List of Figures

1.1 Schematic of typical butterfly scale [12]. 9
1.2 Scale of *Morpho rhetenor* butterfly: TEM micrograph of a cross-section [17]. 10
1.3 Scale of *Papilio palinurus* butterfly: TEM micrograph of a cross-section and top-view SEM micrograph (inset) [5]. 11
1.4 *Morpho rhetenor* butterfly (photo by Luca Plattner). 14
1.5 Wing of *Morpho rhetenor* butterfly: closeup of scales tiling (photo by Luca Plattner). 15
1.6 Scale of *Morpho rhetenor* butterfly (photo by Luca Plattner). 16
1.7 Scale of *Morpho rhetenor* butterfly: closeup of ridged structure (photo by Luca Plattner). 17
1.8 *Aztec* gratings modelled by Cowan [24]. Symmetric structure on the left hand side, blazed structure on the right. 18
1.9 SEM cross-section of two-dimensional PC fabricated by Sato *et. al.* [72]. 31
1.10 Schematic views of three-dimensional PCs fabricated by Kuramochi *et. al.* [74] (left-hand side) and Kawakami *et. al.* [73] (right-hand side). 32
1.11 SEM view (left-hand side, A) and reconstruction (right-hand side, B) of a tree-dimensional PC fabricated by Campbell *et al.* [76]. 34
1.12 SEM cross-sectional view of silica photonic crystal fibre without external cladding (courtesy of W. Belardi, ORC, University of Southampton [87]). 38

2.1 Plots of the dielectric arrangement (left-hand side) and its reciprocal lattice (right-hand side). The *Brillouin* zone including $\vec{k} = (0, 0)$ is highlighted in yellow. 51
2.2 Schematic of the radial scan of the reduced *Brillouin* zone performed by the PWM band solver. 52

2.3 Band diagram of a rectangular two-dimensional periodic structure for a TM polarised field computed with the PWM. 53
2.4 Two-dimensional eigenvalue diagram of a rectangular two-dimensional periodic structure for TM polarisation computed with the PWM. 54
2.5 Plots of the gap between bands belonging to the first class of *Brillouin* zones for TE and TM polarisations with the visible range of wavelengths. 56
2.6 Plots of the dielectric arrangement (left-hand side) and its reciprocal lattice (right-hand side). The *Brillouin* zone including $\vec{k} = (0, 0)$ is highlighted in yellow. 58
2.7 Two-dimensional diagram of the lowest band of a centred rectangular two-dimensional periodic structure computed with the PWM. 59
2.8 Plots of the gap between bands belonging to the first class of *Brillouin* zones for TE and TM polarisations with the visible range of wavelengths. 60
2.9 Illustration of discretisation of fields on a two-dimensional grid for FDTD computations. 65
2.10 Computation field and components of a typical FDTD computation. 71

3.1 Two half 4*inch* silicon wafers coated with quarter-wavelength stacks to generate dielectric mirrors with high-reflectivity bands centered at 594*nm* (yellow half) and 475*nm* for normal incidence (blue half). 78
3.2 BS-SEM micrograph of dielectric mirror cross-section. 79
3.3 Spectral reflectance of a 594*nm*-mirror with TE polarised light impinging at 30° (left-hand side) and spectral transmittance of a 475*nm*-mirror at normal incidence (right-hand side). . . . 82
3.4 Schematic diagram of the fabrication of diffractive structures. 83
3.5 SEM top view of a grating pattern (left-hand side) and a triangular lattice pattern of circles(right-hand side). 84
3.6 SEM cross-sectional view of deep etched rods. 85
3.7 Schematic diagram of two-dimensional volume diffractive structure. 86
3.8 Schematic diagram of three-dimensional volume diffractive structure. 87

3.9 BS-SEM cross-sectional view of a three-dimensional structure. The image is centered around one edge of the diffractive structure and shows the multilayer (1) and air columns etched in the multilayer (2). 88

