

Light Ignition of Carbon Nanotubes for the Initiation of Energetic Materials



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Table of Contents

Table of Contents	i
Summary	iv
Declaration	vi
Acknowledgements	vii
List of Figures	ix
Chapter 1: Introduction and Literature Review	1
1.1: Overview.....	1
1.2: History of Carbon Nanotubes	1
1.3: Synthesis of Carbon Nanotubes	7
1.4: Properties of Carbon Nanotubes	12
1.5: Explosives Classifications and Terminology.....	15
1.6: Current Explosives Initiation Devices	15
1.7: Literature Review of the Light Ignition of Nanomaterials	19
1.8: Energetic Materials with the Light Ignition of Nanotubes	28
1.9: Addition of Fuels to the Light Ignition of Nanotubes	33
1.10: Overview of Previous Work	35
1.11: Structure of the Thesis	36
1.12: References.....	37
Chapter 2: Materials and Experimental Methods	42
2.1: Materials	42
2.2: Powder Mixing of Nanotubes	43
2.3: Carbon Nanotube Purification	44
2.4: Chemical Vapour Deposition (CVD) CNT Synthesis	44
2.5: PETN Loading on Surface Bound MWCNTs	47
2.6: Camera Flash Unit	47

2.7: Photodiode/UV-Vis Spectrometer.....	49
2.8: Initial Experimental Setup.....	49
2.9: Nd-YAG Laser and Experimental Setup.....	50
2.10: Pyrometer	52
2.11: High Speed Camera.....	53
2.12: Confocal Raman Spectroscopy	53
2.13: Thermogravimetric Analysis (TGA).....	58
2.14: References	60
Chapter 3: Photodiode, Camera Flash and Laser Initiation.....	62
3.1: Camera Flash Unit Results	62
3.2: Flash Ignition of Metal Nanoparticles.....	69
3.3: Limitations and Solutions.....	71
3.4: Energy Comparison of the Flash Unit and the Laser	78
3.5: Chapter Conclusions	83
3.6: References	84
Chapter 4: Pyrometer Method with Laser Initiation.....	85
4.1: Laser Settings and Experiment Setup.....	85
4.2: Ferrocene and Ratios of Ferrocene.....	93
4.3: Altering the Wavelength and Energy of the Incident Laser Beam.....	99
4.4: Brands of Carbon Nanotubes	105
4.5: Single-Walled and Multi-Walled Carbon Nanotubes	108
4.6: Thermogravimetric Analysis of Samples.....	111
4.7: Chapter Conclusions	114
4.8: References	115
Chapter 5: Novel Techniques and Additives	117
5.1: Metal Nanoparticles	117
5.2: Cut and Purified Nanotubes	119

5.3: Addition of Oxidizer to Carbon Nanotubes	121
5.4: Polymer Wrapping Around Carbon Nanotubes	123
5.5: Horizontally Aligned Carbon Nanotubes	126
5.6: Vertically Aligned Surface Bound CVD Grown Nanotubes	135
5.7: Chapter Conclusions	144
5.8: References.....	146
Chapter 6: Energetic Materials and Carbon Nanotubes	149
6.1: Introduction.....	149
6.2: Laser Ignition of PETN with APSWCNTs.....	154
6.3: Addition of Ferrocene to APSWCNTs with PETN	160
6.4: Reaction of PETN with Iron Nanoparticles	164
6.5: CVD Grown Vertically Aligned Carbon Nanotubes with PETN	166
6.6: Chapter Conclusions	184
6.7: References.....	185
Chapter 7: Conclusions and Future Direction	187
7.1: Introduction.....	187
7.2: Research Findings.....	188
7.3: Future Directions	191
7.4: References.....	197
Appendix.....	199
A.1: Labview Program Front Panel	199
A.2: Labview VI Block Diagram.....	200

Summary

Carbon nanotubes have been shown to ignite when exposed to an intense flash of light such as from a camera flash or laser. This phenomenon has been proposed as a novel initiation method for fuels or explosives. Light initiation of materials provides many advantages over traditional initiation methods for fuels and explosives such as reduced degradation of the initiator over time, reduced interference from electrical fields, improved safety and faster ignition by initiating many points of a material at once. The purpose of this work was to investigate the use of light initiated carbon nanotubes in mining explosive initiators to replace the sensitive primary explosives currently used.

