Tyler James 10038408 – Thesis corrections

Page numbers refer to the numbers as seen at the foot of the page in the document not the page numbers of the pdf file.

Pre-viva thesis corrections

Old page number	New page number	Change(s)
Various	Various	• Minor formatting corrections, i.e. properly formatting quotation marks and arranging instance of multiple citations in numerical order.
1	1	• Separated the first paragraph into two shorter paragraphs. • Added a sentence to the end of the now first paragraph to note that the terms '2D material' and 'layered material' will be used interchangeably. • Changed the wording of the last sentence of the former second, now third paragraph.
4	4	• Final sentence of top paragraph: replaced 'discussing' with 'fabricating'. • Chapter 5 paragraph: changed 'electrical' to 'electronic', and added definition of acronym 'AFM', moving this definition from Chapter 6 paragraph.
8	8	• First full paragraph. Reworded a sentence to replace the phrase 'graphene's properties' to 'properties of graphene'.
9	9	• First full paragraph: changed 'one of the strongest material' to 'one of the strongest materials'.
10	10	• Math-mode formatted the wavevector symbol.
11	11	• Added 'voltage' to the end of the phrase 'applied gate'.
43	44	• First paragraph: changed final word of the paragraph from 'crystals' to 'layers', since this is the more widely accepted terminology.
97	100	• First full paragraph: added a note that the AC bias applied to the metallised AFM tip has a frequency closely matching the resonant frequency of the cantilever.
132	137	• Final sentence of page, added an example of a possible difference between devices as a result of differences in fabrication.
153	158	• First paragraph: removed erroneous reference to FLG in discussion of IETS data.
193	200	• Final paragraph of page: added missing units to '6.25 μm^2' and moved citation to correct place.
200 – end of chapter	208 – end of chapter	• A LateX compiling error moved all of the figures to be after the text and I missed it upon submission, the figures are now in their correct positions in the text.
299	298	• Added details of the group which provided CVD graphene samples, replacing placeholder note present in examination version.

External assessor comments/corrections

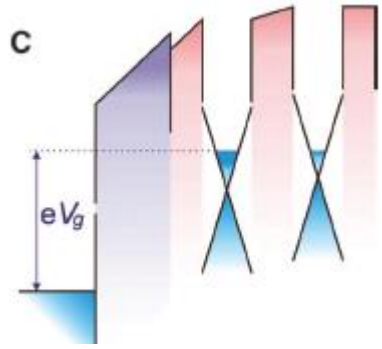
Old page number	New page number	Comment	Correction
vi	vi	Mis-spelling of 'field'	Corrected spelling
2	2	Grammatically-incorrect 'is'	Changed to 'are'
10	10	Should state the number of states at the Fermi energy. It is not zero (or there would be a gap)	Added a value of 2.3x10^-4 effective free electrons per atom, obtained from *The Band Theory of Graphite, P. R. Wallace, 1947*
10	10	Add reference for Fermi velocity of graphene	Added reference: Elias, D. C., Gorbachev, R. v., Mayorov, A. S., Morozov, S. v., Zhukov, A. A., Blake, P., Ponomarenko, L. A., Grigorieva, I. v., Novoselov, K. S., Guinea, F., & Geim, A. K. (2011). Dirac cones reshaped by interaction effects in suspended graphene. *Nature Physics 2011 7:9*, *7*(9), 701–704. https://doi.org/10.1038/nphys2049
10	11	State graphene number of states at E_F	Modified this paragraph to read better and also to refer to the quantum conductance of graphene.
11	11	Fig. 2.5 caption. Reference in wrong place making interpretation of caption confusing.	Moved reference to end of caption.
11	11	Blue shading of fig 2.5b makes interpretation difficult.	Changed shading to reflect the filled vs. empty states to be consistent with the middle panel of Fig. 2.6b
11	11	Incorrect statement about DoS changing.	Removed reference to DoS.
15	16	Grammatically-incorrect 'makes'	Changed to 'make'
18	19	Fig. 2.11 caption. Mis-spelled 'naturally'	Corrected spelling
21	21,22	Need to differentiate vectors from scalars	Use bold font for vectors (to be consistent with wavevectors in another section)
21	22	Graphite rather than graphene x2	Changed both instances to say graphene
23	24	No capitalisation on 'Ohmic'	Capitalised word
46	47	Missing space between number and unit	Added space
47	49	No space between colon and following	Added space

