

# Numerical Control Device for Preparation Nano-Carbon Granule Coating Superhydrophobic Template and Its Application

G R Shang\* and Y Li

Jilin Teachers Institute of Engineering and Technology, China Changchun 130052

\* Corresponding email :shgr888@163.com

**Abstract.** It is one of the ways for changing surface property by fabricating superhydrophobic coating with the help of template that is made of depositing nano-carbon particles of fuel flame on substrate such as pure copper or aluminium alloy. In the process of making template, it is difficult to keep the deposition layer uniformed. In this work, the problem was solved by manufacturing a set of numerical control equipment. It has been proved by application test that the deposition layer was uniformed by means of this facility. The contact angle is more than  $150^\circ$ . A new way has been developed for making superhydrophobic template.

## 1. Introduction

In the area of material surface modification, one major goal is to design and prepare self-cleaning surfaces[1-3]. Many surfaces in nature are superhydrophobic, such as the surface of the lotus leaf and butterfly wings[4,5]. Mimicking its surface topography has resulted in a considerable amount of artificial materials[6,7] and developed many applications in industrial and biological fields[8~10]. Micron-scale air "clusters" are trapped in the depressions of the rough surface beneath the water droplets[11~12]. This compound interface results in the increase of micro-contact angle and the decrease of the contact angle hysteresis, which makes the rolling of the water droplets easier and can take the pollutants away from the surface. However, organic liquids such as alcohols or oils can significantly reduce their own surface tension and induce even surface wetting. The droplet will change state from the hole above the concave (Cassie - Baxter state) to fully wet (Wenzel state)[11]. No natural surface can show that it is greater than  $150^\circ$  of the static contact angle and below  $10^\circ$  of the rolling angle at the same time for water and organic liquid. Such surface is superhydrophobic and superoleophobic[13,14].

In recent years, there have been literature reports in the world, it has been reported that using the candle soot as the medium to prepare the nanometer coating on metal or non-metal substrate. However, in the preparation process, the uniformity of the coating is difficult to guarantee. In this paper, a set of numerical control device has been designed to keep the coating uniformity. The speed regulating motor drives the mechanical gearbox and the speed reduction gear for transmission output speed. The preparation of superhydrophobic template with the substrate of pure copper, or aluminum alloy has been made by burning, nano-scale carbon particles produced by the outer flame as a medium through kerosene, soybean oil, the candle, and laid the foundation for the further preparation of super hydrophobic surface.



## 2. Basic parameters of the numerical control device

Precise displacements were afforded within horizontal and vertical directions by the numerical control device. The uniform motion in horizontal direction is important as the lower surface of samples which have suitable time to keep a touch with outer flame. The nano-carbon particles will have a deposition layer on the lower surface of samples. The velocity of the movement is between 3mm per minute and 60mm per minute. The maximum displacement is 300mm. The accuracy is 50micrometers.

The motion in the vertical direction is used to adjust the height of flame in order to keep the flame position.

Substrates of samples are from Aluminium alloy and pure copper or other materials. The size of sample is between  $(5\text{mm} \times 10\text{mm} \times 1\text{mm})$  and  $(50\text{mm} \times 50\text{mm} \times 1\text{mm})$ . The mass of the load is between 0.135g and 22.25g according to the size of sample.

