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Calculation of Plasma Parameters Resulting From The Wires-Exploding Technique of Copper Material

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Abstract:

In this research the diagnostic of optical emission spectroscopy from exploding copper wires have done by change of wire diameter. By using Boltzman plot can be calculated the plasma electron temperature T_e, and by using Stark broadening can be evaluated the electron density n_e for different copper wire diameter (0.2, 0.25 and 0.3) mm at current 75 A in deionized water. It was observed that the electron density n_e decrease with an increasing wire diameter from 0.2 mm to 0.3 mm while the electron temperatures increase for the same wire diameter. The plasma has a peak 652 nm corresponding to Hα line for .hydrogen .atoms which obtained from .optical emission spectrum (OES), the peaks belong to atomic copper lines. The plasma electron temperature related with emission line intensity and number .density with the formed copper nanoparticles size was studied.

Key words: Plasma, OES, Exploding wire.

1. Introduction:

The refers nano (originated) from the Greek (nanos) which, means 'dwarf'. It is one Billionth of a meter :sH sr?= .; Therefore, whenever we think about nanoscience or nanotechnology, very small objects come to the mind. In fact, this branch of science and technology deals with materials having at least one spatial dimension in the size range of (1 – 100) nm, [1]. Richard P. Feynman (Nobel Laureate in Physics, 1965 is often credited for introducing the concept of nanotechnology about 50 years ago. In the annual meeting of the American Physical Society at California Institute of Technology on 26 December 1959, he delivered a famous lecture entitled "There's Plenty of Room at the Bottom". In this lecture, he talked about writing twenty four volumes [2]. A primary interest in the concept of nanotechnology comes from its connections with biology. The smallest forms of life, bacteria, cells, and the active components of living cells of biology, have sizes in the nanometer range. Nanotechnology can be defined as the ability to create, control and manipulate objects on nano scale with the aim of producing novel materials that have specific properties (functionalized materials). These nanomaterials may have different nano shapes such as nanorod or nanowire and nanotube [3].

Nanotechnology is the design, fabrication and application of nanostructures or nanomaterials and the fundamental understanding of the relationships between physical properties or phenomena and material dimensions. Nanotechnology also promises the possibility of creating nanostructures of metastable phases with non–conventional properties including superconductivity and magnetism, [4]. There are two approaches to the synthesis of nanomaterials : bottom-up and top - down. In the bottom-up approach, molecular components arrange themselves into more complex assemblies atom-by-atom, molecule-by-molecule , cluster-by cluster from the bottom (e.g., growth of a crystal), [5]. In the top-down approach, nanoscale devices are created by using larger, externally -controlled devices to direct their assembly. The top-down approach often uses the traditional workshop or microfabrication methods in which externally controlled tools are used to cut, mill and shape materials into the desired shape and order. Attrition and milling for making nanoparticles are typical top-down processes.

Bottom-up approaches, in contrast, arrange molecular components themselves into some useful conformation using the concept of molecular self-assembly. Synthesis of nanoparticles by colloid dispersions is an example of the bottom-up approach. An approach where both these techniques are employed is known as a hybrid approach . Lithography is an example in which the growth of thin film is a bottom-up method whereas itching is a top-down method [6].

2. Experimental Work:

2.1 Exploding Wire System:

In this study, the details of experimental procedures is described. By exploding copper wires, with different diameters and different current, in deionized water. The plasma parameters were studied by optical emission spectroscopy (OES) depending on the emitted light from the copper plasma plume.

Exploding Cu wires in different diameter (0.2, 0.25 and 0.3mm) in deionized water with 75 A using DC power supply with 28V. After many exploding process in solution.

We used DC welding have two terminal: the negative terminal to the wire by another ohmic connection and from the positive terminal to the metal plate by an ohmic connection.

The first electrode (the metal plate 40 x 20 x 2 mm) is connected to one terminal of 28 V DC battery, while as the second terminal is connected to the wire (as a second electrode) which to be exploded, see figure 1.

