Bibliography

[1] N. Zheludev, *The life and times of the LED — a 100-year history,* Nature Photonics **1**, 189 (2007).

[2] A. L. Schawlow and C. H. Townes, *Infrared and optical masers,* Physical Review **112**, 1940 (1958).

[3] T. H. Maiman, *Stimulated optical radiation in ruby,* Nature **187**, 493 (1960).

[4] R. N. Hall, G. E. Fenner, J. D. Kingsley, T. J. Soltys, and R. O. Carlson, *Coherent light emission from GaAs junctions,* Physical Review Letters **9**, 366 (1962).

[5] M. I. Nathan, W. P. Dumke, G. Burns, F. H. Dill, and G. Lasher, *Stimulated emission of radiation from GaAs p-n junctions,* Applied Physics Letters **1**, 62 (1962).

[6] T. M. Quist, R. H. Rediker, R. J. Keyes, W. E. Krag, B. Lax, A. L. McWhorter, and H. J. Zeigler, *Semiconductor MASER of GaAs,* Applied Physics Letters **1**, 91 (1962).

[7] A. E. Siegman, *Lasers* (University Science Books, 1986).

[8] M. Beckers, B. Weise, S. Kalapis, T. Gries, G. Seide, and C.-A. Bunge, *Basics of light guidance,* in *Polymer Optical Fibres,* edited by C.-A. Bunge, T. Gries, and M. Beckers (Woodhead Publishing, 2017) pp. 9–46.

[9] Y. Xu, *Nature and source of light for plant factory,* in *Plant Factory Using Artificial Light*, edited by M. Anpo, H. Fukuda, and T. Wada (Elsevier, 2019) pp. 47–69.

[10] J. C. Maxwell, *VIII. A dynamical theory of the electromagnetic field,* Philosophical Transactions of the Royal Society of London **155**, 459 (1865).

[11] A. Einstein, *Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt,* Annalen der Physik **322**, 132 (1905).

[12] L. Novotny and B. Hecht, *Principles of Nano-Optics* (Cambridge University Press, 2006).

[13] W. Demtröder, *Laser spectroscopy: Basic concepts and instrumentation,* 3rd ed. (Springer, 2002).

[14] M. Born, E. Wolf, A. B. Bhatia, P. C. Clemmow, D. Gabor, A. R. Stokes, A. M. Taylor, P. A. Wayman, and W. L. Wilcock, *Principles of Optics* (Cambridge University Press, 1999).

[15] A. F. Koenderink and A. Polman, *Nanophotonics: Shrinking light-based technology,* Science **348**, 516 (2015).

[16] S. A. Maier and H. A. Atwater, *Plasmonics: Localization and guiding of electromagnetic energy in metal/dielectric structures,* Journal of Applied Physics **98**, 011101 (2005).

[17] S. Linic, P. Christopher, H. Xin, and A. Marimuthu, *Catalytic and photocatalytic transformations on metal nanoparticles with targeted geometric and plasmonic properties,* Accounts of Chemical Research **46**, 1890 (2013).

[18] M. L. Brongersma, N. J. Halas, and P. Nordlander, *Plasmon-induced hot carrier science and technology,* Nature Nanotechnology **10**, 25 (2015).

[19] U. Aslam, V. G. Rao, S. Chavez, and S. Linic, *Catalytic conversion of solar to chemical energy on plasmonic metal nanostructures,* Nature Catalysis **1**, 656 (2018).

[20] S. Li, P. Miao, Y. Zhang, J. Wu, B. Zhang, Y. Du, X. Han, J. Sun, and P. Xu, *Recent advances in plasmonic nanostructures for enhanced photocatalysis and electrocatalysis,* Advanced Materials **33**, 2000086 (2021).

[21] H. A. Atwater and A. Polman, *Plasmonics for improved photovoltaic devices,* Nature Materials **9**, 205 (2010).

[22] M. L. Brongersma, Y. Cui, and S. Fan, *Light management for photovoltaics using high-index nanostructures,* Nature Materials **13**, 451 (2014).

[23] E. C. Garnett, B. Ehrler, A. Polman, and E. Alarcon-Llado, *Photonics for photovoltaics: Advances and opportunities,* ACS Photonics **8**, 61 (2021).

[24] N. Engheta, *Circuits with light at nanoscales: Optical nanocircuits inspired by metamaterials,* Science **317**, 1698 (2007).

[25] L. Thylén and L. Wosinski, *Integrated photonics in the 21st century,* Photonics Research **2**, 75 (2014).

[26] J. Wang, F. Sciarrino, A. Laing, and M. G. Thompson, *Integrated photonic quantum technologies,* Nature Photonics **14**, 273 (2020).

[27] Z. Zhou, X. Ou, Y. Fang, E. Alkhazraji, R. Xu, Y. Wan, and J. E. Bowers, *Prospects and applications of on-chip lasers,* eLight **3**, 1 (2023).

[28] B. J. Brenny, A. Polman, and F. J. García de Abajo, *Femtosecond plasmon and photon wave packets excited by a high-energy electron on a metal or dielectric surface,* Physical Review B **94**, 155412 (2016).

[29] M. M. Freundlich, *Origin of the electron microscope,* Science **142**, 185 (1963).

[30] R. Egerton, *Physical Principles of Electron Microscopy* (Springer International Publishing, 2016).

[31] F. J. García de Abajo, *Optical excitations in electron microscopy,* Reviews of Modern Physics **82**, 209 (2010).

[32] A. Losquin and T. T. Lummen, *Electron microscopy methods for space-, energy-, and time-resolved plasmonics,* Frontiers of Physics **12**, 127301 (2017).

[33] A. Polman, M. Kociak, and F. J. García de Abajo, *Electron-beam spectroscopy for nanophotonics,* Nature Materials **18**, 1158 (2019).

[34] J. Nelayah, M. Kociak, O. Stéphan, F. J. García de Abajo, M. Tencé, L. Henrard, D. Taverna, I. Pastoriza-Santos, L. M. Liz-Marzán, and C. Colliex, *Mapping surface plasmons on a single metallic nanoparticle,* Nature Physics **3**, 348 (2007).

[35] M. Bosman, V. J. Keast, M. Watanabe, A. I. Maaroof, and M. B. Cortie, *Mapping surface plasmons at the nanometre scale with an electron beam,* Nanotechnology **18**, 165505 (2007).

[36] M. Kociak and O. Stéphan, *Mapping plasmons at the nanometer scale in an electron microscope,* Chemical Society Reviews **43**, 3865 (2014).

[37] C. Colliex, M. Kociak, and O. Stéphan, *Electron energy loss spectroscopy imaging of surface plasmons at the nanometer scale,* Ultramicroscopy **162**, A1 (2016).

[38] R. F. Egerton, *Electron Energy-Loss Spectroscopy in the Electron Microscope* (Springer US, 1996).

[39] F. Hofer, F. P. Schmidt, W. Grogger, and G. Kothleitner, *Fundamentals of electron energy-loss spectroscopy,* IOP Conference Series: Materials Science and Engineering **109**, 012007 (2016).

[40] B. Schaffer, U. Hohenester, A. Trügler, and F. Hofer, *High-resolution surface plasmon imaging of gold nanoparticles by energy-filtered transmission electron microscopy,* Physical Review B - Condensed Matter and Materials Physics **79**, 041401(R) (2009).

