Design and Prototype Mold of Carbon Composite Electrode for Synthesis Graphene with Electrochemical Exfoliation Method

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Abstract: Graphene is a new material that has special electrical, thermal, magnetic, optical, mechanical and chemical properties. The method for synthesis graphene that is currently being developed is through the electrochemical exfoliation because it has the advantages of a fast, environmentally friendly manufacturing process, and low costs in the production process, and the resulting low defect value of the graphene material. One of the most important component for syhnthesis graphene with this method is electrodes. Electrodes at this method act as a source of carbon for synthesis graphene. Most of the researcher use graphite (sheet, rod, and flakes) as a electrodes for this method. This research aims to synthesis graphene with electrochemical exfoliation with carbon composite as a electrode. This paper is the first stage at this research to design and create a mold of carbon composite electrode. The result of the first stage of this research is using material ST 37 that have thick 5mm to create mold of carbon composite electrode, the shapes of this electrodes is block with dimension 15 x 1 x1 [cm].

1 INTRODUCTION

The advantages of graphene material properties because of it is a thin sheet (nanoparticle scale), but have high strength and electrical and thermal conductivity. The thermal conductivity of graphene is five times greater than copper, but the weight of the graphene material is four times lower than copper and the electrical conductivity of graphene is equivalent to copper. Graphene has a lower density than steel, but the strength of graphene can reach up to fifty times that of steel. In addition, graphene has a very high surface area of up to 2,500 m^2 / g (Liu et al., 2019). Therefore, many researcher have research on graphene materials for application in the energy sector, one of which is to store energy such as batteries, solar cells and supercapacitors.

Nowdays, a graphene synthesis method that is more environmentally friendly is being developed, namely the electrochemical exfoliation method. The electrochemical exfoliation method has advantages in terms of a fast, environmentally friendly, and low cost manufacturing process in the production process (Ramadhan et al., 2019). This method produces graphene flakes that have a smaller defect value because the electrochemical removal of the graphite layer requires a lower agitation intensity to disperse the graphene compared to other liquid phase methods (Mir & Shukla, 2018). The synthesis of graphene with the electrochemical exfoliation method requires 3 components, there are an electrolyte solution, an electrode as well as a carbon source, and an electric current.

One of the most important component for synthesis graphene with electrochemical exfoliation method is electrodes. This research aims to synthesis graphene with electrochemical exfoliation with carbon composite electrode. (Pramono et al., 2012) have researched on the electrical conductivity of carbon-carbon composites from coal tar and coconut shell waste. The results showed that the increase in density of the carbon-carbon composite material had an effect on the increase in the conductivity of the electrical material.

Based on those explanation, in this paper, the research focuses on design and create a mold of carbon composite electrode. The shapes of electrodes that will use for synthesis graphene is a block with dimension 15 x 1 x1 [cm]. This research will also tests on the molds that have been created to produce carbon composite electrodes for graphene synthesis, then the electrodes will be tested on initial test for act as a source of carbon to synthesis graphene with electrochemical exfoliation method.

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2 RESEARCH METHOD

This research begin by design the mold of carbon composite electrode that will produce electrode with block shapes 15 x 1 x1 [cm]. One of the most important things to design this mold is procedures to produce this carbon composite electrode. Refer to (Pramono et al., 2012), procedures to produce carbon composites electrode are :

1. Prepare the basic material of carbon 300 mesh and tar with a ratio of 5: 7
2. Melt the tar for the first before mixture with 300 mesh of carbon, and then mix the tar that has been melted with 300 mesh of carbon.
3. Put the mixture into the mold of carbon composite electrode, and giving the pressure at 200 bar.
4. The carbon-carbon composite mixture at the mold of electrode was heating/curing at a temperature of 200^0C.
5. Furthermore, the carbon composite electrode is remove from the mold. To optimize the electrical conductivity of the electrodes, a re-curing process was carried out without mold at a temperature 950^0C.

Based on those explanation about procedure to produce carbon composite electrode, we must create the mold of carbon composite electrode that have specification to easy remove the carbon composite electrode after curing 200^0C. On the other side, the material for the mold must good in mechanical and thermal properties, such as have a good strength, good a conductivity thermal, and good a resistant corrosion, because the mold will be pressed at 200 bar and curing at 200^0C. ST 37 with the thick 5 mm is the best material for this mold. Table 1 showed the mechanical properties of ST 37 and Table 2 showed the chemical composition of ST 37.