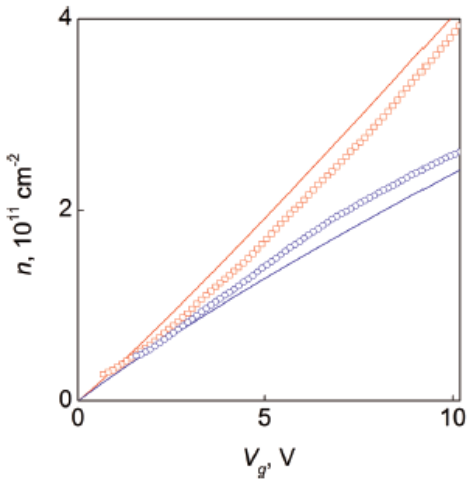
		word in figure caption	
47	48	Misspelled ‘dimensions’	Corrected spelling
50	51	Space between bracket and letter	Removed space
57	58	No space between number and unit x3	Added spaces
61	63	Grammatically incorrect ‘that’	Changed to ‘of’
77	79	Space between number and unit x2	Added space
77	78	Misspelled ‘density’	Corrected spelling
79	81	Contact-AFM typically performed at scan angle of 90 degrees rather than 0 degrees	Changed wording to reflect that contact-mode AFM is performed at a scan angle of 90 degrees
80	81, 82	Fig. 3.4 - Clarify what the terms in the equations in the figure mean in relative to what is shown in the figure, and incorrect geometry of the laser beam in d)	Corrected figure geometry, added the relevant equations to the text and explained where the terms come from.
80	82	Description of the physical meaning of topographic contact-mode AFM images is not correct	Corrected description based on suggestion in comment
81	83	Figure 3.5 inaccurately represents how the tip should be oriented relative to surface	Corrected the angle of the cantilever to reflect the orientation relative to the surface and more accurately showed that in contact-mode imaging the cantilever deflection is kept constant
82	84	Tip in figure 3.6b should not rotate in the way shown, and it is not clear how the scan direction relates to the tip orientation	Corrected tip rotation and labelled scan direction
83	85	Missing comma after ‘however’	Added comma
84	86, 87	Argument regarding surface-sensitivity of conductive AFM is unclear	Made argument clearer and related it to the samples epitaxially-grown hBN on HOPG samples discussed later in Chapter 6

85	87	Missing space between number and unit	Added space
86	88	Described photodetector element as 'window'	Changed to 'element'
86	88	Incorrectly stated that tip-sample forces change the oscillation frequency of the cantilever	Deleted this statement
87	89	Incorrectly hyphenated 'coefficient'	Removed hyphen
88 + 89	90 - 93	Approach to explaining the physics of AFM omits the influence of damping on the oscillation	I've added several paragraphs and equations (3.12 – 3.14) explaining the impact of damping on the oscillation amplitude and resonant frequency of the cantilever.
88	92	'Changes the spring constant of the cantilever' is not the correct explanation	The approach of interpreting the tip-surface force gradient as introducing an additional effective spring constant is the way AFM theory has been taught at Nottingham for many years and has been used by several of Prof. Beton's previous PhD students in the AFM section of their theses with no issues. However, I have added equations 3.20 - 3.21 and supporting text related to resonant frequency shifts introduced by the tip-surface interaction.
88	91	Need to provide a scale for defining 'small oscillations'	Added that these oscillations are small relative to the tip-sample separation
90	94	Fig. 3.11 - Font size of plots too small	Increased font size
91	94	Statement about 'mechanical robustness of cantilevers' is unnecessary	Removed sentence.
92	96	Fig 3.12 – Font size too small and gradients at LHS are incorrect	Re-made this figure using plotted data rather than screenshots, fixed the lines on the LHS, and increased font sizes
92	95	Incorrect statement about 'envelope function' in relation to higher oscillation eigenmodes	Deleted reference to 'envelope function'.
93	96	Need to provide explanation as to	Clarified that the reason for this is that higher eigenmodes have higher kinetic energy at the tip-