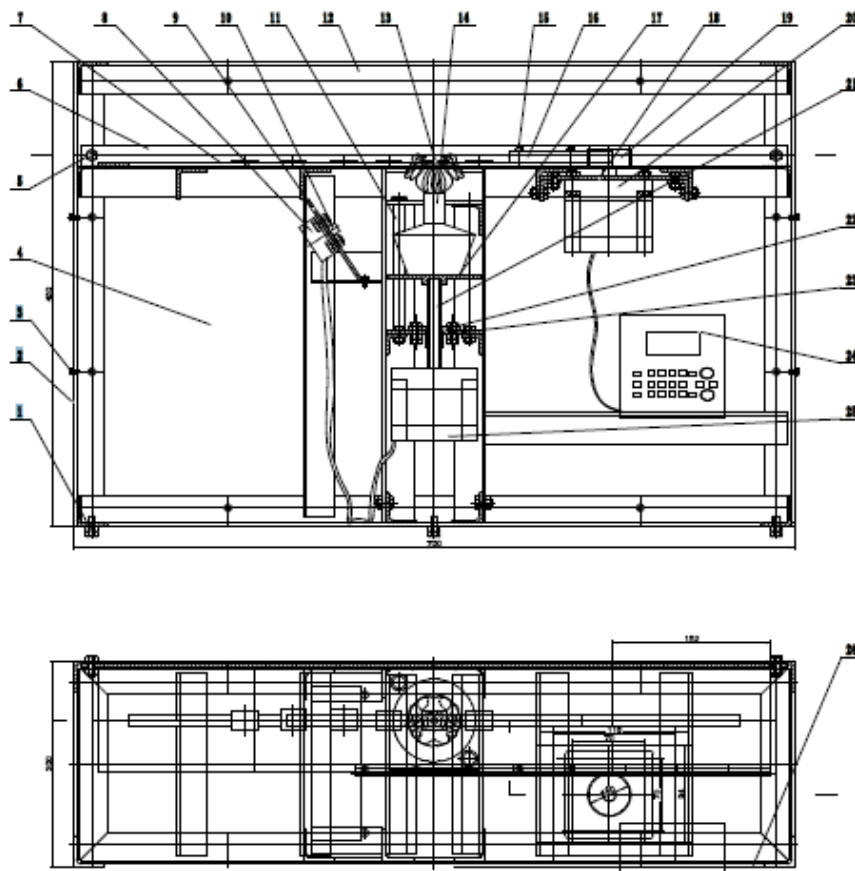
## 3. Principle of the design

The schematic diagram of the numerical control device is shown in Figure 1.

Samples 13 evenly arranged is placed on board 7 in test. When the programmable controller 24 gives a signal, the gear is driven by stepping motor 20 and rack 16 is driven to make a uniform rectilinear motion. Sample layer board 7 is linked with rack 16 by mechanical separator system in order to do a uniform rectilinear motion. Rectangular holes are processed in board 7 to match samples for keeping a touch between samples lower surface and the certain position of the flame.

The flame will gradually weaken with burning, and it makes a effect on concentration of nano-carbon particles on the lower surface of samples. The temperature of flame in certain position is detected by sensor 10 for keeping it in a suitable range. When it is in a designed section, any signal will be sent; when it goes beyond a reasonable range, an order will be sent by PLC 8 to stepping motor 25. Ballscrew 21 will be driven by it and makes a straight line motion in Z direction by means of a set of machine combination which consists of nut 22, screw 21 and other parts in order to keep the temperature.

Nano-carbon particles from the flame of candles, kerosene and soya-bean oil are deposited on the lower surface of samples 13 in this device and the superhydrophobic template is formed.



**Figure 1.** The movement diagram of the mechanism.

1- Horizontal adjustment nail; 2- Side guard plate; 2- Side shield; 3- Fixed screw; 4- Back shroud; 5- Union bolt and nut combination; 6- Guide strip; 7- Sample board; 8- PLC; 9- Temperature measuring instrument mounting plate; 10- Temperature transmitter; 11- Guide cylinder; 12- Welded truss; 13- Sample; 14- fuel source (for example: alcohol burner); 15- Binding screw; 16- Rack; 17- Movable support plate; 18- Motor support plate; 19- Gear; 20- Motor; 21- Balls crew; 22- Nut; 23- Fixed bearing plate; 24- PLC; 25- Motor; 26- front track fender

## 4. Materials and methods

### 4.1. Materials

Aluminium Alloy (5A05), pure copper (TU2), candle, kerosene, soya-bean oil. Kerosene and soybean oil are placed in the alcohol lamp respectively. Lamp wick is cut neatly before burning.

### 4.2. Characterization

The morphology of the soot particles was characterized by Scanning Electron Microscopy (low voltage LEO 1530 Gemini, Germany, and SU8000, Hitachi, Japan). Samples were washed by high speed centrifuge (TG618, Shanghai, China), and were dried in electrothermal constant-temperature dry box (202-3A, Nanjing, China). Contact angles were tested by Optical Contact Angle Measuring instrument (DSA100, KRUS, Germany).

#### 4.3. Methods

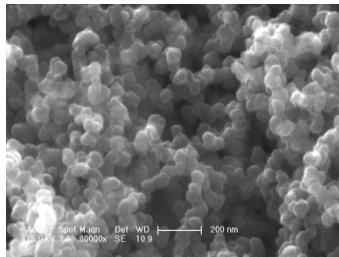
The superhydrophobic deposition layer with nano-carbon particles was made by Numerical Control Device(Fabricating by Project Group). The ambient temperature stays at the rang 25 degrees Celsius. Outer flame was used when burning. Samples were placed in an airtight plastic box.