4.1 Photographs of a portion of the wing of *Morpho rhetenor* taken with different conditions of lighting and collection. . . . 90
4.2 Photographs of the experimental rig. Overview (a), detail of the sample holder and the sample positioning stages mounted on the platform ring (b), and detail of the PCF coupling arrangement (c). 95
4.3 Schematic diagram of the experimental setup. 96
4.4 Spectrum of SC obtain from a PCF and used for spectroscopy purposes. 98
4.5 Total reflection of *Morpho rhetenor* microstructure for angles of incidence of 10°, 30° and 60°, and both polarisations. 101
4.6 Filled contour plots of the scattering off the surface of the wings of *Morpho rhetenor*. 102
4.7 Filled contour plots of the scattering off the surface of a fabricated volume diffractive structure. 105
4.8 Spectra of reflective 0^{th} and 1^{st} diffraction orders for all investigated conditions of incidence. 106

5.1 Plot of the initial field of a typical computation defined over the entire grid with superimposed contour plot of the dielectric structure and a schematic view of the sampling windows. . . . 111
5.2 Example of a typical simulation. 114
5.3 Comparison of the FDTD/NFFFT algorithm with TMM. . . . 115
5.4 Comparison between transmissions and *Bragg* diffraction efficiencies obtained with expansion methods by Sakoda [57] (top plot) and with the numerical FDTD/NFFFT method (bottom plot). 116
5.5 Schematic views of the dielectric structures studied numerically: (a) a rectangular lattice of rectangular dielectric elements; (b) a tapered version of the above, resulting in a pine tree structure with its tips towards the incident front; (c) a centred rectangular lattice of rectangular dielectric elements; and (d) a tapered version of (c), resulting in an asymmetric pine tree structure. 119
5.6 Specular reflection of rectangular structures with different periods at normal incidence and TE polarisation. 120

5.7 Total reflection of rectangular structures at different angles of incidence and polarisation. 121
5.8 Filled contour plots of the computed back-scattering of a straight, rectangular *Morpho*-type structure. 122
5.9 Computed spectra of the diffraction orders of a straight, rectangular *Morpho*-type structure. 123
5.10 Filled contour plots of the computed back-scattering of a tapered, rectangular *Morpho*-type structure. 125
5.11 Computed spectra of the diffraction orders of a tapered, rectangular *Morpho*-type structure. 126
5.12 Total reflection of tapered rectangular structures at different angles of incidence and polarisation. 127
5.13 Total reflection of centred rectangular structures at different angles of incidence and polarisation. 128
5.14 Filled contour plots of the computed back-scattering of a straight, centred rectangular *Morpho*-type structure. 129
5.15 Computed spectra of the diffraction orders of a straight, centred rectangular *Morpho*-type structure. 130
5.16 Filled contour plots of the computed back-scattering of a tapered, asymmetric *Morpho*-type structure. 132
5.17 Computed spectra of the diffraction orders of a tapered, asymmetric *Morpho*-type structure. 133
5.18 Total reflection of tapered asymmetric structures at different angles of incidence and polarisation. 134
5.19 Filled contour plots of the computed back-scattering of a straight lamellar volume diffractive structure with layered diffractive elements. 136
5.20 Computed spectra of the diffraction orders of a straight lamellar volume diffractive structure with layered diffractive elements. 137
5.21 Filled contour plots of the computed back-scattering of a tapered lamellar volume diffractive structure with layered diffractive elements. 138
5.22 Computed spectra of the diffraction orders of a tapered lamellar volume diffractive structure with layered diffractive elements. 139
5.23 Total reflection of a straight lamellar grating at different angles of incidence and polarisation. 140
5.24 Total reflection of a tapered lamellar grating at different angles of incidence and polarisation. 140