		why smaller cantilever oscillations can be used in higher eigenmode imaging	end of the cantilever, thus smaller oscillation amplitudes can be used without the tip getting captured by the sample surface.
94	98	Reference to Q-factor of resonance being material-dependent is incorrect	Removed reference to material-dependence
95	98	No reference to dissipative forces in discussion of phase imaging	Added clarification that the derivation shown considers only elastic forces
95	98	No space between number and unit	Added space
96	99	No reference to the effect of dissipative forces	Added an explanation and additional reference to explain how phase AFM can also be used to map dissipative forces between the tip and sample.
96	100	Stray 'and'	Removed word
100	103	No space between number and unit	Added space
102	106	Missing comma	Added comma
104	108	No space between number and unit x2	Added spaces
108	112	No space between number and unit	Added space
110	114	No space between number and unit	Added space
118	122	Need to add disclaimer that dI/dV data were calculated via numerical differentiation and give details on the method employed	Added details on the approach used
122	126	Add labels to the sub-panels for the figure to match caption	Added sub-panel labels
125	129	Misspelled 'using'	Corrected spelling
127	131	No space between number and unit	Added space
136	141	Reference for anti-Kasha information	Added reference to https://pubs.acs.org/doi/10.1021/cr200166m
137	143	No space between number and unit	Added space
138	144	Fig. 4.9 – Wording of caption	Re-ordered the wording of the caption to read more smoothly
142	147	Fig. 4.11 – Wording of caption	Now Fig. 4.12 - Fixed the wording of the caption to be less repetitive

143	149	No space between number and unit	Added space
144	10, 149 - end	Need to discuss band dispersion of FLG (parabolic) rather than SLG (linear)	I've replaced all of the electrode band structures in the device band structure figures with parabolic FLG bands. I've added a sub-figure to Fig. 2.5 showing the parabolic band structure of FLG to introduce the concept alongside a sentence in the corresponding paragraph explaining that interlayer effects between stacked graphene sheets result in a change in band structure. I've also moved the original version of this discussion into an appendix section since it has been published and the model is valid, provided the contacts are SLG.
144	149, 150	Need to address change in E_F of FLG electrodes	I have re-derived this equation using the FLG band dispersion rather than SLG.
145	150	No space between number and unit	Added space
149	153	Stray capitalisation	Changed to lower case
150	156	Statement about asymmetric bias voltage drops across hBN barriers does not make sense	Removed this statement
151	157	Fig. 4.15 – Font sizes too small	Now Fig. 4.16 - Increased font size
151	157	Fig. 4.15 – 'warming the re-cooling'	Now Fig. 4.16 - Corrected to 'then'
152	158	Stray letter next to figure	Removed letter
152	158	Fig. 4.16 – provide information about active area of devices	Now Fig. 4.17 - Added a table with these details
153	158	Referred to 'Raman peaks'	Changed to 'phonons'
154	160	Fig. 4.17 – Inset font too small	Now Fig. 4.18 - Increased inset font size
158	164	Provide details such as active area and hBN thickness for 'double-molecule' devices	Added this in the form of a table
158	164	Missing 'of'	Added word
160	166 – 169	Discussion in relation to 'interlayer excitons' requires further consideration	Modified this section to make it clear that the attribution to an interlayer exciton is not likely and that additional study would be required to begin to accurately determine the nature of this phenomenon.
161	167	Fig. 4.23 – Font sizes too small	Now Fig. 4.25 - Increased font sizes and rearranged figure layout to enhance readability