In order to investigate this, experimental methods and instruments needed to first be developed to control and reproducibly measure the ignition of carbon nanotubes by light. Subsequently, those experimental methods were used to comparably optimise the ignition output of carbon nanotubes by exploring the variables and investigating various additives and novel techniques.

Results were successfully recorded with the combination of a high speed camera and a high speed pyrometer. A comparison of the reactions when subjected to a camera flash and a laser was performed. It was found that a camera flash unit produced a slow, surface propagated deflagration while a laser produced a much faster explosion-like result which was determined to be preferable for controllable initiation of energetic materials.

The addition of ferrocene to carbon nanotube powder was found to increase the temperature and reaction of light initiated nanotubes and these mixtures were used to successfully ignite pentaerythritol tetranitrate (PETN). Incomplete combustion was found as a result of particle scattering and limited thermal transfer.

Growth of vertically aligned carbon nanotubes on a silicon substrate was performed and investigated as an alternative to randomly aligned nanotube powders. Light initiation of these samples demonstrated higher temperatures and greater reactivity due to the aligned nature of the nanotubes and the strong thermal conductivity of carbon nanotubes along their length. Vertically aligned carbon nanotubes coated in PETN produced explosive results when initiated by a laser and demonstrated great promise for the ignition of energetic materials.

Declaration

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Steven Trewartha

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List of Figures

Figure 1.1: Left; Schematic model of a graphite whisker. Right; Electron microscope image of the scroll (2500X). (<i>Bacon, 1960</i>).....	2
Figure 1.2: TEM images of carbon nanotubes approx. 50nm in diameter produced in 1952. (<i>Radushkevich et al., 1952</i>).....	3
Figure 1.3: Stereoscopic examination of carbon growth in firebricks with an iron catalyst. (<i>Davis, 1953</i>)	4
Figure 1.4: TEM image displaying a single-walled carbon nanotube in a cross-linked carbon fibre. (<i>Oberlin, 1976</i>).....	5
Figure 1.5: TEM image of SWCNTs attached to cobalt and soot clusters. (<i>Bethune, 1993</i>).....	7
Figure 1.6: Schematic representation of an electric arc-discharge system to produce CNTs. (<i>Journet, 1998</i>)	8
Figure 1.7: Example of a catalytic CVD system for MWCNT growth. (<i>Andrews, 2002</i>)	10
Figure 1.8: SEM image displaying highly aligned multi-walled carbon nanotubes produced via CVD on iron. (<i>Andrews, 2002</i>)	10
Figure 1.9: Schematic showing the vectors responsible for different nanotube conformations. (<i>Odom, 2000</i>).....	13
Figure 1.10: Molecular models of single-walled carbon nanotubes; a) armchair configuration, b) zigzag configuration, c) chiral conformation. (<i>Terrones, 2003</i>)	13
Figure 1.11: Schematic of a non-electric detonator. (<i>From Orica Australia general document in correspondence with Rodney Appleby</i>).....	16
Figure 1.12: Schematic representation of a hot-wire initiator, also representative of an exploding bridgewire detonator.	17
Figure 1.13: High Resolution Transmission Electron Microscopy images of SWCNTs pristine (left) and reconstructed carbonaceous material after photoflash (right). (<i>Ajayan, 2002</i>)	20
Figure 1.14: TEM image of single-walled carbon nanotubes post flash ignition showing large formations of iron oxide. (<i>Smits, 2003</i>).....	21
Figure 1.15: TEM image of as-prepared single walled carbon nanotubes showing the distribution of iron nanoparticles (20nm scale) (left) and high-resolution TEM	

