 318(5855):1430–1433, 2007.

[196] S. Nadj-Perge, S. M. Frolov, E. P. A. M. Bakkers, and L. P. Kouwenhoven. Spin-orbit qubit in a semiconductor nanowire. *Nature*, 468:1084–1087, 2010.

[197] J. R. Petta, A. C. Johnson, J. M. Taylor, E. A. Laird, A. Yacoby, M. D. Lukin, C. M. Marcus, M. P. Hanson, and A. C. Gossard. Coherent manipulation of coupled electron spins in semiconductor quantum dots. *Science*, 309:2180, 2005.