161	168	Wording of statement comparing positive and negative bias measurements is not clear.	Modified wording and grammar to try to make this clearer
161	168	Stray 'from'	Removed word
162	168 – 169	Missing commas x2	Added commas
162	168	Need to reconsider validity of statement related to charge transfer	Removed this statement in light of above change
162	168	Re-evaluate idea of gating devices since the FLG electrodes would screen the effect of a gate voltage on the molecules	This comment is an interesting topic to consider. Fig. 1c from DOI: 10.1126/science.1218461 shows a gate voltage having an effect on both the top and bottom SLG electrodes, which suggests that gating could have some effect on the tunnel barrier.  However, the electrodes used in the work presented are FLG which has been predicted to have a strong dependence of electrostatic screening on the number of layers (https://doi.org/10.1038/srep42821), and the degree of screening has also been shown to vary non-linearly with charge carrier concentration:

			 FIG. 2. Nonlinear dependence of charge carrier concentrations in the two graphene electrodes as a function of gate voltage. The symbols are experimental data (red symbols for the bottom graphene layer; blue for the top). The solid curves in the corresponding colours are our modelling. No fitting parameters are used. (https://doi.org/10.1063/1.4795542). As a result, the topic of screening in FLG is a complicated one and the effect of gating may well vary from device to device depending upon their specific construction.
163	169	Add reference to Fig. 4.24 in text	Now Fig. 4.26 - Added reference in text
164	170	Add reference to Fig. 4.25 in text	Now Fig. 4.27 - Added reference in text
164	170	Clarify that '1.5nm' refers to H_2Pc	Added clarifying statement
165	172	Mixing tenses	Changed 'are' to 'were'
169	175	Missing space between number and unit	Added space
171	177	Fig. 5.2 – Incorrect wording in caption	Corrected wording
172 & 173	178 & 179	Fig 5.3 & 5.4 – Text on EDX plots too small, also was recommended to either remove these or re-plot rather than use screenshots	I have removed the EDX plots as per the suggestion and left the EDX data tables in the Appendix. I have correspondingly re-written the figure captions and the surrounding text to account for this.
173	179	Fig. 5.4 – Incorrect statement about TEM support grid, image shows lacey carbon support with Cu grid out of image frame but it is included within the larger-area detection	Amended these statements to reflect these comments.

		of the EDX so appears in the spectra	
174	179	Missing space between number and unit	Added space
175	180	Fig. 5.5 - Statement about 100x magnification incorrect.	Removed statement.
175	180	Fig. 5.5 - Scale bar font too small.	Removed text since the scale bar size is already listed in the caption.
180	186	Fig. 5.9 – Remove references to magnification.	Removed.
180	186	Fig. 5.10 – Clarify which model of Keithley was used.	Added Keithley model number
181	187	Fig. 5.11 – Add a legend to clarify what is being shown and state measurement temperature.	Added legend and stated measurement T of 300 K.
181	187	No capitalisation on 'Ohmic'	Capitalised
181	187	Mismatch between text description and what is shown in Fig. 5.12.	I made a mistake and included an older version of a figure, I've rectified this and included the version which matches the values quoted in the text
182	188	Problem with how I've defined terms after an equation.	Re-worded the highlighted sentence to make the definitions less repetitive
182	188	Eq. 5.2 – Mis-formatting of an equation term	Corrected formatting
183	189	Fig. 5.13 – Formatting issue led to lines around figure	These lines are the result of settings within the user's pdf reader software and not the thesis itself, they are also absent on the printed copy
183	189	Missing space between number and unit	Added space
183	189	Compare measured nanotube resistance with literature values	Added a comparison to literature values
184	190	Missing space between number and unit	Added space
185	191	Fig. 5.15 – Font size too small	Increased font size