[41] H. Brink, M. Barfels, R. Burgner, and B. Edwards, *A sub-50meV spectrometer and energy filter for use in combination with 200kV monochromated (S)TEMs,* Ultramicroscopy **96**, 367 (2003).

[42] O. Krivanek, G. Corbin, N. Dellby, B. Elston, R. Keyse, M. Murfitt, C. Own, Z. Szilagyi, and J. Woodruff, *An electron microscope for the aberration-corrected era,* Ultramicroscopy **108**, 179 (2008).

[43] O. L. Krivanek, T. C. Lovejoy, N. Dellby, T. Aoki, R. W. Carpenter, P. Rez, E. Soignard, J. Zhu, P. E. Batson, M. J. Lagos, R. F. Egerton, and P. A. Crozier, *Vibrational spectroscopy in the electron microscope,* Nature **514**, 209 (2014).

B

[44] R. Egoavil, N. Gauquelin, G. Martinez, S. V. Aert, G. V. Tendeloo, and J. Verbeeck, *Atomic resolution mapping of phonon excitations in STEM-EELS experiments,* Ultramicroscopy **147**, 1 (2014).

[45] M. J. Lagos, A. Trügler, U. Hohenester, and P. E. Batson, *Mapping vibrational surface and bulk modes in a single nanocube,* Nature **543**, 529 (2017).

[46] K. Venkatraman, B. D. A. Levin, K. March, P. Rez, and P. A. Crozier, *Vibrational spectroscopy at atomic resolution with electron impact scattering,* Nature Physics **15**, 1237 (2019).

[47] F. Hage, D. Kepaptsoglou, Q. Ramasse, and L. Allen, *Phonon spectroscopy at atomic resolution,* Physical Review Letters **122**, 016103 (2019).

[48] F. S. Hage, G. Radtke, D. M. Kepaptsoglou, M. Lazzeri, and Q. M. Ramasse, *Single-atom vibrational spectroscopy in the scanning transmission electron microscope,* Science **367**, 1124 (2020).

[49] C. A. Gadre, X. Yan, Q. Song, J. Li, L. Gu, H. Huyan, T. Aoki, S.-W. Lee, G. Chen, R. Wu, and X. Pan, *Nanoscale imaging of phonon dynamics by electron microscopy,* Nature **606**, 292 (2022).

[50] M. J. Lagos, I. C. Bicket, S. S. M. M., and G. A. Botton, *Advances in ultrahigh-energy resolution EELS: phonons, infrared plasmons and strongly coupled modes,* Microscopy **71**, i174 (2022).

[51] N. Yamamoto, K. Araya, and F. J. García de Abajo, *Photon emission from silver particles induced by a high-energy electron beam,* Physical Review B - Condensed Matter and Materials Physics **64**, 2054191 (2001).

[52] E. J. R. Vesseur, R. D. Waele, M. Kuttge, and A. Polman, *Direct observation of plasmonic modes in Au nanowires using high-resolution cathodoluminescence spectroscopy,* Nano Letters **7**, 2843 (2007).

[53] T. Coenen, B. J. Brenny, E. J. Vesseur, and A. Polman, *Cathodoluminescence microscopy: Optical imaging and spectroscopy with deep-subwavelength resolution,* MRS Bulletin **40**, 359 (2015).

[54] C. I. Osorio, T. Coenen, B. J. Brenny, A. Polman, and A. F. Koenderink, *Angle-resolved cathodoluminescence imaging polarimetry,* ACS Photonics **3**, 147 (2016).

[55] S. Mignuzzi, M. Mota, T. Coenen, Y. Li, A. P. Mihai, P. K. Petrov, R. F. Oulton, S. A. Maier, and R. Sapienza, *Energy-momentum cathodoluminescence spectroscopy of dielectric nanostructures,* ACS Photonics **5**, 1381 (2018).

[56] T. Coenen and A. Polman, *Energy-momentum cathodoluminescence imaging of anisotropic directionality in elliptical aluminum plasmonic bullseye antennas,* ACS Photonics **6**, 573 (2019).

B

[57] N. J. Schilder, H. Agrawal, E. C. Garnett, and A. Polman, *Phase-resolved surface plasmon scattering probed by cathodoluminescence holography,* ACS Photonics **7**, 1476 (2020).

[58] D.-S. Yang, O. F. Mohammed, and A. H. Zewail, *Scanning ultrafast electron microscopy,* Proceedings of the National Academy of Sciences **107**, 14993 (2010).

[59] M. Merano, S. Sonderegger, A. Crottini, S. Collin, P. Renucci, E. Pelucchi, A. Malko, M. H. Baier, E. Kapon, B. Deveaud, and J.-D. Ganière, *Probing carrier dynamics in nanostructures by picosecond cathodoluminescence,* Nature **438**, 479 (2005).

[60] M. Kociak and L. Zagonel, *Cathodoluminescence in the scanning transmission electron microscope,* Ultramicroscopy **176**, 112 (2017).

[61] S. Meuret, M. S. Garcia, T. Coenen, E. Kieft, H. Zeijlemaker, M. Lätzel, S. Christiansen, S. Y. Woo, Y. H. Ra, Z. Mi, and A. Polman, *Complementary cathodoluminescence lifetime imaging configurations in a scanning electron microscope,* Ultramicroscopy **197**, 28 (2019).

[62] S. Meuret, L. H. G. Tizei, F. Houdellier, S. Weber, Y. Auad, M. Tencé, H.-C. Chang, M. Kociak, and A. Arbouet, *Time-resolved cathodoluminescence in an ultrafast transmission electron microscope,* Applied Physics Letters **119**, 062106 (2021).

[63] L. Piazza, D. J. Masiel, T. LaGrange, B. W. Reed, B. Barwick, and F. Carbone, *Design and implementation of a fs-resolved transmission electron microscope based on thermionic gun technology,* Chemical Physics **423**, 79 (2013).

[64] K. Bücker, M. Picher, O. Crégut, T. LaGrange, B. W. Reed, S. T. Park, D. J. Masiel, and F. Banhart, *Electron beam dynamics in an ultrafast transmission electron microscope with Wehnelt electrode,* Ultramicroscopy **171**, 8 (2016).

[65] A. Feist, N. Bach, N. R. da Silva, T. Danz, M. Möller, K. E. Priebe, T. Domröse, J. G. Gatzmann, S. Rost, J. Schauss, S. Strauch, R. Bormann, M. Sivis, S. Schäfer, and C. Ropers, *Ultrafast transmission electron microscopy using a laser-driven field emitter: Femtosecond resolution with a high coherence electron beam,* Ultramicroscopy **176**, 63 (2017).

[66] B. Barwick, D. J. Flannigan, and A. H. Zewail, *Photon-induced near-field electron microscopy,* Nature **462**, 902 (2009).

[67] F. J. García de Abajo and M. Kociak, *Electron energy-gain spectroscopy,* New Journal of Physics **10**, 073035 (2008).

[68] F. J. García de Abajo, A. Asenjo-Garcia, and M. Kociak, *Multiphoton absorption and emission by interaction of swift electrons with evanescent light fields,* Nano Letters **10**, 1859 (2010).

[69] S. T. Park, M. Lin, and A. H. Zewail, *Photon-induced near-field electron microscopy (PINEM): Theoretical and experimental,* New Journal of Physics **12**, 123028 (2010).