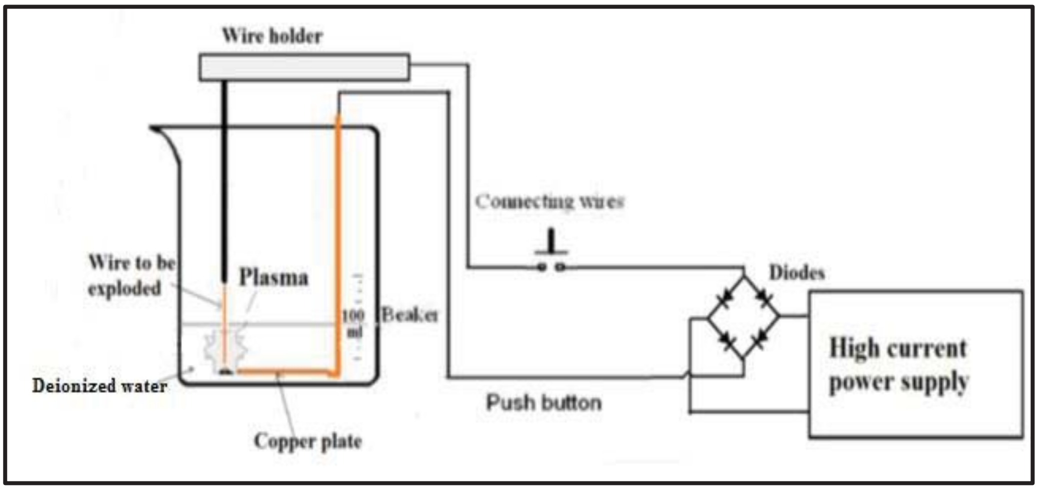


Figure (1): Diagram of the electro-exploding wire.

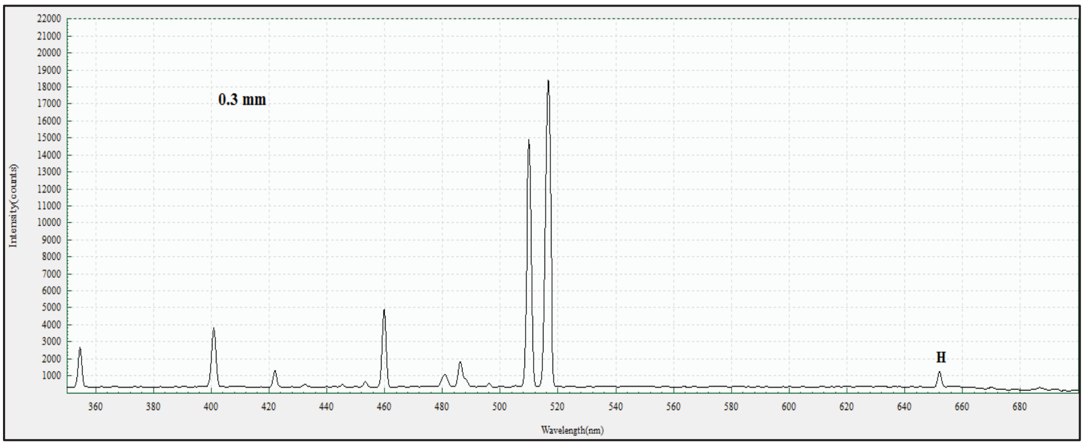
We used A 500 ml beaker as vessel. It is necessary to keep the room between the wire holder and metal plate. The metal plate are fixed on the base of placed in glass vessel that filled by 100 ml of deionized water. When just touching the first electrode, through precise mechanical movement. The wire explosion technique occur for very short time, after the contact is happened between the wire and the plate.
The Cu nanoparticles dispersed in the deionized water. We can use the mentioned length of wire for several contacts, then we replaced it. The deionized water contained the Cu NPs as colloidal form.