186	192	Fig. 5.16 – Magnification statements	Removed
186	192	Explain more clearly how the measurement geometry works	Added an explanation similar to the one already present in Section 5.6.1
186	192	No capitalisation on 'Ohmic'	Capitalised
186	193	Discussion neglects contact resistance	Added in reference to contact resistance to the relevant equation and surrounding discussion, changed conclusion of this section to
187	193	Fig. 5.17 – Font size too small	After consideration in the context of the above correction, I decided to remove the insets. They do not add any additional meaningful information to the plot.
187	193	Fig. 5.17 – State measurement temperature	Added note that measurement was performed at room temperature
187	193	Fig. 5.17 – Problem with initial wording of caption	Changed wording
187	193	Fig. 5.17 – No capitalisation of 'Ohmic'	Capitalised
187	194	Mis-formatting of equation terms	Fixed
189	195	Fig. 5.19 – Remove magnification statement	Removed
189	195	Fig. 5.19 – Add scale bars to images	Added scale bars and added scale bar size to the figure caption
190	196	Missing space between number and unit	Added space
190	196	Fig. 5.21 – Remove magnification statements and add space between number and unit.	Fixed
191	197	Add statement as to the status of unused contact pads during measurement	Added a statement to confirm that the unused contact pads were isolated from the measured pads
192	199	Fig. 5.22 – No capitalisation of 'Ohmic' x2	Fixed
193	200	Missing space between number and unit x2	Fixed

195	201	Missing space between number and unit x2	Fixed
196	202	Missing space between number and unit x2	Fixed
197	203	Formatting issue leaves line around figure	These lines are the result of settings within the user's pdf reader software and not the thesis itself, they are also absent on the printed copy
198	204	Formatting issue leaves line around figure	These lines are the result of settings within the user's pdf reader software and not the thesis itself, they are also absent on the printed copy
199	206	Quoted energy as mV	Changed to meV
200	207	Formatting issue leaves line around figure	These lines are the result of settings within the user's pdf reader software and not the thesis itself, they are also absent on the printed copy
200	206	Need to explain why d^2I/dV^2 are used in IETS rather than dI/dV	I've modified this section of discussion to better explain how the dI/dV data should be interpreted. I had made a mistake and had discussed the peak position rather than the feature onset energy in dI/dV, which is also discussed in 2.9.3
201 – end of chapter	208 – end of chapter	Position of Fig. 5.28 onwards were shifted to the end of the chapter due to a formatting error.	This was corrected before my viva
202	210	Used SLG band dispersion rather than FLG	Corrected this
203	211	Missing space between number and unit	Added space
203	212	Need to re-consider discussion since it relates to graphene rather than FLG/graphite x2	The highly-speculative discussion related to the 1/V^4 scaling of Fowler-Nordheim tunnelling has been removed, since the premise for this discussion rested on treating the MWCNTs as having a graphene band structure which has been shown to be inaccurate
203	212	Need to justify statement regarding the proposed scaling of Fowler-Nordheim tunnelling between two graphene electrodes	See above ^
206	215	Missing space between number and unit	Added space
208	217	No capitalisation of 'Ohmic'	Capitalised

208	217	Stray ‘be’	Removed
210	210	Fig. 5.29 – Should use FLG band dispersion, not SLG	Now Fig. 5.28 - Fixed this
210	211	Fig. 5.30 – Add units to gradients	Now Fig. 5.29 - Added units
211	~212	Fig. 5.31 – Add units to gradients	This figure was removed
214	218	‘It’ rather than ‘is’	Replaced
216	220	‘Form’ rather than ‘from’	Replaced
219	223	Full stop rather than comma	Replaced
220	224	Fig. 6.2 – Inset font too small	Increased inset font size
221	225	Fig. 6.3 – Scale bar font too small	Increased size of scalebar and font
222	226	‘Are’ not ‘is’	Replaced
223	227	Missing space between number and unit	Added space
224	228	Fig. 6.7 – Inconsistent brackets in caption	Fixed
225	225	Fig. 6.8 – ‘deashed’ rather than ‘dashed’	Fixed spelling
228	233	Fig. 6.10 – Missing space between number and unit	Added space
229	234	Fig. 6.11 – Lines around plot and height profile axis font too small	These lines are the result of settings within the user’s pdf reader software and not the thesis itself, they are also absent on the printed copy
230	235	Missing space between number and unit x2	Added spaces
231	236	‘Suggesting’ rather than ’suggests’	Fixed
232	232	Missing space between number and unit x2	Added spaces
233	238	Fig. 6.16 – Lines around plot	These lines are the result of settings within the user’s pdf reader software and not the thesis itself, they are also absent on the printed copy
238	243	Sentence trails off and is largely repeated at the start of the next paragraph	Removed the trailing sentence
240	245	Fig. 6.20 – Inset text illegible	Increased inset font size