6.1 TEM micrograph showing the cross-section of a scale of *Morpho rhetenor* [17] (left-hand side). Example of a model of the *Morpho* microstructure (right-hand side). 144
6.2 CIE standard observer color matching function for green (function $y_{10}(\lambda)$) and blue (function $z_{10}(\lambda)$) colours [104]. 146
6.3 Total reflection of *Morpho rhetenor* microstructure for angles of incidence of 10°, 30° and 60°, and both polarisations. 147
6.4 Filled contour plots of the scattering from the surface of the wings of *Morpho rhetenor*. 149
6.5 Comparison between the dependence of the long-wavelength edge of the high-reflection band on the angle of incidence for the *Morpho* microstructure and a multilayer model. 150
6.6 Band diagram (left-hand side) of the rectangular structure discussed in section 2.1.3 and lowest bandgap between neighbouring *Brillouin* zones for the same structure (right-hand side). . 152
6.7 First band for rectangular structures with different filling fractions along the direction of the long period f_x and constant filling fraction in the perpendicular direction ($f_z = 0.5$). The computation was performed for TM polarised waves with the method described in section 2.1.3. 154
6.8 Illustration of the two-layer model of the *Morpho* microstructure with superimposed expansion terms of a propagating mode and resulting diffraction orders. A distribution of lateral periods causes a spread in the directions of propagation of waves inside and outside the microstructure. 156
6.9 Illustration of the interaction of light with the *Morpho* microstructure. The wave vector of the incident wave $\vec{k}_i$ is separated in its components parallel and perpendicular to the ridges, $\vec{k}_{i\parallel}$ and $\vec{k}_{i\perp}$. The wave vector of the scattered wave $\vec{k}_s$ is equally separated in its components parallel and perpendicular to the ridges, $\vec{k}_{s\parallel}$ and $\vec{k}_{s\perp}$. 159
6.10 Diffraction efficiency of the 1$^{\text{st}}$ order for an angle of incidence of 30° and both polarisation (top graph) and relative polarisation extinction ratio in logarithmic scale (bottom graph). 162

A.1 Reconstruction of the dielectric function of the rectangular lattice. 175
A.2 Reconstruction of the dielectric function of the rectangular centred lattice. 176

C.1 Schematic illustration of phase delay in binary multilayer. . . 183

List of Tables

1.1 Materials composing most animal microstructures [8]. 8
1.2 Taxonomical designation of *Morpho rhetenor* butterflies [23]. . 13

2.1 Normalised coefficients of the eigenvectors of the pre-ordered third and fourth band for two values of the wave vector component k_z. 55

B.1 Plasma enhanced chemical vapour deposition (PECVD) of SiO_2 177
B.2 Plasma enhanced chemical vapour deposition (PECVD) of Si_3N_4 178
B.3 Electron beam evaporation of Cr 178
B.4 Ion beam milling 178
B.5 Reactive ion etching (RIE) 179

List of Symbols

Chapter 1

$FWHM$	full width at half maximum
N	complex index of refraction

Chapter 2

Section 2.1

$\cdot$	scalar product of the *Euclidean* space
$\times$	cross product
∇	nabla operator, $\nabla = (\partial/\partial x, \partial/\partial y, \partial/\partial z)^T$
∂	partial derivative symbol
∂S	edge of surface S
∂V	surface of volume V
α	a scalar
$\varepsilon(\vec{r})$	dielectric function
ε_0	dielectric constant of vacuum, $\varepsilon_0 = 8.85 \cdot 10^{-12} As/Vm$
μ_0	magnetic permeability of vacuum, $\mu_0 = 4\pi \cdot 10^{-7} Vs/Am$
ω	angular frequency
ϕ, $\phi(z)$	scalar function of the z coordinate defining the amplitude of the magnetic field
$\rho(\vec{r})$	density of charges
Θ, $\Theta(\bullet)$	operator on three-dimensional vector-field space
a	lattice constant
b	reciprocal lattice constant
c	speed of light in vacuum, $c = 3 \cdot 10^8 m/s$
$\vec{c}_{k_x,q}$	*Fourier* expansion coefficients of the *Bloch* state
da	integration over a surface
$d\vec{l}$	integration along a curve
dV	integration over a volume