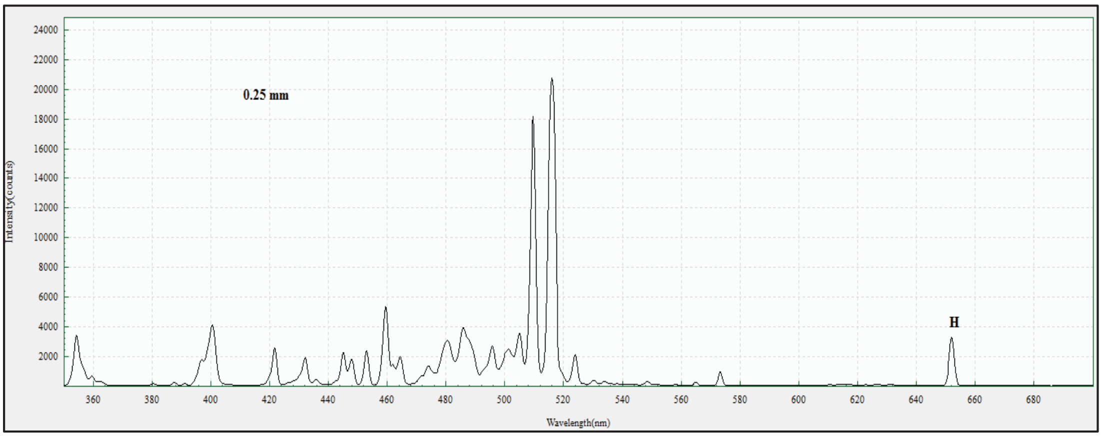
2.2 Deionized Water:

Deionized water was used to preparation of all samples and solution in this work. Even such water is entirely pure; however, it is contaminated by salts ions. Deionized water was prepared in laboratory in glass containers avoid the contamination.

3. Results and Discussion:

Figure 2 shows the OES for plasma produced by exploding of different diameters (0.2, 0.25, 0.3) mm copper wires and constant DC current of 75A.
A strong peak located at about 652 nm corresponding to Hα line for hydrogen atoms produced from water molecular dissociate. Also, a small peak appear at 575 nm corresponding to sodium [7] comes from the impurity. It can be observed that the intensities of peaks increase with decreasing wire diameter, so the density of current increasing. This result is in accept with Wankhede [8].





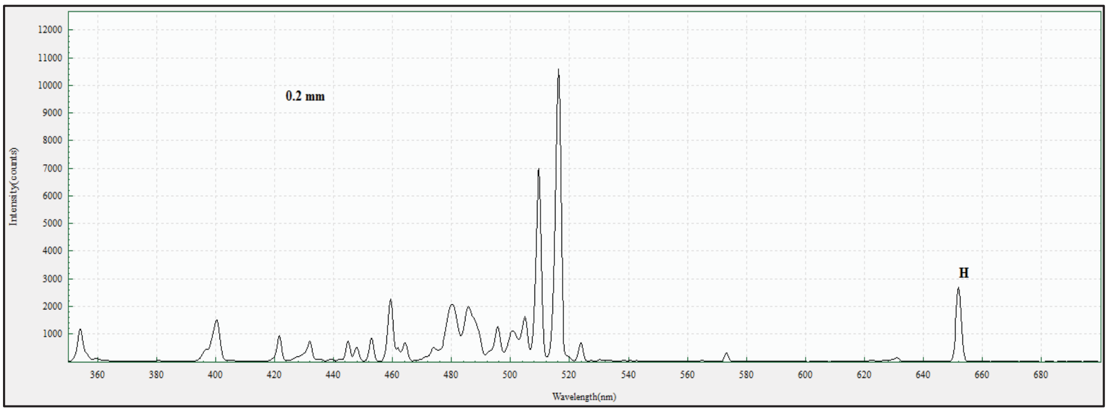
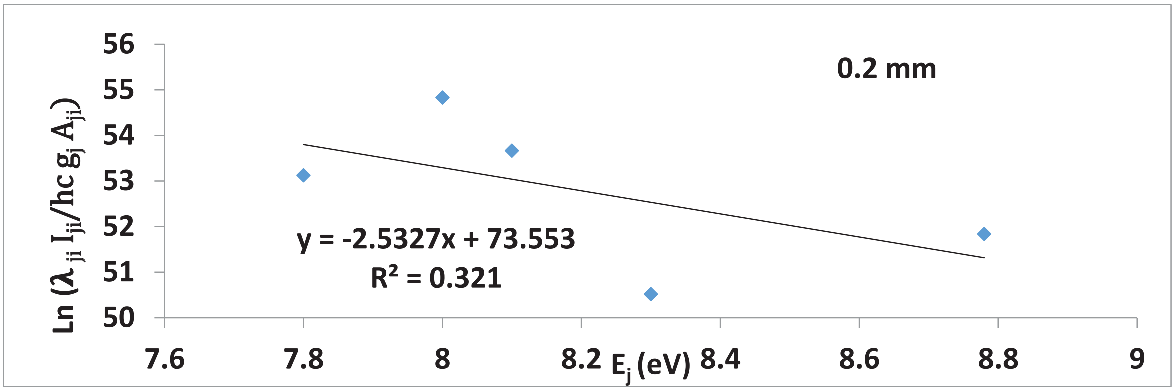
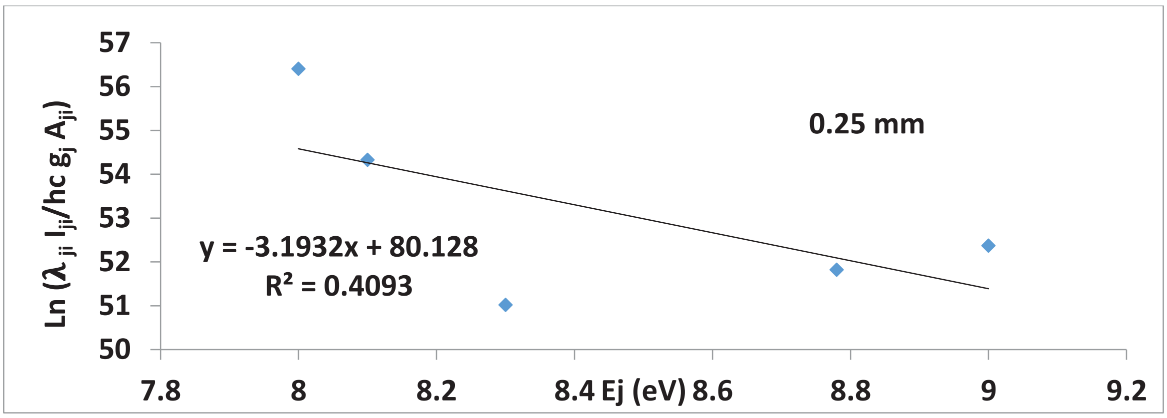