243	248	Fig. 6.23 – Inconsistent brackets	Fixed
246	252	Fig. 6.25 – Text too small in graphs	Increased size and font size of sub-graphs
247	253	‘is’ rather than ‘of’	Fixed
248	253	Fig. 6.26 – Figure text too small	Increased font size
249	254	Justification for including factor of 0.66 in Eq. 6.2 not clear	Added a passage justifying where this factor comes from.
250	255	Fig. 6.27 – Lines around figure	These lines are the result of settings within the user’s pdf reader software and not the thesis itself, they are also absent on the printed copy
251	257	Discussion around assuming equal quantities of monolayer and multilayer HOPG steps not clear	Resolved by an above change.
256	262	Address quenching by underlying HOPG on single-photon emission	Added note that thicker C-doped hBN layers may be required to decouple the uppermost grown layers from the substrate.
291	298	Left in a note to add details	Added details before my viva

Internal assessor comments/corrections

Old page number	New page number	Comment	Correction
i	i	• Add 'transparent' to 'thin insulating layers' • Make the distinction between carbon nanotubes and MBE clearer • Remove 'first chapter' when introducing the content of the research chapters	• Added 'transparent' • Reworded to make it clear that the two topics are distinct • Removed 'first chapter'
viii	viii	Add acronym for single-layer graphene	Added acronym
1	1	Add mention that hBN is commonly used to encapsulate graphene to first paragraph.	Added statement and accompanying reference
2	2	• Add 'yet' to 'has had limited success' • Add mention of EBL when discussing arrays of heterostructure devices	Added both
3	3	Unclear whether the 'high-quality hBN layers' referred to in the context of MBE chapter are the same ones used for devices	Added clarification that these layers are epitaxial and grown on HOPG
5	5	Definition of 2D material is vague	Added a statement about the atomic-scale thickness of 2D materials to make definition more explicit
6	6	• Add acronym for HOPG • Specify that HOPG is made up of stacked layers of graphene	Added both
7	7	Add note that HOPG is also easy to exfoliate	Added to the start of the sentence discussing cleaning HOPG via exfoliation
8	8	Add reference to the isolation of graphene in relation to the Nobel Prize discussion	Added and capitalised Hall in 'quantum Hall effect'
9	9	Specify that the ease of observation of graphene with an optical microscope is substrate-dependent	Added clarification and an example of SiO_2 on Si.
10	11	Change discussion of graphene Density of States at the Fermi energy to be in terms of quantum conductance (this is related to comments from Internal Assessor)	Modified paragraph to address quantum conductance.
11	11	• Change 'species of charge carrier' to 'type of charge carrier'	• Changed word • Added clarification

		• Change ‘transistor’ to FET and specify that current can be switched off with gate voltage	
15	15	Fig. 2.9 caption - Add reference to which colour corresponds to which atom species	Added
16	16	• Add figure reference to graphene bonding figure • Compare hBN breakdown voltage and dielectric constants to those of SiO_2	• Added figure reference • Added comparison and associated references
17	17	Make mention of the benefit that hBN does not dope graphene, unlike almost all other dielectrics	Added sentence
18	18	Add a number for ‘small bulk hBN crystal’	Removed ‘small’ and added: (lateral size: 10s – 100s μm)
23	23	Make comparison between semiconducting carbon nanotubes and graphene – these nanotubes can be used to make FETs, unlike graphene	Added a sentence with this comparison.
25	25	Poor formatting of sentence below figure	Adding other corrections shifted this part of the text and fixed the problem.
37	37	• Add ‘Optical studies of’ to the title of Section 2.5 • Add a section reference to Section 2.3 when discussing self-assembly of molecular monolayers	Added both
41	42	When discussing van der Waals heterostructures, make the point that unlike epitaxial techniques, there is no requirement to have the same lattice type or lattice constant	Added this point
42	43	Add reference to the ‘recently published work by Nottingham Nanoscience Group’	Added references
43	44	When discussing lateral heterostructures, make it explicit what is meant by ‘incomplete layers’	To make it more explicit, I replaced ‘incomplete layers’ with ‘sub-monolayer coverages’
44	45	• Add figure reference when discussing molecular heterostructure design • Explain why an AC signal was used in measurements of PTCDA electroluminescence from the literature	• Added figure references • Added an explanation for the AC signal based on the information in the original paper
45	46	No clear contact to graphene in Fig. 2.32a schematic	This figure was adapted directly from the referenced paper, I think this is an error