B

[70] A. Feist, K. E. Echternkamp, J. Schauss, S. V. Yalunin, S. Schäfer, and C. Ropers, *Quantum coherent optical phase modulation in an ultrafast transmission electron microscope,* Nature **521**, 200 (2015).

[71] V. D. Giulio, M. Kociak, and F. J. García de Abajo, *Probing quantum optical excitations with fast electrons,* Optica **6**, 1524 (2019).

[72] A. Yurtsever and A. H. Zewail, *Direct visualization of near-fields in nanoplasmonics and nanophotonics,* Nano Letters **12**, 3334 (2012).

[73] L. Piazza, T. T. Lummen, E. Quiñonez, Y. Murooka, B. W. Reed, B. Barwick, and F. Carbone, *Simultaneous observation of the quantization and the interference pattern of a plasmonic near-field,* Nature Communications **6**, 6407 (2015).

[74] E. Pomarico, I. Madan, G. Berruto, G. M. Vanacore, K. Wang, I. Kaminer, F. J. García de Abajo, and F. Carbone, *meV resolution in laser-assisted energy-filtered transmission electron microscopy,* ACS Photonics **5**, 759 (2018).

[75] T. R. Harvey, J. W. Henke, O. Kfir, H. Lourenço-Martins, A. Feist, F. J. García de Abajo, and C. Ropers, *Probing chirality with inelastic electron-light scattering,* Nano Letters **20**, 4377 (2020).

[76] M. Liebtrau, M. Sivis, A. Feist, H. Lourenço-Martins, N. Pazos-Pérez, R. A. Alvarez-Puebla, F. J. García de Abajo, A. Polman, and C. Ropers, *Spontaneous and stimulated electron–photon interactions in nanoscale plasmonic near fields,* Light: Science and Applications **10**, 82 (2021).

[77] R. Shiloh, T. Chlouba, and P. Hommelhoff, *Quantum-coherent light-electron interaction in a scanning electron microscope,* Physical Review Letters **128**, 235301 (2022).

[78] J. H. Gaida, H. Lourenço-Martins, M. Sivis, T. Rittmann, A. Feist, F. J. García de Abajo, and C. Ropers, *Attosecond electron microscopy by free-electron homodyne detection,* (2023), arXiv:2305.03005 [physics.optics] .

[79] K. Wang, R. Dahan, M. Shentcis, Y. Kauffmann, A. B. Hayun, O. Reinhardt, S. Tsesses, and I. Kaminer, *Coherent interaction between free electrons and a photonic cavity,* Nature **582**, 50 (2020).

[80] Y. Morimoto and P. Baum, *Diffraction and microscopy with attosecond electron pulse trains,* Nature Physics **14**, 252 (2018).

[81] O. Kfir, H. Lourenço-Martins, G. Storeck, M. Sivis, T. R. Harvey, T. J. Kippenberg, A. Feist, and C. Ropers, *Controlling free electrons with optical whispering-gallery modes,* Nature **582**, 46 (2020).

[82] R. Dahan, S. Nehemia, M. Shentcis, O. Reinhardt, Y. Adiv, X. Shi, O. Be'er, M. H. Lynch, Y. Kurman, K. Wang, and I. Kaminer, *Resonant phase-matching between a light wave and a free-electron wavefunction,* Nature Physics **16**, 1123 (2020).

B

[83] J. W. Henke, A. S. Raja, A. Feist, G. Huang, G. Arend, Y. Yang, F. J. Kappert, R. N. Wang, M. Möller, J. Pan, J. Liu, O. Kfir, C. Ropers, and T. J. Kippenberg, *Integrated photonics enables continuous-beam electron phase modulation,* Nature **600**, 653 (2021).

[84] T. Fishman, U. Haeusler, R. Dahan, M. Yannai, Y. Adiv, T. L. Abudi, R. Shiloh, O. Eyal, P. Yousefi, G. Eisenstein, P. Hommelhoff, and I. Kaminer, *Imaging the field inside nanophotonic accelerators,* Nature Communications **14**, 3687 (2023).

[85] L. D. Broglie, *Waves and quanta,* Nature **112**, 540 (1923).

[86] C. Davisson and L. H. Germer, *Diffraction of electrons by a crystal of nickel,* Physical Review **30**, 705 (1927).

[87] G. P. Thomson and A. Reid, *Diffraction of cathode rays by a thin film,* Nature **119**, 890 (1927).

[88] D. J. Griffiths and D. F. Schroeter, *Introduction to Quantum Mechanics* (Cambridge University Press, 2018).

[89] K. E. Echternkamp, A. Feist, S. Schäfer, and C. Ropers, *Ramsey-type phase control of free-electron beams,* Nature Physics **12**, 1000 (2016).

[90] K. E. Priebe, C. Rathje, S. V. Yalunin, T. Hohage, A. Feist, S. Schäfer, and C. Ropers, *Attosecond electron pulse trains and quantum state reconstruction in ultrafast transmission electron microscopy,* Nature Photonics **11**, 793 (2017).

[91] G. M. Vanacore, I. Madan, G. Berruto, K. Wang, E. Pomarico, R. J. Lamb, D. McGrouther, I. Kaminer, B. Barwick, F. J. García de Abajo, and F. Carbone, *Attosecond coherent control of free-electron wave functions using semi-infinite light fields,* Nature Communications **9**, 2694 (2018).

[92] G. M. Vanacore, G. Berruto, I. Madan, E. Pomarico, P. Biagioni, R. J. Lamb, D. McGrouther, O. Reinhardt, I. Kaminer, B. Barwick, H. Larocque, V. Grillo, E. Karimi, F. J. García de Abajo, and F. Carbone, *Ultrafast generation and control of an electron vortex beam via chiral plasmonic near fields,* Nature Materials **18**, 573 (2019).

[93] I. Madan, V. Leccese, A. Mazur, F. Barantani, T. LaGrange, A. Sapozhnik, P. M. Tengdin, S. Gargiulo, E. Rotunno, J.-C. Olaya, I. Kaminer, V. Grillo, F. J. García de Abajo, F. Carbone, and G. M. Vanacore, *Ultrafast transverse modulation of free electrons by interaction with shaped optical fields,* ACS Photonics **9**, 3215 (2022).

[94] A. Feist, S. V. Yalunin, S. Schafer, and C. Ropers, *High-purity free-electron momentum states prepared by three-dimensional optical phase modulation,* Physical Review Research **2**, 043227 (2020).

[95] A. Konečná and F. J. García de Abajo, *Electron beam aberration correction using optical near fields,* Physical Review Letters **125**, 030801 (2020).

B

[96] O. Kfir, *Entanglements of electrons and cavity photons in the strong-coupling regime,* Physical Review Letters **123**, 103602 (2019).

[97] O. Reinhardt and I. Kaminer, *Theory of shaping electron wavepackets with light,* ACS Photonics **7**, 2859 (2020).

[98] V. D. Giulio and F. J. García de Abajo, *Free-electron shaping using quantum light,* Optica **7**, 1820 (2020).

[99] R. Dahan, A. Gorlach, U. Haeusler, A. Karnieli, O. Eyal, P. Yousefi, M. Segev, A. Arie, G. Eisenstein, P. Hommelhoff, and I. Kaminer, *Imprinting the quantum statistics of photons on free electrons,* Science **373**, eabj7128 (2021).

[100] A. Konečná, F. Iyikanat, and F. J. García de Abajo, *Entangling free electrons and optical excitations,* Science Advances **8**, eabo7853 (2022).