$\vec{j}(\vec{r})$	electric charge current
k_x, k_y	wave vector components in x, y direction, respectively
$\hat{n}$	unit outward normal to the surface of integration
p	integer number
q	integer number
$\vec{r}$	position vector in the *Euclidean* space
$\vec{u}_{k_x}(x)$	periodic vector field function with one-dimensional domain, *Bloch* state
t	time
x, y, z	coordinates of the *Euclidean* space, $(x, y, z) = \vec{r}$
$\hat{x}$, $\hat{y}$, $\hat{z}$	normalised (unit) vectors defining an orthogonal system of coordinates in the *Euclidean* space
xz	plane defined by the $\hat{x}$ and $\hat{z}$ axes
A	a scalar constant
$\vec{B}(\vec{r})$	magnetic induction
$\vec{D}(\vec{r})$	dielectric displacement
$\vec{E}(\vec{r})$, $\vec{E}(\vec{r}, t)$, $\vec{E}(\vec{r}, \omega)$	electric field
$\vec{F}$, $\vec{F}(\vec{r})$	a vector field
$\vec{G}$	a vector field
$\vec{H}(\vec{r})$, $\vec{H}(\vec{r}, t)$, $\vec{H}(\vec{r}, \omega)$	magnetic field
$\vec{R}$	lattice vector in *Euclidean* space
S	surface
$T_{\vec{R}}$	discrete translation operator on vector-field space
V	volume

Section 2.1.1

∂	partial derivative symbol
$\varepsilon(\vec{r})$	dielectric function
k_0	wave number or magnitude of wave vector in vacuum
x, y, z	coordinates of the *Euclidean* space, $(x, y, z) = \vec{r}$
$\hat{x}$, $\hat{y}$, $\hat{z}$	normalised (unit) vectors defining an orthogonal system of coordinates in the *Euclidean* space
xz	plane defined by the $\hat{x}$ and $\hat{z}$ axes
$E(\vec{r})$	electric field magnitude
$H(\vec{r})$	magnetic field magnitude

Section 2.1.2

(ϕ, ψ)	one-dimensional scalar product $(\phi, \psi) = \int \phi \cdot \psi^* dx$
$\varepsilon(\vec{r})$	dielectric function
ε_p	*Fourier* coefficient of dielectric function
ϕ	scalar function
ψ	scalar function
b	reciprocal lattice constant
k_0	wave number or magnitude of wave vector in vacuum
p	integer number
q	integer number
x	coordinate of one-dimensional space
$E(\vec{r})$	electric field magnitude
E_p	*Fourier* coefficient of electric field

Section 2.1.3

$\angle(\bullet, \bullet)$	angle between two vectors
ω	angular frequency
a_x, a_z	lattice constants in x, z direction
c	speed of light in vacuum, $\mathrm{c} = 3 \cdot 10^8 m/s$
$\vec{k}$	wave vector
k_x, k_z	wave vector components in x, z direction
x, z	coordinates of the *Euclidean* space
$\hat{x}$, $\hat{y}$, $\hat{z}$	normalised (unit) vectors defining an orthogonal system of coordinates in the *Euclidean* space
xz	plane defined by the $\hat{x}$ and $\hat{z}$ axes

Section 2.1.4

a_x, a_z	lattice constants in x, z direction
c	speed of light in vacuum, $\mathrm{c} = 3 \cdot 10^8 m/s$
$\vec{k}$	wave vector
k_x, k_z	wave vector components in x, z direction
x, z	coordinates of the *Euclidean* space
$\hat{x}$, $\hat{y}$, $\hat{z}$	normalised (unit) vectors defining an orthogonal system of coordinates in the *Euclidean* space
xz	plane defined by the $\hat{x}$ and $\hat{z}$ axes