			on the part of the paper's author
54	55	Unpublished work has measured devices of MBE-grown SLG of size ~1µm	This comment was made in relation to a section detailing attempts at graphene MBE prior to the more successful high-temperature graphene MBE done at Nottingham, I have made this fact clearer by moving the reference to lower growth temperatures to the start of the sentence.
55	57	Add a reference to the substrate preparation process	This is detailed in sections 3.2.1 and 3.2.2, I have added a section reference to these parts
58	60	Clarify what is meant by 'this reduction'	This was worded incorrectly. Changed the wording to 'This increase in vertical resistance with increasing hBN thickness'
59	60	Fig. 2.43 - Quote a value for the increase in resistance vs hBN thickness	Added value from paper of ~40X increase per hBN layer
62	63 – 64	Compare Eq. 2.18 with fit shown in Fig. 2.43d	Added a comparison between experimental data and Eq. 2.18.
67	68	Fowler-Nordheim tunnelling won Nobel Prize in 197?	Electron tunnelling was the subject of the Nobel Prize in 1973, I've added a statement to mention this
69	70	May see oscillations in transmission coefficient in Fowler-Nordheim tunnelling	No tunnel current oscillations are observed in the high-bias device measurement data presented in Chapter 5, so this aspect of the background was omitted
75	77	• Add reference to invention of AFM • Add 'of AFM' to title of 3.1.2	Added both
82	84 – 85	In discussion of AFM lithography, add reference to the fact that the technique can also be used to cut graphene as shown by work at Manchester	Added mention of this and a corresponding reference
92	96	Font on Fig. 3.12 too small	Rectified as this was also raised by the external examiner
95	98	Add section reference to where phase AFM experimental data in later chapter(s)	Added section references
99	103	Add reference to 'Scotch tape method'	Added reference
100	104	Add reference to flame annealing	Added reference

101	105	Add ‘organic’ to ‘growth of high-quality films’	Added ‘organic’
104	107 – 108	Add a value for PTCDI deposition rate in terms of ML/second	Added values for the deposition rates of PTCDI (0.05 ML/min) and H_2Pc (0.2 ML/min)
108	112	Add size scale for ‘large-area’	Added scale range of 100s µm to 1 mm
109	112	Mis-spelled ‘PDMS’	Corrected spelling
113	116	Add section references for optical measurements and figure reference for device structure	Added section reference, added a reference to Fig. 2.33 (PTCDI device schematic), and reworked the first sentence of the first EL paragraph.
114	118	Add figure reference for spectrometer	Added reference
115	119	Spectrometer shown as outside the equipment casing	Corrected this mistake in Fig. 3.24
116	120	Add figure reference for PL map	Added a reference to Fig. 4.26 (PL map data)
117	121	Show photo of mounted device rather than floating pins	Reworked Fig. 3.25 and modified the caption accordingly
118	120 – 122	• Add figure reference for Keithley • Add figure references for dI/dV and d^2I/dV^2	Added figure references
120	124	• Add reference to prior work on H_2Pc devices • Specify that devices were fabricated in Nottingham	• Added a reference for the unpublished work • Added clarification
121	125	Remove pluralisation of ‘>10s nm’	Removed pluralisation
123 - 124	127	Need photos of stamping process	Added a figure (4.2) showing optical microscope images of an example flake transfer.
129	134	Fig. 4.4 needs more detail, such as a band diagram for the device and making the sub-figures larger	Increased the size of sub-figures b) and c) and added the band structure of the device under zero bias
130	135 - 136	• Several references to the device being a FET • Clarify that the device has 2 hBN barriers • Add a list/table with details of Devices 1 and 2	• These devices could potentially be employed as FETs with the application of a gate voltage but that was not done in the presented measurements • Added pluralisation to ‘barrier’ • Added summary table