[101] F. J. García de Abajo and V. D. Giulio, *Optical excitations with electron beams: Challenges and opportunities,* ACS Photonics **8**, 945 (2021).

[102] A. Asenjo-Garcia and F. J. García de Abajo, *Plasmon electron energy-gain spectroscopy,* New Journal of Physics **15**, 103021 (2013).

[103] R. H. Pantell and M. A. Piestrup, *Free-electron momentum modulation by means of limited interaction length with light,* Applied Physics Letters **32**, 781 (1978).

[104] N. Talebi, *Strong interaction of slow electrons with near-field light visited from first principles,* Physical Review Letters **125**, 80401 (2020).

[105] J. Breuer and P. Hommelhoff, *Laser-based acceleration of nonrelativistic electrons at a dielectric structure,* Physical Review Letters **111**, 134803 (2013).

[106] Y. Adiv, K. Wang, R. Dahan, P. Broaddus, Y. Miao, D. Black, K. Leedle, R. Byer, O. Solgaard, R. J. England, and I. Kaminer, *Quantum nature of dielectric laser accelerators,* Physical Review X **11**, 041042 (2021).

[107] S. J. Smith and E. M. Purcell, *Visible light from localized surface charges moving across a grating,* Physical Review **92**, 1069 (1953).

[108] N. Yu and F. Capasso, *Flat optics with designer metasurfaces,* Nature Materials **13**, 139 (2014).

[109] D. Lin, P. Fan, E. Hasman, and M. L. Brongersma, *Dielectric gradient metasurface optical elements,* Science **345**, 298 (2014).

[110] S. Chen, Z. Li, Y. Zhang, H. Cheng, and J. Tian, *Phase manipulation of electromagnetic waves with metasurfaces and its applications in nanophotonics,* Advanced Optical Materials **6**, 1800104 (2018).

[111] S. M. Kamali, E. Arbabi, A. Arbabi, and A. Faraon, *A review of dielectric optical metasurfaces for wavefront control,* Nanophotonics **7**, 1041 (2018).

[112] D. Neshev and I. Aharonovich, *Optical metasurfaces: new generation building blocks for multi-functional optics,* Light: Science and Applications **7**, 58 (2018).

[113] J. Hu, S. Bandyopadhyay, Y. hui Liu, and L. yang Shao, *A review on metasurface: From principle to smart metadevices,* Frontiers in Physics **8**, 586087 (2021).

[114] E. Hasman, V. Kleiner, G. Biener, and A. Niv, *Polarization dependent focusing lens by use of quantized Pancharatnam–Berry phase diffractive optics,* Applied Physics Letters **82**, 328 (2003).

[115] F. Aieta, P. Genevet, M. A. Kats, N. Yu, R. Blanchard, Z. Gaburro, and F. Capasso, *Aberration-free ultrathin flat lenses and axicons at telecom wavelengths based on plasmonic metasurfaces,* Nano Letters **12**, 4932 (2012).

[116] M. Khorasaninejad, W. T. Chen, R. C. Devlin, J. Oh, A. Y. Zhu, and F. Capasso, *Metalenses at visible wavelengths: Diffraction-limited focusing and subwavelength resolution imaging,* Science **352**, 1190 (2016).

[117] W. T. Chen, A. Y. Zhu, V. Sanjeev, M. Khorasaninejad, Z. Shi, E. Lee, and F. Capasso, *A broadband achromatic metalens for focusing and imaging in the visible,* Nature Nanotechnology **13**, 220 (2018).

[118] S. Wang, P. C. Wu, V.-C. Su, Y.-C. Lai, M.-K. Chen, H. Y. Kuo, B. H. Chen, Y. H. Chen, T.-T. Huang, J.-H. Wang, R.-M. Lin, C.-H. Kuan, T. Li, Z. Wang, S. Zhu, and D. P. Tsai, *A broadband achromatic metalens in the visible,* Nature Nanotechnology **13**, 227 (2018).

[119] F. Yue, D. Wen, J. Xin, B. D. Gerardot, J. Li, and X. Chen, *Vector vortex beam generation with a single plasmonic metasurface,* ACS Photonics **3**, 1558 (2016).

[120] A. Faßbender, J. Babocký, P. Dvořák, V. Křápek, and S. Linden, *Direct phase mapping of broadband Laguerre-Gaussian metasurfaces,* APL Photonics **3**, 110803 (2018).

[121] H. Kwon, D. Sounas, A. Cordaro, A. Polman, and A. Alù, *Nonlocal metasurfaces for optical signal processing,* Physical Review Letters **121**, 173004 (2018).

[122] H. Kwon, A. Cordaro, D. Sounas, A. Polman, and A. Alù, *Dual-polarization analog 2D image processing with nonlocal metasurfaces,* ACS Photonics **7**, 1799 (2020).

[123] A. Silva, F. Monticone, G. Castaldi, V. Galdi, A. Alù, and N. Engheta, *Performing mathematical operations with metamaterials,* Science **343**, 160 (2014).

[124] A. Cordaro, H. Kwon, D. Sounas, A. F. Koenderink, A. Alù, and A. Polman, *High-index dielectric metasurfaces performing mathematical operations,* Nano Letters **19**, 8418 (2019).

B

[125] G. Li, S. Zhang, and T. Zentgraf, *Nonlinear photonic metasurfaces,* Nature Reviews Materials **2**, 17010 (2017).

[126] S. Keren-Zur, L. Michaeli, H. Suchowski, and T. Ellenbogen, *Shaping light with nonlinear metasurfaces,* Advances in Optics and Photonics **10**, 309 (2018).

[127] N. Nookala, J. Lee, M. Tymchenko, J. S. Gomez-Diaz, F. Demmerle, G. Boehm, K. Lai, G. Shvets, M.-C. Amann, A. Alu, and M. Belkin, *Ultrathin gradient nonlinear metasurface with a giant nonlinear response,* Optica **3**, 283 (2016).

[128] T. Santiago-Cruz, A. Fedotova, V. Sultanov, M. A. Weissflog, D. Arslan, M. Younesi, T. Pertsch, I. Staude, F. Setzpfandt, and M. Chekhova, *Photon pairs from resonant metasurfaces,* Nano Letters **21**, 4423 (2021).

[129] M. Semmlinger, M. L. Tseng, J. Yang, M. Zhang, C. Zhang, W.-Y. Tsai, D. P. Tsai, P. Nordlander, and N. J. Halas, *Vacuum ultraviolet light-generating metasurface,* Nano Letters **18**, 5738 (2018).

[130] L. Huang, S. Zhang, and T. Zentgraf, *Metasurface holography: from fundamentals to applications,* Nanophotonics **7**, 1169 (2018).

[131] H. Zhou, B. Sain, Y. Wang, C. Schlickriede, R. Zhao, X. Zhang, Q. Wei, X. Li, L. Huang, and T. Zentgraf, *Polarization-encrypted orbital angular momentum multiplexed metasurface holography,* ACS Nano **14**, 5553 (2020).

[132] O. A. M. Abdelraouf, Z. Wang, H. Liu, Z. Dong, Q. Wang, M. Ye, X. R. Wang, Q. J. Wang, and H. Liu, *Recent advances in tunable metasurfaces: Materials, design, and applications,* ACS Nano **16**, 13339 (2022).