Section 2.2

$\cdot$	scalar product of the *Euclidean* space
∇	nabla operator, $\nabla = (\partial/\partial x, \partial/\partial y, \partial/\partial z)^T$
∂	partial derivative symbol
$\partial\Omega$	surface of volume Ω
ε_0	dielectric constant of vacuum, $\varepsilon_0 = 8.85 \cdot 10^{-12} As/Vm$
μ_0	magnetic permeability of vacuum, $\mu_0 = 4\pi \cdot 10^{-7} Vs/Am$
$\mu(S)$	area of the surface S
ω	angular frequency
θ_{inc}	angle of incidence
θ_p	angle of diffraction of p^{th} order
Ω	arbitrary volume
b	reciprocal lattice constant
da	integration over a surface
i	imaginary unit $i = \sqrt{-1}$
$\vec{k}_0$	wave vector of oscillating scalar field U parallel to $\vec{r}_0$
k_0	magnitude of $\vec{k}_0$
k_{0x}	x component of $\vec{k}_0$
$\hat{n}$	unit inward normal to the surface of integration
p	integer number
$\vec{r}$	position vector in the *Euclidean* space
$\vec{r}_0$	arbitrary point in space
r_0	magnitude of $\vec{r}_0$
$\hat{r}_0$	unit vector of $\vec{r}_0$
$\vec{r}_1$	mirror image of $\vec{r}_0$ with respect to a plane
x	coordinate of the *Euclidean* space
$\hat{x}$, $\hat{y}$, $\hat{z}$	normalised (unit) vectors defining an orthogonal system of coordinates in the *Euclidean* space
$\vec{E}(\vec{r})$, $\vec{E}(x)$	electric field
$\vec{E}_p$	*Fourier* coefficient of scaled electric field
$\vec{H}(\vec{r})$, $\vec{H}(x)$	magnetic field
$\vec{H}_p$	*Fourier* coefficient of scaled magnetic field
S	plane surface generating the far-field effect
U	scalar function of the *Euclidean* space
V	scalar function of the *Euclidean* space
Z_0	impedance of vacuum, $Z_0 = \sqrt{\mu_0/\varepsilon_0} = 376.73 V/A$

Section 2.3.1

$\cdot$	scalar product of the *Euclidean* space
$\times$	cross product
∇	nabla operator symbol, $\nabla = (\partial/\partial x, \partial/\partial y, \partial/\partial z)^T$
∂	partial derivative symbol
(x_i, z_j), (i, j)	point of the discrete space, grid point
(i, j, n)	point of the discrete space/time
ε, $\varepsilon(\vec{r})$, $\varepsilon(i, j)$	dielectric function
ϵ_0	dielectric constant of vacuum, $\epsilon_0 = 8.85 \cdot 10^{-12} As/Vm$
λ	vacuum wavelength of field oscillation
μ_0	magnetic permeability of vacuum, $\mu_0 = 4\pi \cdot 10^{-7} Vs/Am$
ω	angular frequency
σ_{kl}	electric conductivity tensor
$\sigma_\perp$	component of σ_{kl} perpendicular to PML
σ_0	conductivity at the surface of a PML with geometric profile
τ_{kl}	magnetic conductivity tensor
$\tau_\perp$	component of τ_{kl} perpendicular to PML
$\Delta\tau$	scalar parameter $\Delta\tau = \mathrm{c}\Delta t$
Δs	space grid step
Δt	time step
Δx	scalar indicating displacement
Δz	scalar indicating displacement
c	speed of light in vacuum, $\mathrm{c} = 3 \cdot 10^8 m/s$
d	scalar, penetration depth into the PML
g	scalar, factor describing the geometric profile of the PML
$\vec{j}_e$	electric current
$\vec{j}_m$	magnetic current, artificial physical quantity
$\vec{k}$	wave vector of a plane wave
$\hat{k}$	unit vector of $\vec{k}$
k_0	vacuum wave vector magnitude of $\vec{k}$
n	time-step index
$\vec{r}$	position vector in the *Euclidean* space