of a bundle showing that most of the iron appears to be encased in carbon (2nm scale) (right). (<i>Smits, 2003</i>)	22
Figure 1.16: SEM image of nanotube/polymer film after ignition of laser showing the large craters. (<i>Singamaneni, 2006</i>)	23
Figure 1.17: Optical image of the two-terminal device used to measure photocurrent. A drop of silver paint is at either end with an aligned bundle of SWCNTs connecting the drops. Inset: SEM image of the aligned nanotubes. (<i>Liu, 2007</i>)	25
Figure 1.18: SWCNT enwrapped in a polymer microcapsule before laser irradiation (left) and after laser irradiation (right). (<i>Kang, 2008</i>)	27
Figure 1.19: A) TEM image of RDX coated MWCNTs with dashed line showing the boundary between the materials. B) Schematic of the mechanism of reaction to create the thermopower wave. (<i>Choi, 2010</i>)	29
Figure 1.20: High-resolution TEM image of Zr/KClO ₄ /SWCNT after ignition from a photoflash displaying onion-like structures from significant reconstruction of nanotube structure. (<i>Xiang, 2012</i>)	32
Figure 1.21: High frame rate photo (5ms after initiation) comparison of camera flash initiated ignition of SWCNTs in ethylene/air creating a distributed ignition across many points (left) and spark initiated comparison that created a combustion wave which expanded from the centre (right). (<i>Berkowitz, 2011</i>)	34
Figure 2.1: Schematic of CNT growth by chemical vapour deposition.	46
Figure 2.2: The two growth models of carbon filaments from a supported catalyst. (<i>Dupuis, 2005</i>)	47
Figure 2.3: Measured wavelength range and intensity of the light from the camera flash unit.	48
Figure 2.4: Photograph of initial camera flash initiation experimental setup.	50
Figure 2.5: Nd-YAG laser setup showing the path of the laser to the sample stage (red line).	51
Figure 2.6: Laser calibration of the measured output energy as a function of the Q-switch time in the laser.	52
Figure 2.7: Energy level diagram showing the Raman Effect. Rayleigh scattering is inelastic while Stokes and anti-Stokes are elastic and the energy change can be measured by emitted photons.	54

Figure 2.8: Vibrational modes of carbon in carbon nanotubes. (a) Vibrations of G-band showing G^+ vibrations along the tube axis and G^- vibrations around the tube circumference, (b) cross-section of a nanotube showing the RBM of the tube and (c) vibrations of the D-band. (<i>modified from Raravikar, 2002</i>)	55
Figure 2.9: Schematic of the Confocal Raman microscope used. (<i>WITec product catalogue</i>)	57
Figure 2.10: Raman intensity image of the G-band (1580cm^{-1}) peak of carbon nanotubes horizontally on a surface with reference to the point spectra highlighted. X-axis is relative wavenumber (cm^{-1}), y-axis is CCD counts.	58
Figure 2.11: TGA profile of as-prepared unpurified SWCNTs (a) and purified SWCNTs (b). (<i>Modified from Chiang, 2001</i>).....	59
Figure 3.1: Photograph of the initial experimental setup to record the flash initiated ignition of nanotubes.	63
Figure 3.2: Camera flash unit initiation results of APSWCNT and ferrocene (1:4, 5mg total) recorded with a photodiode.	64
Figure 3.3: Photograph of a post-camera flash ignition sample of APSWCNT/ferrocene (1:4, 10mg total) displaying evidence of oxidation of metal particles.	65
Figure 3.4: Camera flash initiation results of multiple identically prepared samples of APSWCNT/ferrocene (1:4, 5mg total) to examine reproducibility....	66
Figure 3.5: Comparison of camera flash initiation of APSWCNT/ferrocene (1:4) with two different total sample masses; 5mg and 12mg.....	67
Figure 3.6: UV-Vis spectrum of the ignition of APSWCNT/ferrocene (1:4, 5mg total) in the first 100ms.	68
Figure 3.7: High speed camera showing the ignition of Carbon Solutions APSWCNT/ferrocene (1:4, 5mg) with the camera flash unit. Time shown refers to the amount of time passed since the flash unit was triggered.....	69
Figure 3.8: Iron nanoparticle (26nm diameter) shown before exposure to camera flash (left) and after initiation from the camera flash unit (right) having undergone oxidation.	70
Figure 3.9: Light intensity loss from the camera flash as a function of distance from the flash unit.	72
Figure 3.10: Laser initiation results of multiple identically prepared samples of APSWCNT/ferrocene (1:4, 5mg total) to examine reproducibility.....	73

Figure 3.11: Camera flash initiation of APSWCNT/ferrocene (1:2, 10mg) recorded with the high speed pyrometer. A blank recording is also performed, and a second camera flash after the sample had completed flash ignition but was still physically blocking light on the sample stage.....75

Figure 3.12: Laser ignition of a sample of APSWCNT/ferrocene (1:2, 10mg) using the pyrometer to record the data.77

Figure 3.13: High speed camera frames showing the ignition of APSWCNT/ferrocene (1:2, 10mg) with the laser (50mJ). Time shown refers to the amount of time passed since the laser was triggered.....78

Figure 3.14: Side view diagram of the diverged laser beam path to the sample. Image not to scale.....80