[133] F. J. García de Abajo and M. Kociak, *Probing the photonic local density of states with electron energy loss spectroscopy,* Physical Review Letters **100**, 106804 (2008).

[134] A. Losquin and M. Kociak, *Link between cathodoluminescence and electron energy loss spectroscopy and the radiative and full electromagnetic local density of states,* ACS Photonics **2**, 1619 (2015).

[135] A. Losquin, L. F. Zagonel, V. Myroshnychenko, B. Rodríguez-González, M. Tencé, L. Scarabelli, J. Förstner, L. M. Liz-Marzán, F. J. García de Abajo, O. Stéphan, and M. Kociak, *Unveiling nanometer scale extinction and scattering phenomena through combined electron energy loss spectroscopy and cathodoluminescence measurements,* Nano Letters **15**, 1229 (2015).

[136] T. Coenen, J. V. D. Groep, and A. Polman, *Resonant modes of single silicon nanocavities excited by electron irradiation,* ACS Nano **7**, 1689 (2013).

[137] T. Coenen, F. B. Arango, A. F. Koenderink, and A. Polman, *Directional emission from a single plasmonic scatterer,* Nature Communications **5**, 3250 (2014).

[138] T. Coenen, D. T. Schoen, B. J. Brenny, A. Polman, and M. L. Brongersma, *Combined electron energy-loss and cathodoluminescence spectroscopy on individual and composite plasmonic nanostructures,* Physical Review B **93**, 195429 (2016).

[139] S. Raza, N. Stenger, A. Pors, T. Holmgaard, S. Kadkhodazadeh, J. B. Wagner, K. Pedersen, M. Wubs, S. I. Bozhevolnyi, and N. A. Mortensen, *Extremely confined gap surface-plasmon modes excited by electrons,* Nature Communications **5**, 4125 (2014).

[140] S. Raza, M. Esfandyarpour, A. L. Koh, N. A. Mortensen, M. L. Brongersma, and S. I. Bozhevolnyi, *Electron energy-loss spectroscopy of branched gap plasmon resonators,* Nature Communications **7**, 13790 (2016).

[141] E. J. R. Vesseur, T. Coenen, H. Caglayan, N. Engheta, and A. Polman, *Experimental verification of n=0 structures for visible light,* Physical Review Letters **110**, 013902 (2013).

[142] R. Sapienza, T. Coenen, J. Renger, M. Kuttge, N. F. V. Hulst, and A. Polman, *Deep-subwavelength imaging of the modal dispersion of light,* Nature Materials **11**, 781 (2012).

[143] S. Peng, N. J. Schilder, X. Ni, J. V. D. Groep, M. L. Brongersma, A. Alù, A. B. Khanikaev, H. A. Atwater, and A. Polman, *Probing the band structure of topological silicon photonic lattices in the visible spectrum,* Physical Review Letters **122**, 117401 (2019).

[144] C. Liu, Y. Wu, Z. Hu, J. A. Busche, E. K. Beutler, N. P. Montoni, T. M. Moore, G. A. Magel, J. P. Camden, D. J. Masiello, G. Duscher, and P. D. Rack, *Continuous wave resonant photon stimulated electron energy-gain and electron energy-loss spectroscopy of individual plasmonic nanoparticles,* ACS Photonics **6**, 2499 (2019).

[145] P. Das, J. D. Blazit, M. Tencé, L. F. Zagonel, Y. Auad, Y. H. Lee, X. Y. Ling, A. Losquin, C. Colliex, O. Stéphan, F. J. García de Abajo, and M. Kociak, *Stimulated electron energy loss and gain in an electron microscope without a pulsed electron gun,* Ultramicroscopy **203**, 44 (2019).

[146] N. Pazos-Perez, L. Guerrini, and R. A. Alvarez-Puebla, *Plasmon tunability of gold nanostars at the tip apexes,* ACS Omega **3**, 17173 (2018).

[147] E. Hao, R. C. Bailey, G. C. Schatz, J. T. Hupp, and S. Li, *Synthesis and optical properties of "branched" gold nanocrystals,* Nano Letters **4**, 327 (2004).

[148] C. L. Nehl, H. Liao, and J. H. Hafner, *Optical properties of star-shaped gold nanoparticles,* Nano Letters **6**, 683 (2006).

[149] F. Hao, C. L. Nehl, J. H. Hafner, and P. Nordlander, *Plasmon resonances of a gold nanostar,* Nano Letters **7**, 729 (2007).

B

[150] P. S. Kumar, I. Pastoriza-Santos, B. Rodríguez-González, F. J. García de Abajo, and L. M. Liz-Marzán, *High-yield synthesis and optical response of gold nanostars,* Nanotechnology **19**, 015606 (2008).

[151] C. Hrelescu, T. K. Sau, A. L. Rogach, F. Jäckel, G. Laurent, L. Douillard, and F. Charra, *Selective excitation of individual plasmonic hotspots at the tips of single gold nanostars,* Nano Letters **11**, 402 (2011).

[152] S. Mazzucco, O. Stéphan, C. Colliex, I. Pastoriza-Santos, L. M. Liz-Marzan, F. J. García de Abajo, and M. Kociak, *Spatially resolved measurements of plasmonic eigenstates in complex-shaped, asymmetric nanoparticles: Gold nanostars,* EPJ Applied Physics **54**, 33512 (2011).

[153] L. Shao, A. S. Susha, L. S. Cheung, T. K. Sau, A. L. Rogach, and J. Wang, *Plasmonic properties of single multispiked gold nanostars: Correlating modeling with experiments,* Langmuir **28**, 8979 (2012).

[154] P. Das, A. Kedia, P. S. Kumar, N. Large, and T. K. Chini, *Local electron beam excitation and substrate effect on the plasmonic response of single gold nanostars,* Nanotechnology **24**, 1 (2013).

[155] A. Maity, A. Maiti, P. Das, D. Senapati, and T. K. Chini, *Effect of intertip coupling on the plasmonic behavior of individual multitipped gold nanoflower,* ACS Photonics **1**, 1290 (2014).

[156] M. Sivis, N. Pazos-Perez, R. Yu, R. Alvarez-Puebla, F. J. García de Abajo, and C. Ropers, *Continuous-wave multiphoton photoemission from plasmonic nanostars,* Communications Physics **1**, 13 (2018).

[157] F. J. García de Abajo and A. Howie, *Retarded field calculation of electron energy loss in inhomogeneous dielectrics,* Physical Review B - Condensed Matter and Materials Physics **65**, 1154181 (2002).

[158] U. Hohenester and A. Trügler, *MNPBEM - A Matlab toolbox for the simulation of plasmonic nanoparticles,* Computer Physics Communications **183**, 370 (2012).

[159] U. Hohenester, *Simulating electron energy loss spectroscopy with the MNPBEM toolbox,* Computer Physics Communications **185**, 1177 (2014).

[160] L. Rodríguez-Lorenzo, R. A. Álvarez Puebla, I. Pastoriza-Santos, S. Mazzucco, O. Stéphan, M. Kociak, L. M. Liz-Marzán, and F. J. García de Abajo, *Zeptomol detection through controlled ultrasensitive surface-enhanced raman scattering,* Journal of the American Chemical Society **131**, 4616 (2009).

[161] A. Gloter, A. Douiri, M. Tencé, and C. Colliex, *Improving energy resolution of EELS spectra: An alternative to the monochromator solution,* Ultramicroscopy **96**, 385 (2003).