133	138	Clarify which publication is referred to	Added a reference to make it clear which publication.
138	142	Fig. 4.9 needs a band diagram for the device	I've added a band diagram to this figure showing the device under 0V and -2.5V biases to show EL emission.
140	145	Quote energy of emitted photon	Added photon energy value of 1.72eV
141	146 - 147	• Need band diagram for up-conversion mechanism • Compare dependence of EL intensity on I with Fig. 4.8 • Explain why the EL efficiency decreases beyond 2.54 V	• Band diagram is shown later in the section, I have included other versions of the band structure earlier in the section • There is not currently an explanation for this behaviour, the voltage at which the decrease in efficiency is observed does not correlate with any of the energy levels considered for H_2Pc and requires further investigation.
142	147	Why is the EL intensity not proportional to I?	At present there is not a satisfactory explanation for the observed dependence of EL intensity on current and requires further investigation. Similar behaviour has been reported in one other paper in the literature, as noted in the thesis, but this other work also does not have an explanation which matches with the observed behaviour presented in the thesis.
143	149	Move Fig. 4.12 earlier	I think this can stay where it is now that I have added band structures earlier in the section
148	153	Refer to which device was measured for PL	This measurement was not carried out on a device but was performed on unencapsulated monolayer H_2Pc on hBN. I've noted in the first sentence that the material was uncapped
149	154 - 155	Mark on plot the peak identities	Added peak identities.

150	155	Add reference to measured device(s)	Added references to device details table
151	157	Fig. 4.15 – Add arrows to show peak positions	Added arrows to figure
152	158	Add details for PTCDI and H_2Pc devices	Added these as a table
156	162	Question of the effect of light on the telegraph noise	Optical measurements could not be performed on this device due to problems with the measurement equipment, and the device broke upon attempting to re-measure later
157	164	Add band diagram for 'double-molecule' device	Added this as a figure after the images of the device (now Fig. 4.22)
165	171	Fig. 4.26 – Increase font size and add scale bars	Increased font size and added scale bar with scale bar length given in the caption.
177	182 - 183	Explain more clearly how and why the nanotube deposition and manipulation differs from methods used in the literature	Added a paragraph which details the techniques used in other methods in the literature to contrast the method I used.
181	187 – 188	- Add legend to Fig. 5.11 - State how many nanotubes were measured - Clear up conflicting quoted resistance values	- Added a legend and the number of nanotubes shown to the body of the text. - Conflict resolved, please see below point.
182	188	Conflicting average resistance value with page 181	Corrected this, I had included an older version of the figure which didn't match the values in the text. Added the correct figure.
187	193 - 194	Two-nanotube I-V plots are too close together, and why not use 4-terminal measurements?	This is related to a comment by the external examiner. My original analysis neglected the influence of contact resistance, despite discussing it in detail in the prior section. I've amended the discussion to make it clear that contact resistance is likely the dominant influence causing this.
194	200	Fig. 5.23 is largely redundant with Fig. 5.22	I agree, removed the figure and reference to it in the text.

196	203 – 204	Fig. 5.24 – Add arrows to indicate peak positions	Added arrows to Figs. 5.24 and 5.25 (new figure numbers after corrections)
210	210	Fig. 5.29 - MWCNT band dispersion should not be graphene-like, but should be graphitic/parabolic	Now Fig. 5.28 - Corrected this in the figure
216	220	Add a plot related to the single-photon emission	Added figure and added reference to it in the text.
254	260	Add a foreword to the conclusion since the thesis does not start at Chapter 4	Added two paragraphs to introduce the conclusions section and to summarise the first three chapters of the thesis.
255	261	Add explicit reference to Chapter 6 at start of discussing MBE section	Added a statement to this effect
291	298	Missing details on NEST who supplied the CVD graphene	Added pre-viva