t	time
u, $u(i,j)$	scalar function representing a field component
$\hat{x}$, $\hat{y}$, $\hat{z}$	normalised (unit) vectors defining an orthogonal system of coordinates in the *Euclidean* space
xz	plane defined by the $\hat{x}$ and $\hat{z}$ axes
$\vec{E}$, $\vec{E}(\vec{r},t)$, $\vec{E}(i,j,n)$	electric field vector
E_x, E_y, E_z	components of the electric field vector
$\vec{H}$, $\vec{H}(\vec{r},t)$ $\vec{H}(i,j,n)$	magnetic field vector
H_x, H_y, H_z	components of the magnetic field vector
$P(i,j)$	polinomial
Z_0	impedance of vacuum, $Z_0 = \sqrt{\mu_0/\varepsilon_0} = 376.73V/A$

Section 2.3.2

$\times$	cross product
∂	partial derivative symbol
(i,j)	point of the discrete space, grid point
(i,j,n)	point of the discrete space/time
θ	angle of scattering
Δs	space grid step
Δt	time step
Γ	line
$d\gamma$	line integral
n	time-step index
n'	retarded time-step index
$\hat{n}$	unit inward normal to the surface of integration
p	a point in space $p = \left(i_0, j_{p+\frac{1}{2}}\right)$
$\vec{r}$	position vector in the *Euclidean* space
$\vec{r}_0$	arbitrary point in space
r_0	magnitude of $\vec{r}_0$
$\hat{r}_0$	unit vector of $\vec{r}_0$
t	time
t'	retarded time
C	scalar constant
$\vec{E}$, $\vec{E}(\vec{r})$,	electric field vector

$\vec{E}(\vec{r},t)$, $\vec{E}(n,\theta)$	
$\vec{E}(\omega,\theta)$	
$\vec{E}_1(\omega,\theta)$	contribution to electric field from first sampling window
$\vec{E}_2(\omega,\theta)$	contribution to electric field from second sampling window
E_x, E_z	components of the electric field vector
$\vec{H}$, $\vec{H}(\vec{r},t)$,	magnetic field vector
H_y	components of the magnetic field vector
Z_0	impedance of vacuum, $\mathrm{Z}_0 = \sqrt{\mu_0/\varepsilon_0} = 376.73V/A$

Appendix A

Section A.1

δ_{ij}	*Kronecker* symbol
$\varepsilon(\vec{r})$	dielectric function
$\mu(\Omega)$	volume of primitive cell
$\eta_{\vec{G}}$	*Fourier* coefficient of the inverse dielectric function
ω	angular frequency
Ω	primitive cell
$\vec{a}_1$, $\vec{a}_2$, $\vec{a}_3$	basis vectors of primitive lattice cell
$\vec{b}_1$, $\vec{b}_2$, $\vec{b}_3$	basis vectors of *Brillouin* zone
c	speed of light in vacuum, $\mathrm{c} = 3 \cdot 10^8 m/s$
i	imaginary unit $i = \sqrt{-1}$
j	integer index
$\vec{k}$	wave vector in the periodic structure
l_1, l_2, l_3	integers
$\vec{r}$	position vector in the *Euclidean* space
$\vec{u}_{\vec{k}}(\vec{r},\omega)$	periodic vector field function with three-dimensional domain, *Bloch* state
$\vec{u}_{\vec{k},\vec{G}'}$	*Fourier* coefficient of a *Bloch* state
$\vec{G}$, $\vec{G}'$, $\vec{G}''$	reciprocal lattice vectors
$\vec{H}_{\vec{k}}(\vec{r},\omega)$	magnetic field vector plane wave with wave vector $\vec{k}$
$\vec{R}$	lattice vector in *Euclidean* space