Figure 3.15: Flash paper measuring the spot size of the diverged laser beam. The laser spot without lens defocusing is indicated by the arrow for comparison.....81

Figure 3.16: Schematic of light reflections and refractions through a concave lens showing the reflected focal point of light.....82

Figure 4.1: Photograph of the Surelite SLIII Nd-YAG laser. The arrow shows the mirror which reflects the beam down to the sample stage.85

Figure 4.2: Laser initiation results of 5 separate samples of APSWCNT (10mg) ignited at 152mJ to examine consistency between samples.....86

Figure 4.3: High speed camera frames showing the ignition of unconfined APSWCNT/ferrocene (1:2, 10mg total) with the laser. Time shown refers to the amount of time passed since the laser was triggered.....87

Figure 4.4: High speed camera frame series of APSWCNT/ferrocene (1:2, 10mg) taped to double sided carbon tape and initiated by the laser. Time shown is time after laser initiation.....89

Figure 4.5: High speed camera photos of the laser initiation of APSWCNT/ferrocene (1:2, 10mg total) displaying the initial ignition (a-d) followed by a secondary ignition (e-f) when the ferrocene is initiated and oxidizes.....91

Figure 4.6: Laser initiation of two samples of APSWCNT/ferrocene (1:2, 10mg total) when initiated from within a glass sample tube demonstrating the consistency of results.....92

Figure 4.7: Pyrometer recorded ignition results of varying laser energy levels on samples of APSWCNT/ferrocene (1:2, 10mg total) using IR laser wavelength 1064nm. Complete initiation to 110ms not displayed. 93

Figure 4.8: Comparison of the ignition of APSWCNT to APSWCNT/ferrocene (1:2, 10mg) displaying a higher temperature and longer burn time in the presence of ferrocene. The results are displayed at two different scales to show the full reaction of the APSWCNT/ferrocene (1:2, 10mg) (top) and then zoomed in on the first 2ms (bottom). 95

Figure 4.9: High speed camera photos of the laser initiation of APSWCNT (10mg) displaying the initial ignition (a-b) followed by some scattering of the nanotubes but no secondary ignition..... 96

Figure 4.10: Laser initiation results for various ratios of APSWCNT/ferrocene (3.5mg total) at 152mJ. 98

Figure 4.11: Optical absorption spectrum of SWCNTs spun-coated onto quartz. (*Hartschuh, 2005*)..... 101

Figure 4.12: Pyrometer recorded ignition results of varying laser energy levels on samples of APSWCNT/ferrocene (1:2, 10mg total) using visible laser wavelength of 532nm. 103

Figure 4.13: Pyrometer recorded ignition results of varying laser energy levels on samples of APSWCNT/ferrocene (1:2, 10mg total) using UV laser wavelength of 355nm. 104

Figure 4.14: Comparison of the initiation of three different brands of SWCNTs. Carbon Solutions (~35wt% Ni/Y), Unidym (~35wt% Fe) and NTP (<3wt% Fe). 106

Figure 4.15: Laser initiation of APSWCNT/ferrocene (1:2, 10mg total) compared to Unidym and NTP SWCNT/ferrocene (1:2, 10mg total) displaying a 2ms scale (top) to see the initial reaction and a 100ms scale (bottom) to show the complete reaction..... 107

Figure 4.16: Laser initiation of a sample of NTP MWCNTs (10mg) compared to APSWCNTs (10mg). 109

Figure 4.17: Laser initiation of NTP MWCNT/ferrocene (1:2, 10mg total) compared to APSWCNT/ferrocene (1:2, 10mg total) displaying a 2ms scale (top) to see the initial reaction and a 100ms scale (bottom) to show the complete reaction..... 110