[162] M. Bosman, E. Ye, S. F. Tan, C. A. Nijhuis, J. K. Yang, R. Marty, A. Mlayah, A. Arbouet, C. Girard, and M. Y. Han, *Surface plasmon damping quantified with an electron nanoprobe,* Scientific Reports **3**, 1312 (2013).

[163] N. Kawasaki, S. Meuret, R. Weil, H. Lourenço-Martins, O. Stéphan, and M. Kociak, *Extinction and scattering properties of high-order surface plasmon modes in silver nanoparticles probed by combined spatially resolved electron energy loss spectroscopy and cathodoluminescence,* ACS Photonics **3**, 1654 (2016).

[164] N. Bach, T. Domröse, A. Feist, T. Rittmann, S. Strauch, C. Ropers, and S. Schäfer, *Coulomb interactions in high-coherence femtosecond electron pulses from tip emitters,* Structural Dynamics **6**, 014301 (2019).

[165] K. C. Vernon, A. M. Funston, C. Novo, D. E. Gómez, P. Mulvaney, and T. J. Davis, *Influence of particle-substrate interaction on localized plasmon resonances,* Nano Letters **10**, 2080 (2010).

[166] V. Myroshnychenko, J. Rodríguez-Fernández, I. Pastoriza-Santos, A. M. Funston, C. Novo, P. Mulvaney, L. M. Liz-Marzán, and F. J. García de Abajo, *Modelling the optical response of gold nanoparticles,* Chemical Society Reviews **37**, 1792 (2008).

[167] J. Schefold, S. Meuret, N. Schilder, T. Coenen, H. Agrawal, E. C. Garnett, and A. Polman, *Spatial resolution of coherent cathodoluminescence super-resolution microscopy,* ACS Photonics **6**, 1067 (2019).

[168] G. Boudarham and M. Kociak, *Modal decompositions of the local electromagnetic density of states and spatially resolved electron energy loss probability in terms of geometric modes,* Physical Review B - Condensed Matter and Materials Physics **85**, 245447 (2012).

[169] N. Talebi, W. Sigle, R. Vogelgesang, M. Esmann, S. F. Becker, C. Lienau, and P. A. V. Aken, *Excitation of mesoscopic plasmonic tapers by relativistic electrons: Phase matching versus eigenmode resonances,* ACS Nano **9**, 7641 (2015).

[170] B. J. Brenny, T. Coenen, and A. Polman, *Quantifying coherent and incoherent cathodoluminescence in semiconductors and metals,* Journal of Applied Physics **115**, 244307 (2014).

[171] Y. Pan and A. Gover, *Spontaneous and stimulated emissions of a preformed quantum free-electron wave function,* Physical Review A **99**, 052107 (2019).

[172] O. Kfir, V. D. Giulio, F. J. García de Abajo, and C. Ropers, *Optical coherence transfer mediated by free electrons,* Science Advances **7**, eabf6380 (2021).

[173] A. Karnieli, N. Rivera, A. Arie, and I. Kaminer, *The coherence of light is fundamentally tied to the quantum coherence of the emitting particle,* Science Advances **7**, eabf8096 (2021).

[174] N. Talebi, *Electron-light interactions beyond adiabatic approximation,* in *Near-Field-Mediated Photon-Electron Interactions* (Springer International Publishing, Cham, 2019) pp. 195–243.

[175] Y. Yang, A. Massuda, C. Roques-Carmes, S. E. Kooi, T. Christensen, S. G. Johnson, J. D. Joannopoulos, O. D. Miller, I. Kaminer, and M. Soljačić, *Maximal spontaneous photon emission and energy loss from free electrons,* Nature Physics **14**, 894 (2018).

[176] F. J. García de Abajo, *Multiple excitation of confined graphene plasmons by single free electrons,* ACS Nano **7**, 11409 (2013).

[177] J. Turkevich, *Colloidal gold. Part II,* Gold Bulletin **18**, 125 (1985).

[178] F. de la Peña, T. Ostasevicius, V. T. Fauske, P. Burdet, P. Jokubauskas, M. Nord, E. Prestat, M. Sarahan, K. E. MacArthur, D. N. Johnstone, J. Taillon, J. Caron, T. Furnival, A. Eljarrat, and S. Mazz, *Hyperspy 1.3,* (2017).

[179] T. Coenen, S. V. den Hoedt, and A. Polman, *A new cathodoluminescence system for nanoscale optics, materials science, and geology,* Microscopy Today **24**, 12 (2016).

[180] P. B. Johnson and R. W. Christy, *Optical constant of the nobel metals,* Physical Review B **6**, 4370 (1972).

[181] Z. Bomzon, G. Biener, V. Kleiner, and E. Hasman, *Space-variant Pancharatnam–Berry phase optical elements with computer-generated subwavelength gratings,* Optics Letters **27**, 1141 (2002).

[182] Z. Bomzon, G. Biener, V. Kleiner, and E. Hasman, *Radially and azimuthally polarized beams generated by space-variant dielectric subwavelength gratings,* Optics Letters **27**, 285 (2002).

[183] N. Yu, P. Genevet, M. A. Kats, F. Aieta, J.-P. Tetienne, F. Capasso, and Z. Gaburro, *Light propagation with phase discontinuities: Generalized laws of reflection and refraction,* Science **334**, 333 (2011).

[184] X. Ni, N. K. Emani, A. V. Kildishev, A. Boltasseva, and V. M. Shalaev, *Broadband light bending with plasmonic nanoantennas,* Science **335**, 427 (2012).

[185] E. Karimi, S. A. Schulz, I. D. Leon, H. Qassim, J. Upham, and R. W. Boyd, *Generating optical orbital angular momentum at visible wavelengths using a plasmonic metasurface,* Light: Science and Applications **3**, 167 (2014).

[186] G. Li, M. Kang, S. Chen, S. Zhang, E. Y.-B. Pun, K. W. Cheah, and J. Li, *Spin-enabled plasmonic metasurfaces for manipulating orbital angular momentum of light,* Nano Letters **13**, 4148 (2013).

[187] G. Zheng, H. Mühlenbernd, M. Kenney, G. Li, T. Zentgraf, and S. Zhang, *Metasurface holograms reaching 80% efficiency,* Nature Nanotechnology **10**, 308 (2015).

[188] E. Maguid, R. Chriki, M. Yannai, V. Kleiner, E. Hasman, A. A. Friesem, and N. Davidson, *Topologically controlled intracavity laser modes based on Pancharatnam-Berry phase,* ACS Photonics **5**, 1817 (2018).

[189] A. S. Solntsev, G. S. Agarwal, and Y. Y. Kivshar, *Metasurfaces for quantum photonics,* Nature Photonics **15**, 327 (2021).

[190] K. Rong, B. Wang, A. Reuven, E. Maguid, B. Cohn, V. Kleiner, S. Katznelson, E. Koren, and E. Hasman, *Photonic Rashba effect from quantum emitters mediated by a Berry-phase defective photonic crystal,* Nature Nanotechnology **15**, 927 (2020).

[191] M. Krüger, M. Schenk, and P. Hommelhoff, *Attosecond control of electrons emitted from a nanoscale metal tip,* Nature **475**, 78 (2011).

