

# **SYNTHESIS OF CARBON NANOTUBES ON STAINLESS STEEL 304 SUBSTRATES BY THERMAL CVD METHOD: EFFECT OF HCL SURFACE ETCHING ON CNT GROWTH**

A Dissertation submitted in partial fulfillment  
of the requirements for the award of the Degree of

## **MASTER OF TECHNOLOGY IN NANOSCIENCE AND TECHNOLOGY**

Submitted by

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# CERTIFICATE

This is to certify that the dissertation title “**Synthesis of Carbon Nanotubes on Stainless Steel 304 Substrates by Thermal CVD Method: Effect of HCl Surface Etching on CNT Growth**” is the authentic work of **Mr. Gaurav Garg** under my guidance and supervision for the partial fulfillment for the award of degree of Master of Technology in Nanoscience and Technology at Applied Physics Department, Delhi Technological University, Delhi.

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## **CANDIDATE DECLARATION**

I hereby declare that the work presented in this dissertation entitled “**Synthesis of Carbon Nanotubes on Stainless Steel 304 Substrates by Thermal CVD Method: Effect of HCl Surface Etching on CNT Growth**” has been carried out by me under the guidance of **Dr. Pawan Kumar Tyagi**, Assistant Professor, Department of Applied Physics, Delhi Technological University, Delhi and hereby submitted for the partial fulfillment for the award of degree of Master of Technology in Nanoscience and Technology at Applied Physics Department, Delhi Technological University, Delhi.

I further undertake that the work embodied in this major project has not been submitted for the award of any other degree elsewhere.

**Gaurav Garg**  
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## ABSTRACT

Multi-walled carbon nanotubes were directly grown by thermal chemical vapor deposition on as received and hydrogen chloride treated Stainless Steel 304 substrates without application of an external catalyst. To study effect of hydrogen chloride etching on growth of CNTs, three samples were used with different variations in etching and they were (1) SS 304 substrate dipped and sonicated in concentrated hydrogen chloride for 10 minutes. (2) SS 304 substrate only dipped in concentrated hydrogen chloride for 10 minutes. (3) SS 304 substrate as received untreated with hydrogen chloride. Synthesis of CNTs was carried out in a thermal chemical vapor deposition set up with growth temperature of 800 °C and C<sub>2</sub>H<sub>2</sub> as carbon carrier gas. Scanning electron microscopy observations suggests that carbon nanotubes were there in each substrate but CNTs coverage density and CNTs diameter was different. Untreated SS 304 substrate shows maximum CNTs coverage density and minimum CNTs diameter. Hydrogen chloride sonicated SS 304 substrate shows more amorphous carbon and less CNTs.

## Shortforms Used

CNTs	Carbon nanotubes
MWCNTs	Multi Walled Carbon nanotubes
SWCNTs	Single Walled Carbon nanotubes
CVD	Chemical Vapor Deposition
T-CVD	Thermal Chemical Vapor Deposition
SS 304	Stainless Steel 304
FESEM	Field Emission Scanning Electron Microscopy
AFM	Atomic Force Microscopy
EDX	Energy-dispersive X-ray spectroscopy