5 Conclusion

The present thesis work comprised of a study of the theoretical and experimental aspects of Boron doped single Walled Carbon Nanotubes.

Care was taken to introduce the reader to the state-of-art of the research on Carbon Nanotubes science, on the “Overview of the Research Field” chapter. Pristine and Boron doped Carbon Nanotubes were compared in terms of electronic and optical properties, so that the reader could understand the experimental results.

In the “Methodology” chapter, the work already done on the scientific community was taken into account, so that some new experiments could be proposed:

- Synthesizing Boron doped single Walled Carbon Nanotubes, from Trimethyl Borate in high vacuum CVD.
- Synthesizing single Walled Nanotube junctions in a controlled manner, by changing the precursor substance in the middle of the synthesis.

Along with the experimental proposal, the characterization techniques used to analyze the produced materials were described.

In the “Results” chapter, the analysis results were presented, and discussed under the light of the theory, and literature references given in chapter “Overview of the Research Field”. It was concluded that:

Different from literature results in general, the experiments seem to suggest that Boron doping within the synthesis method of this thesis, results in no shift of the G^+ band.

The decrease of precursor molecule size, from Triisopropyl to Triethyl, and then to Trimethyl Borate, not only increases the relative amount of Boron to Carbon atoms available in the synthesis, but also the relative amount of Oxygen in the synthesis, which works to decrease the synthesis yield, and increase the amount defective Nanotubes and Amorphous Carbon produced.

Trimethyl Borate showed the potentiality to produce highly doped single Walled Carbon Nanotubes, with doping levels around 15 %. However, further studies should be done to confirm these high doping levels, interpreted from XPS.

The present experiments seem to point that the proposed methodology of using different trialkyl Borates (Triisopropyl, Triethyl, and Trinethyl) and their mixture to produce controlled doping levels did not achieve its objective, since all samples produced showed no significant difference in doping concentrations.

Finally, some future work should be pointed out so as to answer the doubts that remained from this thesis experimental results chapter:

- Another set of precursors could be used to better understand the Carbon Nanotube growth mechanism. For instance, the role of Oxygen within the

Boron doped Single Walled Carbon Nanotubes growth could be accessed if one compared synthesis using trialkyl borates to synthesis using trialkyl boranes. This should be possible since some groups use trialkyl boranes to produce Boron doped Carbon Nanotubes, like Hashim et. al. [72]. On another hand, a better understanding of the growth and doping mechanisms might be achieved if one compared pristine/Boron doped Nanotube precursors in pairs: Methanol with Trimethyl borate, Ethanol with Triethyl Borate, and Isopropanol with Triisopropyl Borate.

- Raman measurements should be used with other laser energies, between $1.5\ eV$ and $2.0\ eV$, to probe for a possible semiconducting population in the synthesized Boron doped single Walled Carbon Nanotubes. This would be important to test hypothesis on why no upshift was observed for the G^+peak position.
- Electric measurements should be made to access possible rectifying properties of the Experiment Runs 11, 12 and 13, so as to test if the production of Boron Doped SWNT Junctions *in situ* was successful.