[192] A. Massuda, C. Roques-Carmes, Y. Yang, S. E. Kooi, Y. Yang, C. Murdia, K. K. Berggren, I. Kaminer, and M. Soljačić, *Smith-Purcell radiation from low-energy electrons,* ACS Photonics **5**, 3513 (2018).

[193] G. Adamo, K. F. MacDonald, Y. H. Fu, C.-M. Wang, D. P. Tsai, F. J. García de Abajo, and N. I. Zheludev, *Light well: A tunable free-electron light source on a chip,* Physical Review Letters **103**, 113901 (2009).

[194] P. G. O'Shea and H. P. Freund, *Free-electron lasers: Status and applications,* Science **292**, 1853 (2001).

[195] G. Adamo, J. Y. Ou, J. So, S. D. Jenkins, F. De Angelis, K. F. MacDonald, E. Di Fabrizio, J. Ruostekoski, and N. I. Zheludev, *Electron-beam-driven collective-mode metamaterial light source,* Physical Review Letters **109**, 217401 (2012).

[196] J. Christopher, M. Taleb, A. Maity, M. Hentschel, H. Giessen, and N. Talebi, *Electron-driven photon sources for correlative electron-photon spectroscopy with electron microscopes,* Nanophotonics **9**, 4381 (2020).

[197] S. E. Korbly, A. S. Kesar, J. R. Sirigiri, and R. J. Temkin, *Observation of frequency-locked coherent terahertz Smith-Purcell radiation,* Physical Review Letters **94**, 054803 (2005).

[198] T. Shintake, H. Tanaka, T. Hara, T. Tanaka, K. Togawa, M. Yabashi, Y. Otake, Y. Asano, T. Bizen, T. Fukui, S. Goto, A. Higashiya, T. Hirono, N. Hosoda, T. Inagaki, S. Inoue, M. Ishii, Y. Kim, H. Kimura, M. Kitamura, T. Kobayashi, H. Maesaka, T. Masuda, S. Matsui, T. Matsushita, X. Maréchal, M. Nagasono, H. Ohashi, T. Ohata, T. Ohshima, K. Onoe, K. Shirasawa, T. Takagi, S. Takahashi, M. Takeuchi, K. Tamasaku, R. Tanaka, Y. Tanaka, T. Tanikawa, T. Togashi, S. Wu, A. Yamashita, K. Yanagida, C. Zhang, H. Kitamura, and T. Ishikawa, *A compact free-electron laser for generating coherent radiation in the extreme ultraviolet region,* Nature Photonics **2**, 555 (2008).

[199] M. Shentcis, A. K. Budniak, X. Shi, R. Dahan, Y. Kurman, M. Kalina, H. H. Sheinfux, M. Blei, M. K. Svendsen, Y. Amouyal, S. Tongay, K. S. Thygesen, F. H. L. Koppens, E. Lifshitz, F. J. García de Abajo, L. J. Wong, and I. Kaminer, *Tunable free-electron X-ray radiation from van der Waals materials,* Nature Photonics **14**, 686 (2020).

[200] N. van Nielen, M. Hentschel, N. Schilder, H. Giessen, A. Polman, and N. Talebi, *Electrons generate self-complementary broadband vortex light beams using chiral photon sieves,* Nano Letters **20**, 5975 (2020).

[201] N. Talebi, S. Meuret, S. Guo, M. Hentschel, A. Polman, H. Giessen, and P. A. van Aken, *Merging transformation optics with electron-driven photon sources,* Nature Communications **10**, 599 (2019).

[202] G. Li, B. P. Clarke, J.-K. So, K. F. MacDonald, and N. I. Zheludev, *Holographic free-electron light source,* Nature Communications **7**, 13705 (2016).

[203] S. Tsesses, G. Bartal, and I. Kaminer, *Light generation via quantum interaction of electrons with periodic nanostructures,* Physical Review A **95**, 013832 (2017).

[204] Z. Su, B. Xiong, Y. Xu, Z. Cai, J. Yin, R. Peng, and Y. Liu, *Manipulating Cherenkov radiation and Smith–Purcell radiation by artificial structures,* Advanced Optical Materials **7**, 1801666 (2019).

[205] R. Remez, N. Shapira, C. Roques-Carmes, R. Tirole, Y. Yang, Y. Lereah, M. Soljačić, I. Kaminer, and A. Arie, *Spectral and spatial shaping of Smith-Purcell radiation,* Physical Review A **96**, 061801(R) (2017).

[206] Z. Wang, K. Yao, M. Chen, H. Chen, and Y. Liu, *Manipulating Smith-Purcell emission with Babinet metasurfaces,* Physical Review Letters **117**, 157401 (2016).

[207] L. Jing, X. Lin, Z. Wang, I. Kaminer, H. Hu, E. Li, Y. Liu, M. Chen, B. Zhang, and H. Chen, *Polarization shaping of free-electron radiation by gradient bianisotropic metasurfaces,* Laser and Photonics Reviews **15**, 2000426 (2021).

[208] Z. Su, F. Cheng, L. Li, and Y. Liu, *Complete control of Smith-Purcell radiation by graphene metasurfaces,* ACS Photonics **6**, 1947 (2019).

[209] Y. C. Lai, T. C. Kuang, B. H. Cheng, Y. C. Lan, and D. P. Tsai, *Generation of convergent light beams by using surface plasmon locked Smith-Purcell radiation,* Scientific Reports **7**, 11096 (2017).

[210] B. P. Clarke, J. So, K. F. MacDonald, and N. I. Zheludev, *Smith-Purcell radiation from compound blazed gratings,* (2017), arXiv:1711.09018 [physics.optics] .

[211] T. Fu, D. Wang, Z. Yang, Z. lan Deng, and W. Liu, *Steering Smith-Purcell radiation angle in a fixed frequency by the Fano-resonant metasurface,* Optics Express **29**, 26983 (2021).

[212] L. Li, K. Yao, Z. Wang, and Y. Liu, *Harnessing evanescent waves by bianisotropic metasurfaces,* Laser and Photonics Reviews **14**, 1900244 (2020).

[213] X. Shi, M. Shentcis, F. J. García de Abajo, and I. Kaminer, *Free-electron interactions with designed van der Waals materials: Novel source of lensed X-ray radiation,* (Optica Publishing Group, 2021) p. JTu3A.5.

[214] I. Kaminer, S. E. Kooi, R. Shiloh, B. Zhen, Y. Shen, J. J. López, R. Remez, S. A. Skirlo, Y. Yang, J. D. Joannopoulos, A. Arie, and M. Soljacic, *Spectrally and spatially resolved Smith-Purcell radiation in plasmonic crystals with short-range disorder,* Physical Review X **7**, 011003 (2017).

[215] Y. Yang, C. Roques-Carmes, I. Kaminer, A. Zaidi, A. Massuda, Y. Yang, S. E. Kooi, K. K. Berggren, and M. Soljačić, *Manipulating Smith-Purcell radiation polarization with metasurfaces,* (Optica Publishing Group, 2018) p. FW4H.1.

[216] A. Epstein and G. V. Eleftheriades, *Arbitrary power-conserving field transformations with passive lossless Omega-type bianisotropic metasurfaces,* IEEE Transactions on Antennas and Propagation **64**, 3880 (2016).

[217] H. Überall, *High-energy interference effect of Bremsstrahlung and pair production in crystals,* Physical Review **103**, 1055 (1956).