Figure (2) Emission spectra for copper wire with different diameter by exploding wire and 75A current.

The electron temperature T_e were calculated by Boltzman plot using five of Cu lines at (400, 422, 453, 459, 480) nm for the different wire diameter, as shown in figure 3. The T_e values were calculated using the relation between $Ln(\frac{I_{ji}\,\lambda_{ji}}{h\;c\;g_j A_{ji}})$ versus upper energy level (E_j). The equations of fitting lines and the R^2 were shown in the figure. R^2 is a statistical coefficient indicating the goodness of the linear fit which takes a value between (0, 1), where values closer to1 is the best one. The figure shows that the value of R^2 varies from 0.321 to 0.4235.





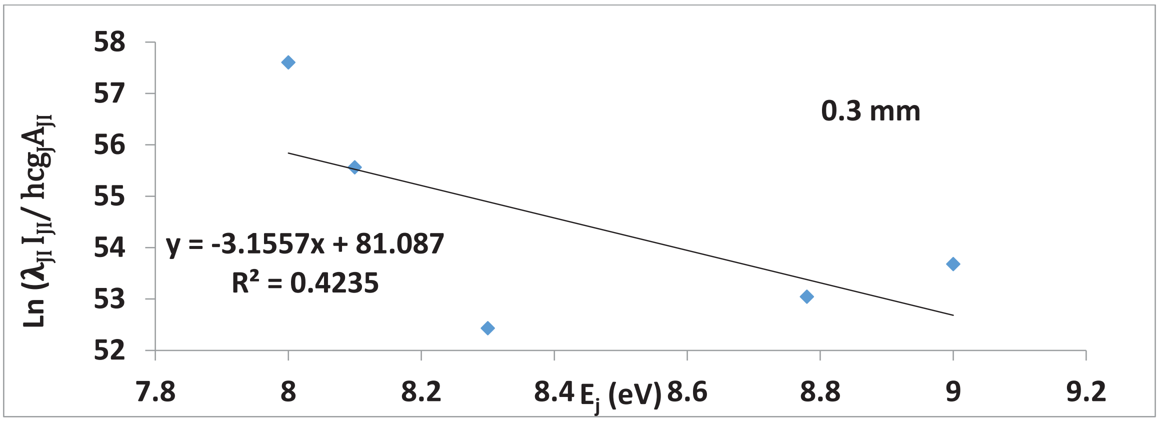


Figure (3) Boltzmann plot from five Cu lines produced by exploding wire with 75A.