Section A.2

$\varepsilon(z)$	dielectric function
ε_1, ε_2	dielectric constants

η_G, η_l	*Fourier* coefficient of the inverse dielectric function
ω	angular frequency
a	period of a one-dimensional lattice
c	speed of light in vacuum, $\mathrm{c} = 3 \cdot 10^8 m/s$
f	filling fraction
$g(z)$	scalar top-hat function
i	imaginary unit $i = \sqrt{-1}$
$\vec{k}$	wave vector in the periodic structure
k_x, k_z	components of wave vector $\vec{k}$
l, l', l''	integers
$\vec{u}_{\vec{k},l}$	*Fourier* coefficient of a *Bloch* state
$u_{\vec{k},l,x}$, $u_{\vec{k},l,y}$, $u_{\vec{k},l,z}$	components of $\vec{u}_{\vec{k},l}$
$\hat{x}$, $\hat{y}$, $\hat{z}$	normalised (unit) vectors defining an orthogonal system of coordinates in the *Euclidean* space
xz	plane defined by the $\hat{x}$ and $\hat{z}$ axes
z	coordinate of the *Euclidean* space
z_0	arbitrary point on $\hat{z}$ axis
G	multiple of $\frac{2\pi}{a}$
$\vec{G}'$, $\vec{G}''$	reciprocal lattice vectors
M	square matrix of the eigenvalue problem
$M_{l,l'}$	2×2 block matrix components of M in the TE case
N	integer, limit for the number of terms in the expansions
R	multiple of a

Section A.3

η_{l_x,l_z}	*Fourier* coefficient of the inverse dielectric function
ω	angular frequency
a_x, a_z	lattice constants
c	speed of light in vacuum, $\mathrm{c} = 3 \cdot 10^8 m/s$
$\vec{k}$	wave vector in the periodic structure
k_x, k_z	components of wave vector $\vec{k}$
l_x, l'_x, l_z, l'_z	integers
$\vec{u}_{\vec{k},l_x,l_z}$	*Fourier* coefficient of a *Bloch* state
$u_{\vec{k},l_x,l_z,x}$, $u_{\vec{k},l_x,l_z,y}$,	components of $\vec{u}_{\vec{k},l_x,l_z}$

$u_{\vec{k},l_x,l_z,z}$	
$\hat{x}$, $\hat{y}$, $\hat{z}$	normalised (unit) vectors defining an orthogonal system of coordinates in the *Euclidean* space
$\vec{G}_x$, $\vec{G}'_x$, $\vec{G}_z$, $\vec{G}'_z$	reciprocal lattice vectors
M	square matrix of the eigenvalue problem
M_{l_x,l'_x}	2×2 block matrix components of M in the TE case
N	integer, limit for the number of terms in the expansions

Section A.3.1

$\varepsilon(x,z)$	dielectric function
ε_1, ε_2	dielectric constants
η_{l_x,l_z}	*Fourier* coefficient of the inverse dielectric function
a_x, a_z	lattice constants
f_x, f_z	linear filling fractions
$g_x(x)$, $g_z(z)$	scalar top-hat functions
l_x, l_z	integers
x, z	coordinates of the *Euclidean* space

Section A.3.2

$\delta_{lx,lz}$	*Kronecker*'s symbol
ε_2	dielectric constant
η_{l_x,l_z}, η'_{l_x,l_z}	*Fourier* coefficient of the inverse dielectric function
l_x, l_z	integers

Appendix C

$\bullet^*$	complex conjugate
$\delta_{b\gamma}$	*Kronecker* symbol
δ_j	phase delay for single travel in the j^{th} layer of the stack
γ	symbolic index, $\gamma = f, b$
κ_j	imaginary factor to n_j in N_j
ν_0	angle of incidence
ν_1, ν_2	*Euler* angles of propagation
ν_j	*Euler* angle of propagation in j^{th} material in the stack
ω	angular frequency
$\zeta_{j\,TE}$, $\zeta_{j\,TM}$	scalar terms for the construction of the j^{th} transfer matrix