[218] V. G. Baryshevsky, I. D. Feranchuk, and A. P. Ulyanenkov, *Parametric X-Ray Radiation in Crystals*, Vol. 213 (Springer Berlin Heidelberg, 2005).

[219] V. Baryshevsky and I. Feranchuk, *Parametric X-rays from ultrarelativistic electrons in a crystal: Theory and possibilities of practical utilization,* Journal de Physique **44**, 913 (1983).

[220] K. Mizuno, J. Pae, T. Nozokido, and K. Furuya, *Experimental evidence of the inverse Smith–Purcell effect,* Nature **328**, 45 (1987).

[221] R. Remez, A. Karnieli, S. Trajtenberg-Mills, N. Shapira, I. Kaminer, Y. Lereah, and A. Arie, *Observing the quantum wave nature of free electrons through spontaneous emission,* Physical Review Letters **123**, 060401 (2019).

[222] L. Reimer, *Scanning Electron Microscopy*, Vol. 45 (Springer Berlin Heidelberg, 1998).

[223] S. Zhang, D. A. Genov, Y. Wang, M. Liu, and X. Zhang, *Plasmon-induced transparency in metamaterials,* Physical Review Letters **101**, 047401 (2008).

[224] M. Kuttge, E. J. Vesseur, A. F. Koenderink, H. J. Lezec, H. A. Atwater, F. J. García de Abajo, and A. Polman, *Local density of states, spectrum, and far-field interference of surface plasmon polaritons probed by cathodoluminescence,* Physical Review B - Condensed Matter and Materials Physics **79**, 113405 (2009).

B

[225] T. Bucher, R. Ruimy, S. Tsesses, R. Dahan, G. Bartal, G. M. Vanacore, and I. Kaminer, *Free-electron Ramsey-type interferometry for enhanced amplitude and phase imaging of nearfields,* (2023), arXiv:2305.02727 [physics.optics] .

[226] A. Karnieli, D. Roitman, M. Liebtrau, S. Tsesses, N. V. Nielen, I. Kaminer, A. Arie, and A. Polman, *Cylindrical metalens for generation and focusing of free-electron radiation,* Nano Letters **22**, 5641 (2022).

[227] Y. Yang, C. Roques-Carmes, S. E. Kooi, H. Tang, J. Beroz, E. Mazur, I. Kaminer, J. D. Joannopoulos, and M. Soljačić, *Photonic flatband resonances for free-electron radiation,* Nature **613**, 42 (2023).

[228] N. Talebi, *Schrödinger electrons interacting with optical gratings: Quantum mechanical study of the inverse Smith-Purcell effect,* New Journal of Physics **18**, 123006 (2016).

[229] J. K. So, K. F. MacDonald, and N. I. Zheludev, *Fiber optic probe of free electron evanescent fields in the optical frequency range,* Applied Physics Letters **104**, 201101 (2014).

[230] J. K. So, F. J. García de Abajo, K. F. MacDonald, and N. I. Zheludev, *Amplification of the evanescent field of free electrons,* ACS Photonics **2**, 1236 (2015).

[231] W. Liu, Y. Liu, Q. Jia, and Y. Lu, *Enhanced Smith–Purcell radiation by coupling surface plasmons on meta-films array with resonator modes on a grating,* Journal of Physics D: Applied Physics **52**, 075104 (2019).

[232] N. Yamamoto, F. J. García de Abajo, and V. Myroshnychenko, *Interference of surface plasmons and Smith-Purcell emission probed by angle-resolved cathodoluminescence spectroscopy,* Physical Review B - Condensed Matter and Materials Physics **91**, 125144 (2015).

[233] J. S. Huang, V. Callegari, P. Geisler, C. Brüning, J. Kern, J. C. Prangsma, X. Wu, T. Feichtner, J. Ziegler, P. Weinmann, M. Kamp, A. Forchel, P. Biagioni, U. Sennhauser, and B. Hecht, *Atomically flat single-crystalline gold nanostructures for plasmonic nanocircuitry,* Nature Communications **1**, 150 (2010).

[234] L. Skuja, *Optically active oxygen-deficiency-related centers in amorphous silicon dioxide,* Journal of Non-Crystalline Solids **239**, 16 (1998).

[235] J. Fournier, J. Néauport, P. Grua, V. Jubera, E. Fargin, D. Talaga, and S. Jouannigot, *Luminescence study of defects in silica glasses under near-UV excitation,* Physics Procedia **8**, 39 (2010).

[236] L. Rayleigh, *On the dynamical theory of gratings,* Proceedings of the Royal Society of London. Series A, Containing Papers of a Mathematical and Physical Character **79**, 399 (1907).

[237] B. Luk'Yanchuk, N. I. Zheludev, S. A. Maier, N. J. Halas, P. Nordlander, H. Giessen, and C. T. Chong, *The Fano resonance in plasmonic nanostructures and metamaterials,* Nature Materials **9**, 707 (2010).

[238] A. E. Miroshnichenko, S. Flach, and Y. S. Kivshar, *Fano resonances in nanoscale structures,* Reviews of Modern Physics **82**, 2257 (2010).

[239] B. Gallinet and O. J. F. Martin, *Ab initio theory of Fano resonances in plasmonic nanostructures and metamaterials,* Physical Review B **83**, 235427 (2011).

[240] A. Feist, G. Huang, G. Arend, Y. Yang, J.-W. Henke, A. S. Raja, F. J. Kappert, R. N. Wang, H. Lourenço-Martins, Z. Qiu, J. Liu, O. Kfir, T. J. Kippenberg, and C. Ropers, *Cavity-mediated electron-photon pairs,* Science **377**, 777 (2022).

[241] A. Arbouet, G. M. Caruso, and F. Houdellier, *Ultrafast transmission electron microscopy: Historical development, instrumentation, and applications,* in *Advances in Imaging and Electron Physics*, Vol. 207, edited by P. W. Hawkes (Elsevier, 2018) pp. 1–72.

[242] T. Coenen, E. J. R. Vesseur, A. Polman, and A. F. Koenderink, *Directional emission from plasmonic Yagi-Uda antennas probed by angle-resolved cathodoluminescence spectroscopy,* Nano Letters **11**, 3779 (2011).

[243] J. A. Simpson, *Design of retarding field energy analyzers,* Review of Scientific Instruments **32**, 1283 (1961).

[244] M. van der Heijden, *Energy spread measurement of the Nano Aperture Ion Source*, Master's thesis, Delft University of Technology (2011).

[245] D. A. Dahl, *SIMION for the personal computer in reflection,* International Journal of Mass Spectrometry **200**, 3 (2000).

[246] M. S. Bronsgeest, *Physics of Schottky electron sources*, Ph.D. thesis, Delft University of Technology (2009).

[247] R. Haindl, A. Feist, T. Domröse, M. Möller, J. H. Gaida, S. V. Yalunin, and C. Ropers, *Coulomb-correlated electron number states in a transmission electron microscope beam,* Nature Physics **19**, 1410 (2023).

[248] Y. Cui, Y. Zou, A. Valfells, M. Reiser, M. Walter, I. Haber, R. A. Kishek, S. Bernal, and P. G. O'Shea, *Design and operation of a retarding field energy analyzer with variable focusing for space-charge-dominated electron beams,* Review of Scientific Instruments **75**, 2736 (2004).

[249] M. M. Solà Garcia, *Electron-matter interaction probed with time-resolved cathodoluminescence*, Ph.D. thesis, University of Amsterdam (2021).