Fig. 4 shows the 652 nm hydrogen line peak profile. The FWHM can by using Gaussian fitting to evaluated the density of electron for different samples can using Stark effect depending on the standard values.

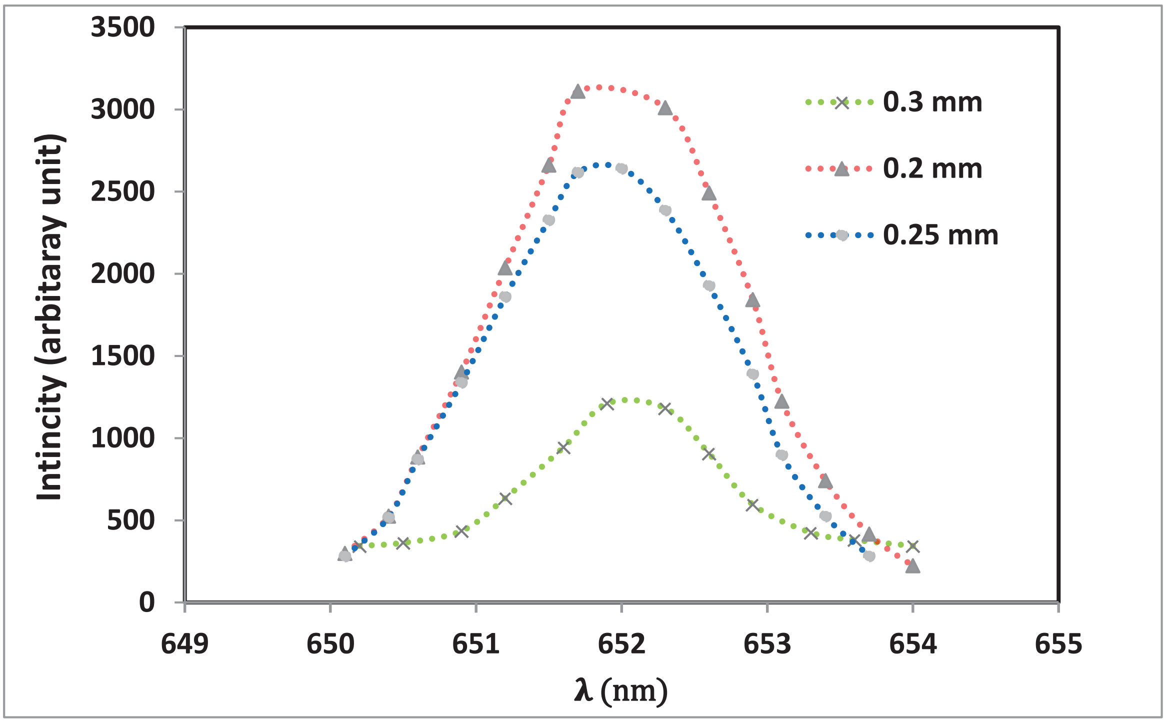


Figure (4) H 652.279 nm peaks broadening and there Gaussian fitting for different wire diameters and current of 75 A.

The variation of temperature of electron T_e and density of electron n with wire diameter were shown in Fig. 4 and Fig 5. This figure shows that ne decrease from 27.4313×10^{17} cm^{-3} to 24.0353×10^{17} cm^{-3} with increasing wire diameter from (0.2) mm to (0.3)mm the result of current density is decreasing . This result is agree with Wankhede [8]. The decrement in concentration cause decreasing in collision which caused to increase in electron temperature, where the electron temperatures lose by different ways (elastic, excitation and ionization collisions).

