SYNTHESES OF NANOPARTICLES BY WIRE EXPLOSION TECHNIQUE

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ABSTRACT

Nanoparticles generally refer to particles with sizes less than 100 nm. They exhibit distinguished properties compared to their bulk form due to their small size and high surface-to-volume ratio. Various methods have been developed to fabricate such particles where wire explosion technique is one of them. In brief, wire explosion is realized by allowing a high power pulsed current to pass through a thin wire. The current will provide the energy to vaporize the wire due to the Joule heating effect. The formation of nanoparticles starts when the vaporized wire forms a supersaturated vapour that is followed by nucleation of vapour particles. Subsequent growth of the nuclei will lead to formation of nano-sized particles.

In this work, we had investigated the effect of ambient gas and pressure on the characteristics of nanoparticles synthesized by the wire explosion technique. Copper wires 125 µm in diameter with a length of 6.1 cm had been exploded with current supplied by a 1.85 µF capacitor being charged up to 10 kV. In order to investigate the effect of the ambient gas on the characteristics of nanoparticles being produced, copper wires were exploded in ambient gas of nitrogen, argon and nitrogen-argon admixtures at a pressure of 500 mbar. Meanwhile, study on the effect of ambient gas pressure had been conducted by exploding the copper wires in air and nitrogen ambient at 1 bar, 500 mbar, 100 mbar and 50 mbar. The size of the particles had been evaluated by transmission electron microscope (TEM) while the crystalline structure of the particles was examined by using X-ray diffraction (XRD) method.

The magnetic pick-up coil and high voltage probe had been used to record the current and voltage across the wire during the wire explosion. The amount of energy deposited into the wire was derived from the current and voltage signal. Meanwhile, the PIN diode was used to register the time-resolved intensity of visible light emitted from the wire explosion. From the current, voltage and PIN diode signals, the discharge characteristics of the wire explosion in different experimental conditions were studied.

ABSTRAK

Zarah-zarah nano secara umumnya merujuk kepada zarah-zarah bersaiz kurang daripada 100 nm. Zarah-zarah ini mempamerkan sifat-sifat yang unik berbanding dengan zarah-zarah dalam bentuk pukal kerana saiz mereka yang kecil dan nisbah luas permukaan kepada isipadu yang tinggi. Pelbagai kaedah telah dimajukan untuk menghasilkan zarah-zarah tersebut di mana teknik letupan wayar adalah salah satu daripada mereka. Secara ringkas, letupan wayar dapat direalisasi dengan membenarkan arus denyutan berkuasa tinggi melalui satu wayar halus. Arus itu akan membekalkan tenaga untuk mengewapkan wayar disebabkan kesan pemanasan Joule. Pembentukan zarah-zarah nano bermula apabila bahan wayar yang telah mengewap membentuk wap supertepu yang diikuti dengan penukleusan zarah wap. Pertumbuhan nukleus-nukleus yang berikutan akan membawa kepada pembentukan zarah-zarah bersaiz nano.

Dalam kerja ini, kami telah mengkaji kesan gas dan tekanan sekitaran ke atas ciri-ciri zarah-zarah nano yang disintesis oleh teknik letupan wayar. Wayar-wayar kuprum berdiameter 125 µm dengan panjang 6.1 cm telah diletup dengan arus yang dibekal oleh satu kapasitor 1.85 µF yang dicas kepada 10 kV. Untuk mengkaji kesan gas sekitaran ke atas ciri-ciri zarah-zarah nano yang dihasilkan, wayar-wayar kuprum telah diletup dalam gas sekitaran nitrogen, argon dan campuran nitrogen-argon pada tekanan 500 mbar. Sementara itu, kajian ke atas kesan tekanan gas sekitaran telah dijalankan dengan meletup wayar-wayar kuprum dalam sekitaran udara dan nitrogen pada 1 bar, 500 mbar, 100 mbar dan 50 mbar. Saiz zarah-zarah telah dinilai dengan mikroskop elektron pancaran (TEM) manakala struktur kristal zarah-zarah dikaji dengan menggunakan kaedah pembelauan sinar-X (XRD).

Gegelung magnet dan kuar voltan tinggi telah diguna untuk merekod arus dan voltan merentasi wayar semasa letupan wayar. Amaun bagi tenaga yang dimendap ke dalam wayar telah diperoleh daripada isyarat arus dan voltan. Sementara itu, diod PIN telah diguna untuk merekod keamatan resolusi masa bagi cahaya-boleh-nampak yang dipancar daripada letupan wayar. Daripada isyarat arus, voltan dan diod PIN, ciri-ciri nyahcas letupan wayar dalam keadaan eksperimen yang berbeza telah dikaji.

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TABLE OF CONTENTS

Chapter 5 Discussion

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDIX

LIST OF ABBREVIATIONS

AFM	*Atomic Force Microscope*
BET	*Brunauer-Emmett-Teller*
FESEM	*Field-Emission Scanning Electron Microscope*
FTIR	*Fourier Transform Infrared Spectroscopy*
HRTEM	*High-Resolution Transmission Electron Microscope*
MHD	*Magnetohydrodynamics*
SAED	*Selected Area Electron Diffraction*
STM	*Scanning Tunneling Microscope*
TEM	*Transmission Electron Microscope*
TG-DTA	*Thermogravimetric - Differential Thermal Analyzer*
XPS	*X-ray photoelectron spectroscopy*
XRD	*X-ray Diffraction*