Figure 4.18: TGA results of Carbon Solutions APSWCNTs and ferrocene in various ratios and neat. Ferrocene sublimates at $\sim 170^{\circ}\text{C}$ while other mass loss is carbon combustion.	112
Figure 4.19: TGA results of NTP SWCNTs and ferrocene at (1:2) and neat. Ferrocene sublimates at $\sim 170^{\circ}\text{C}$ while other mass loss is carbon combustion.	113
Figure 5.1: Laser ignition characteristic of iron (26nm) and nickel (20nm) nanoparticles compared to APSWCNTs.	118
Figure 5.2: Photograph of iron nanoparticles (26nm) after camera flash unit initiation displaying an orange colour due to oxidation. (Reproduced from Chapter 3.2).....	119
Figure 5.3: Laser initiation of filtered and purified SWCNT compared to APSWCNTs.	120
Figure 5.4: Ignition of APSWCNT mixed with potassium nitrite and sodium perchlorate respectively at a ratio of (1:2).....	122
Figure 5.5: Laser initiation of a sample of APSWCNT/ferrocene/sodium perchlorate (1:2:6, 18mg total) displaying two ignition peaks. Firstly for ferrocene igniting, and secondly for the sodium perchlorate igniting. APSWCNT/ferrocene (1:2, 10mg total) is displayed as a comparison.	123
Figure 5.6: Chemical structure of polystyrene sulfonate.	124
Figure 5.7: Laser ignition results of APSWCNT wrapped in polystyrene sulfonate and the monomer dry mixed with APSWCNT compared to the raw chemicals.	125
Figure 5.8: Comparison of the ignition of APSWCNT/ferrocene (1:2, 10mg total) and APSWCNT/PSS (1:2, 10mg total).	126
Figure 5.9: Horizontally aligned rows of carbon nanotubes on glass produced by the 'coffee cup effect' during evaporation.	127
Figure 5.10: Raman spectrum of horizontally aligned SWCNTs on glass displaying a high purity as a result of the very low D-band (1345cm^{-1}).....	128
Figure 5.11: Optical microscopy image of horizontally aligned SWCNTs on glass.	129
Figure 5.12: Optical microscopy image of horizontally aligned SWCNTs on glass. Inset: Raman intensity image of the 1598cm^{-1} carbon peak showing alignment of the array. Scale bar in the Raman image is $7\mu\text{m}$	130
Figure 5.13: Laser ignition of horizontally aligned SWCNTs on glass at two concentrations and compared to 'fluffy' APSWCNT.	131

Figure 5.14: Photo of a horizontally aligned sample of SWCNTs after ignition by the laser showing an ablation spot where the laser hit the sample.....	132
Figure 5.15: Horizontally aligned SWCNTs with double concentration of the original sample showing the spot where ignition and partial ablation occurred from the laser.	133
Figure 5.16: Laser initiation of horizontally aligned SWCNTs with ferrocene added compared to no ferrocene and APSWCNTs.....	134
Figure 5.17: Schematic of CVD grown MWCNTs showing the vertically arrayed nature and the location of the catalyst nanoparticles.	136
Figure 5.18: Comparison of the ignition of three samples of CVD grown vertically aligned MWCNTs with APSWCNT as a reference.....	137
Figure 5.19: High speed video frames of laser initiation of MWCNT surface. Top: 1 frame after the laser initiation showing a small fireball above the sample. Bottom: 25ms after laser initiation with airborne material circled in red.....	138
Figure 5.20: Photo of vertical MWCNT arrays after initiation by the laser showing the burnt spot where the laser beam hit the sample.....	139
Figure 5.21: Laser initiation at 150mJ of the same MWCNT surface four times in succession displaying the lowering reaction as more of the sample is oxidized and ablated.....	139
Figure 5.22: Comparison of the ignition of MWCNT arrays with and without the supporting sputter coated layer of aluminium.	141
Figure 5.23: Laser ignition of vertically aligned MWCNT surface with ferrocene sprinkled on top compared to ferrocene evaporated into the nanotubes via acetone.	143
Figure 5.24: Data as presented in Figure 5.23 with a broader x-axis scale to display the full reaction.....	144
Figure 6.1: Schematic of the expanding detonation shockwave when propagating through a charge (a) in a cylindrical charge with a radial shockwave and (b) in a film charge with a 1-dimensional shockwave. (<i>Petel, 2007</i>).....	152
Figure 6.2: Absorption spectra of PETN. (1) Overview spectrum left and bottom axis, (2) maximum sensitivity spectrum right and top axis. (<i>Aluker, 2008</i>).....	153
Figure 6.3: Laser ignition response of PETN, APSWCNTs and a mixture of both displaying that there is no reaction for PETN in the absence of nanotubes.	154