$\Delta\phi$	phase delay between waves reflected at interfaces shifted by one period in a periodic stack
c	speed of light in vacuum, c $= 3 \cdot 10^8 m/s$
$\hat{e}_0$	electric field orientation (unit vector) of incident plane wave
j	integer index
k_0	wave vector magnitude of incident plane wave
$\hat{k}_0$	propagation direction (unit wave vector) of incident plane wave
$\vec{k}_0$	wave vector of incident plane wave
k_1, k_2	wave vector magnitudes
k_j	magnitude of wave vector in j^{th} material of the stack
$\hat{k}_{j\gamma}$	direction of propagation of plane wave $\vec{E}_{j\gamma}(\vec{r}, t)$
$\vec{k}_{j\gamma}$	wave vector of plane wave $\vec{E}_{j\gamma}(\vec{r}, t)$
n_0	real index of refraction of the incident medium
n_1, n_2	real indexes of refraction
n_j	real index of refraction of j^{th} material in the stack
p	symbolic index, $p = TM$, TE
$\vec{r}$	position vector in the *Euclidean* space
t_1, t_2	layer thicknesses
$\hat{x}$, $\hat{y}$, $\hat{z}$	normalised (unit) vectors defining an orthogonal system of coordinates in the *Euclidean* space
x, y, z	coordinates of the *Euclidean* space, $(x, y, z) = \vec{r}$
xz	plane defined by the $\hat{x}$ and $\hat{z}$ axes of coordinates
AB, AF, BC	geometrical segments
E_0	electric field amplitude of incident plane wave
E_{0bp}	oscillation amplitude of the backward travelling plane wave component of the electric field in the incident medium for p polarisation
E_{0fp}	oscillation amplitude of the forward travelling plane wave component of the electric field in the incident medium for p polarisation
E_{Nbp}	oscillation amplitude of the backward travelling plane wave component of the electric field in the transmission medium for p polarisation
E_{Nfp}	oscillation amplitude of the forward travelling plane wave component of the electric field in the transmission medium for p polarisation

$\vec{E}_{j\gamma}$, $\vec{E}_{j\gamma}(\vec{r},t)$	either forward or backward travelling electric field vector in the j^{th} material in the stack
$E_{j\gamma x}$, $E_{j\gamma y}$, $E_{j\gamma z}$	components of $\vec{E}_{j\gamma}$
$\vec{H}_{j\gamma}$	either forward or backward travelling magnetic field vector in j^{th} material of the stack
M_{jp}	characteristic matrix of the j^{th} layer in the stack for p polarisation
N_j	complex index of refraction of j^{th} material in the stack
P_j	propagation matrix of the j^{th} layer in the stack
R_p	reflected fraction of the power (reflectance) incident on a multilayer stack
T_p	transmitted fraction of the power (transmittance) incident on a multilayer stack
Z_0	impedance of vacuum, $\mathrm{Z}_0 = \sqrt{\mu_0/\varepsilon_0} = 376.73V/A$

List of Acronyms

AR, ARC	antireflective coating
BBO	beta barium borate
BS-SEM	backscattered electrons scanning electron microscopy
ECR	electron cyclotron resonance
FD	finite difference
FDTD	finite-difference time-domain
FEM	finite element method
FWHM	full width at half maximum
GT	*Glan-Taylor* polariser
IPA	isopropyl alcohol
IR	infrared
KKR	*Korringa-Kohn-Rostocker*
KTP	potassium titanil phosphate
MST	multiple-scattering theory
NFFFT	near-field to far-field transformation
PC, PCs	photonic crystal, photonic crystals
PCF, PCFs	photonic crystal fibre, photonic crystal fibres
PECVD	plasma-enhanced chemical vapour deposition
PML	perfectly matched layer
PMMA	Polymethyl methacrylate
PWM	plane wave method
RCWT	rigorous coupled wave technique
RF	radio frequency
RIE	reactive ion etching
RMM	rigorous modal method
SC	supecontinuum
SEM	scanning electron microscopy

ST	scalar thory
TE	transverse electric
TEM	transmission electron microscopy
TM	transverse magnetic
TMM	transfer matrix method
TTV	total thickness variation