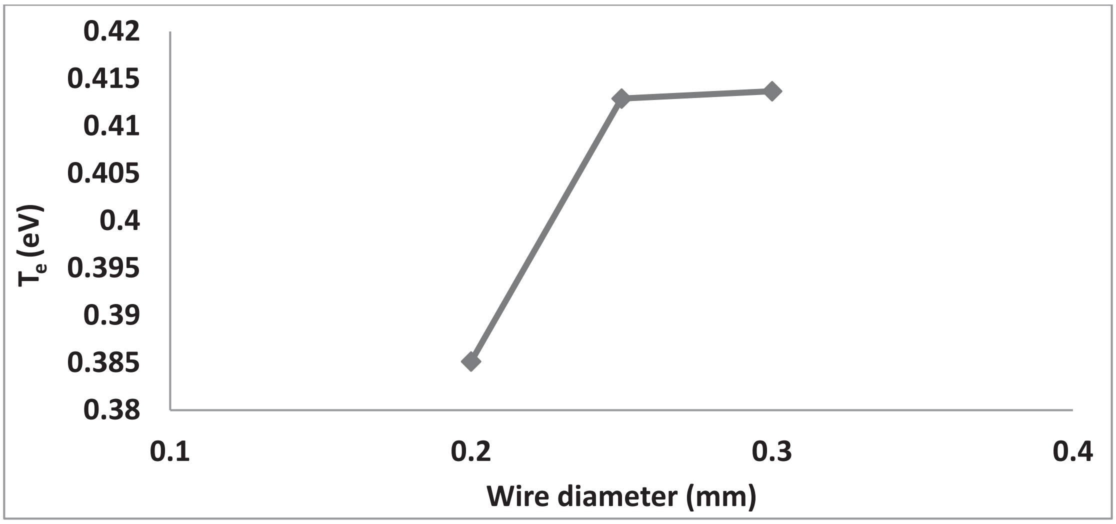


Figure (5) Thevariation of T_e for different diameter copper wires and 75 A current.

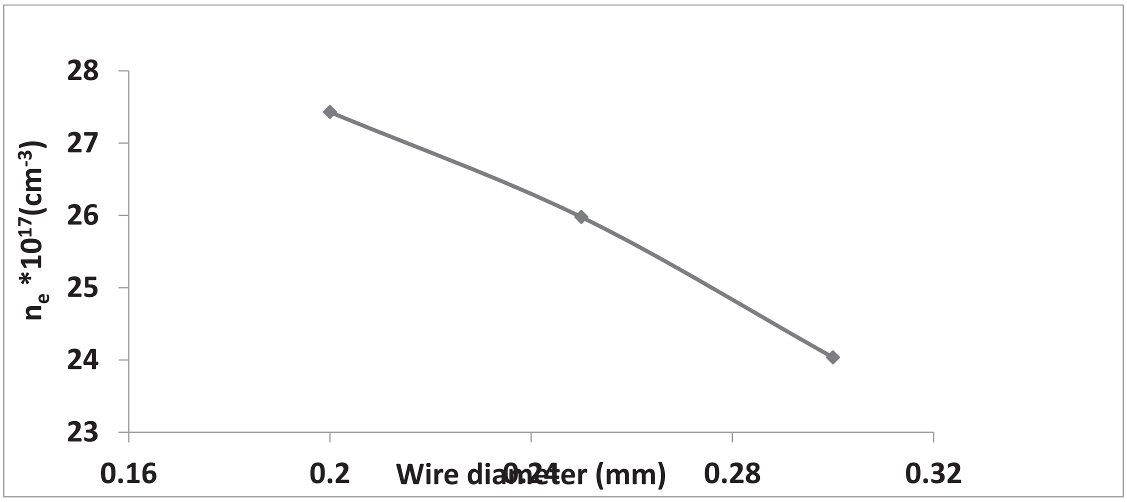


Figure (6) Thevariation of n_e for different diameter copper wires and 75 A current.

4. **Conclusions:**
1. There is a relationship between the density of electrons in the plasma and the number of particles measured by atomic absorption and generated by the detonation of wires.
2. Higher energy with the lower wire diameter should be preferred for finer size nanoparticles
3. The plasma temperature measured increase when the diameter of the wire is increase and increase with increase the current.
4. The electron density in the plasma measured increase with increase current and decrease with increase wire diameter.
5. The wire explosion technique is ecologically safe, pollution free process, which is desirable for our environment protection.

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