Figure 6.4: High speed camera photos of the laser initiation of APSWCNT/PETN (1:1, 20mg total). Times shown is the time since the first frame where a reaction can be seen (a), i.e. the first frame captured upon laser impact.	156
Figure 6.5: High speed camera photos of the laser initiation of APSWCNT (10mg) displaying the comparatively smaller reaction with no PETN present. (Reused from Chapter 4.2).....	157
Figure 6.6: Ignition response of APSWCNT and PETN mixed by dissolving in acetone and evaporating.	158
Figure 6.7: Ignition response at 800mJ of laser energy of APSWCNT and PETN mixed by dissolving in acetone and evaporating.....	159
Figure 6.8: Laser initiation of APSWCNT/PETN (1:33, 34mg total) at 800mJ laser energy highlighting only a minor increase in reaction with PETN compared to APSWCNT only.....	160
Figure 6.9: Laser initiation of APSWCNT/ferrocene/PETN (1:2:5, 16mg total) compared to without PETN. Bottom trace (green) shows a sample of APSWCNT/ferrocene/PETN after being dissolved in acetone and air dried.....	161
Figure 6.10: Laser initiation of APSWCNT/ferrocene/PETN (1:2:5) compared to without PETN, x-axis changed to show full reaction time of the PETN containing sample.....	162
Figure 6.11: High speed camera photos of the laser initiation of APSWCNT/ferrocene/PETN (1:2:5, 16mg total) showing a rapid and intense ignition (a-c) as a result of the PETN which causes ferrocene to ignite quickly (d-e).....	163
Figure 6.12: High speed camera photos of the laser initiation of APSWCNT/ferrocene (1:2, 6mg total) displaying the initial ignition (a-d) followed by a secondary ignition (e-f) when the ferrocene is initiated.....	164
Figure 6.13: Initiation of iron nanoparticles with and without PETN (1:1) at 850mJ.	165
Figure 6.14: Optical microscopy image of a PETN layer on vertically aligned MWCNTs. PETN crystals have formed in an aligned fashion due to the movement of the expanding then evaporating acetone droplet.	167
Figure 6.15: Optical microscopy image of a PETN layer on vertically aligned MWCNTs illustrating a different sample with different PETN crystal morphology.	168

Figure 6.16: Optical microscopy image of a MWCNT surface loaded with PETN. The right white area out of focus is the silicon surface, the dark material is MWCNTs, and the reflective parts on it is PETN. The green circle shows where Raman spectra was collected from. 170

Figure 6.17: Raman spectra of the side of a MWCNT surface with PETN loading (green) in comparison to reference spectra of MWCNT and PETN (blue and red respectively). 170

Figure 6.18: Laser initiation of a vertically aligned MWCNT surface with and without a PETN layer on the surface. 172

Figure 6.19: High speed camera frames of the laser initiation of a MWCNT surface (a-c) and the same sample with a layer of PETN (d-f). 173

Figure 6.20: High speed camera photos of the MWCNT surface with PETN layer displaying the silicon wafer flipping through the air. 174

Figure 6.21: Optical microscope image of the PETN layer (10-12 μ m) on a silicon wafer. 175

Figure 6.22: Laser initiation of a silicon wafer sputtered with aluminium and iron. The wafer was then charged with a PETN layer and initiated. 176

Figure 6.23: Laser initiation of a vertically aligned MWCNT surface with and without a PETN layer on the surface. 177

Figure 6.24: Laser initiation of a vertical MWCNT array of length \sim 2mm displaying first the ignition of the nanotubes, then the sample loaded with PETN. Finally the laser energy was increased to 850mJ to initiate another region of the sample. 178

Figure 6.25: High speed camera frames of MWCNT (\sim 2mm) array initiated by laser. Only one frame of flame is observed and very little ablation of particles can be seen. 179

Figure 6.26: High speed camera frames of MWCNT (\sim 2mm) array with PETN loaded initiated by laser (150mJ). Particle matter is seen firing to the left of the sample (c-d) after the initial ignition. 180

Figure 6.27: High speed camera frames of MWCNT (\sim 2mm) array with PETN loaded initiated by laser (850mJ). A large ignition is first seen (a) and lots of particles scatter (b) before the whole silicon wafer flips over (c-f). 181

Figure 6.28: High speed camera frames of the laser initiation of a MWCNT surface loaded with PETN displaying a rapid explosion and shattering of the silicon wafer. 182

Figure 6.29: Laser initiation of a vertically aligned MWCNT surface with and without a PETN layer on the surface..... 183

Figure 7.1: TEM image of the metal nanoparticles with ‘sea urchin-like’ structure of carbon nanotubes grown out of the surface. (*Moon, 2009*) 194