World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:5, No:7, 2011

Characterization of Carbon Based Nanometer Scale Coil Growth

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Abstract**—**The carbon based coils with the nanometer scale have the 3 dimension helix geometry. We synthesized the carbon nano-coils by the use of chemical vapor deposition technique with iron and tin as the catalysts. The fabricated coils have the external diameter of ranging few hundred nm to few thousand nm. The Scanning Electro-Microscope (SEM) and Tunneling Electro-Microscope has shown detail images of the coil's structure. The fabrication of the carbon nano-coils can be grown on the metal and non-metal substrates, such as the stainless steel and silicon substrates. Besides growth on the flat substrate; they also can be grown on the stainless steel wires. After the synthesis of the coils, the mechanical and electro-mechanical property is measured. The experimental results were reported.

Keywords**—**Carbon nanocoils, chemical vapor deposition, nano-materials

Open Science Index, Materials and Metallurgical Engineering Vol:5, No:7, 2011 publications.waset.org/14229/pdf

I. Introduction

THE Carbon nanocoils (CNCs) has a three dimensional helical geometry that have interest applications in nanosprings [1-2], electromagnetic wave absorbers [3] and micro-sensors [4]. Use of chemical vapor deposition to grow the CNCs is efficient and popular. But its growth mechanism is rather a complex process of the mixing of solutions comprising two types of catalysts, i.e., Fe and Sn in our case. For a wider application, it is important to determine how to easily control the effective growth of the CNCs.

II. Fabrication

In this report, the experimental study used the chemical vapor deposition (CVD) technique to grow the carbon nanocoils with Fe and Sn as the catalysts. The substrate was annealed in argon gas in temperature of 650 degree C to control the particle size of both Fe and Sn. When we used the stainless steel material as the substrate, the substrate was oxidized at 600 °C in air to allow the catalytic activity of Fe and Sn combination. The substrate was sent into the quartz tube of the heating furnace. It then was heated to 700 °C under a proper flow of Ar gas. At temperature of 700 °C, carbon source of C_2H_2 gas was supplied for approximate 15-20 min to grow CNCs. The chamber is then cool in nature.

III. Experiments

The synthesized CNCs were examined using the SEM and TEM. The images illustrate the characteristic dimension of the CNCs is approximately 0.4-2 microns in CNC diameter. The wire diameter of CNC ranges from 0.1 to 0.3 microns. The pitch of the CNC is proportional to the CNC diameter. The different geometry from the existing literature is that the pitch is larger such that the CNC wires are not in touch with their adjacent wires. It provides a better structure when the CNC is in resonant vibration. The air space in between the wires allows free space for wire to vibrate and thus allow may absorb vibration energy or electro-magnetic wave.The success yield of the CNC growth depends on both the composition of the catalysts and process temperatures. Before the synthesis, the oxidation temperature of the substrate coated with a 0.1 M Sn solution and annealed at 700°C. The SEM image shows the average diameter of the catalysts was around few microns. The higher oxidation temperature usually brought the smaller diameter of the catalysts. The oxidation temperature is quite sensitive in the CNC growth. The 2nd important factor is the composition of the Fe to Sn ratio. We had conducted the experiments using different concentration of the Sn solution and examine the synthesis effect. The anneal temperature of 700 to 900 degree C was conducted and evaluated for optimum condition.

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IV. Summary

We present the growth of the carbon nanocoils that has characteristic dimension of diameter in micron to sub-micron, coil wire in several hundreds nm. The pitch of the coils is proportional to the coil diameters. We had used the SEM and TEN to examine the coil's images. The catalysts remained in the carbon nanocoils were also examined using the EDX and found the chemical composition matching the initial composition of the catalyst before the CVD synthesis. The oxidation temperature and concentration of Fe-Sn solution were important in the yield of CNCs growth.

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