#### 4.4. Rules of samples labeling

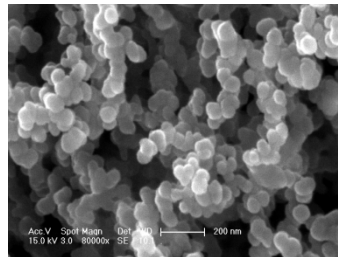
Each sample is marked with three set of numbers. The first set of numbers represents the fuel flame type. For example: 1- Kerosene flame; 2-Candle flame; 3-Soya-bean flame. The second set of numbers represents the base materials. For instance: 1-Pure copper substrate(TU2); 2- Aluminium Alloy(5A05). The third group represents deposition time(senond).

### 5. Result and discussion

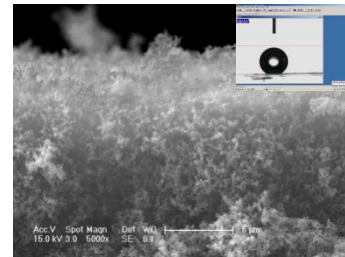
Morphology of template and static contact angle were shown in Figure 2~4.



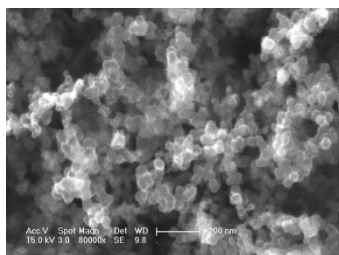
**Figure 2.(a)** 1-1-10 Top view



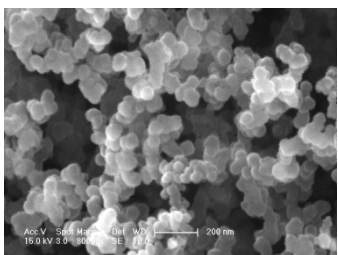
**Figure 2. (b)** 1-2-10 Top view



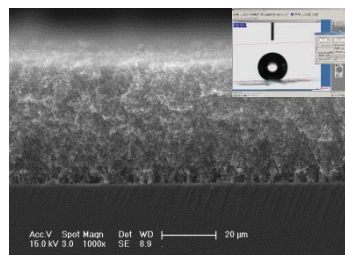
**Figure 2. (c)** 1-2-10 left view



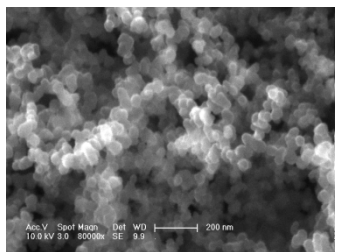
**Figure 3. (a)** 2-1-30 Top view



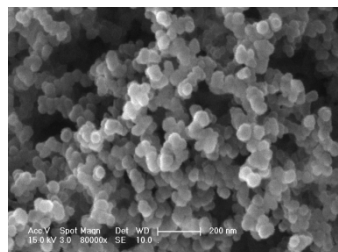
**Figure 3. (b)** 2-2-30 Top view



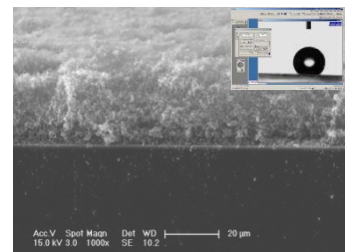
**Figure 3.(c)** 2-2-30 left view



**Figure 4. (a)** 3-1-30 Top view



**Figure 4. (b)** 3-2-30 Top view



**Figure 4.(c)** 3-2-30 left view

It is shown from morphology of SEM image that the diameter of carbon particles on the deposition layer is between 50 nanometer and 70 nanometer. The distribution of particles is random. The carbon particles deposited on the pure copper substrate have higher densities; The porosity of carbon particles deposited on the base of aluminum alloy is higher (Shown in Figure 2). With the deposition time increases, the density augment, the porosity reduced, and the thickness of the sediments increases synchronously (Shown in Figure 3~4).The thickness of the sediment is uniformed and is about 50~70micrometer(Shown in Figure 2~4c). It has been indicated that static contact angle is

above 150° (Shown in Figure 2~4c). Because of the surface energy of aluminum alloy is lower than that of pure copper, the contact angle is higher correspondingly.

## 6. Conclusions and prospect

It is indicated in test that the uniform motion in the horizontal direction of the template afforded by the numerical control devices ensures the uniformity of nano-carbon particles on substrates and the static contact angle more than 150°. The superhydrophobic characteristics are presented. It is a foundation for manufacturing the superhydrophobic surface further.

## Acknowledgments

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