Table 1 Mechanical Properties of ST.37

Grade	Tensile strength (Mpa)	Yield strength (Mpa) not less than		Elongation (%) not less than
		= 16 mm	>16 mm	
St37	350-480	235	225	25

Table 2 Chemical Composition of ST 37

Grade	C	Si	Mn	P	S	Cr	Ni	Cu
St37	0.17	0.17-0.37	0.35-0.65	0.025	0.02	0.25	0.25	0.25

3 RESULTS AND DISCUSSION

To create the mold of carbon composite electrode that have specification easy to remove the electrode after curing at 200^0C and produce the carbon composite electrodes that have a good conductivity, design the mold is important thing for the first step. Figure 1 showed the design for the part of the base of the mold. The design for this mold is to produce 4 electrodes that each electrode have dimension 15 x 1x 1 [cm]. The method to create this part is by the welding the material ST 37 refer to the design. The mold have length and width 230 x 140 [mm]. There is a part like a fin at the mold base that act as a holder with dimension 10 x 20 [mm], this part will be welded on the mold base. The number of fins on the one of the side at the mold base is 6, the distance between the fins is 10 mm.

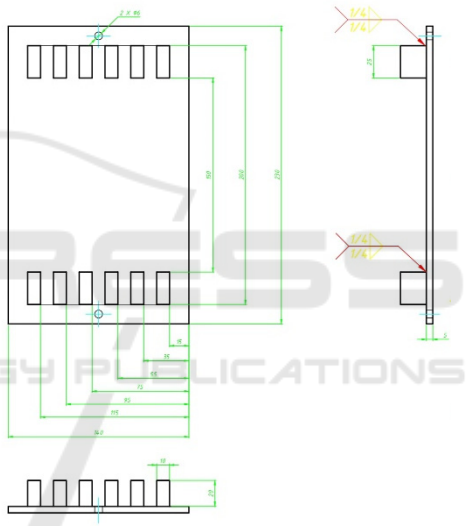

Figure 1: Part of the Mold base

Figure 2 showed the design for part of the mold base that act as a holder that will put into the part between the fins, this material is amuntit. This part is not welded to the mold base because of the molding must have spesification easy to remove the electrodes after the curing at 200^0C. The dimension of this part is 200 x 10 x 20 [mm].

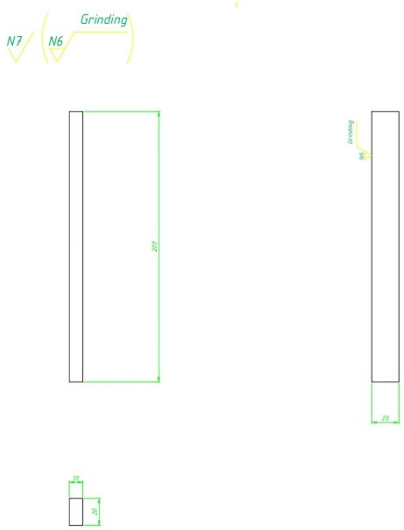

Figure 2: Holder of the Mold Base

Figure 3 showed the final mold base of carbon composite electrode that will produce 4 electrodes, combination figure 3 and 4.

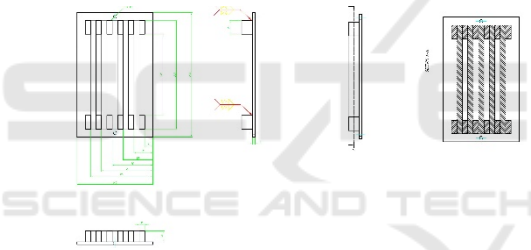

Figure 3: Mold Base of Carbon Composite Electrode

Figure 4 showed the design for the mold top that have part to press the material electrode. The material for this part is ST 37, same to the material for the mold base. The method to create this part is by the welding the material ST 37 refer to the design. The length and width of the mold top is 230 x 140 [mm], there are 4 parts that act as a press the material electrode. The dimension for this part is 150 x 10 x 5 [mm]. The final result of the mold of carbon composite electrode can be seen at figure 5.

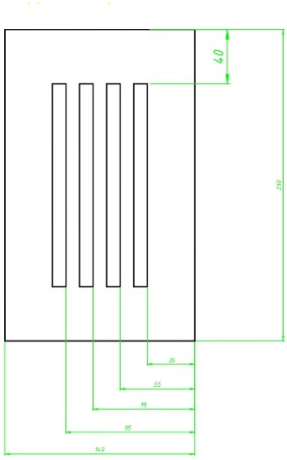

Figure 4: Mold Top of Carbon Composite Electrode

Figure 5: Mold of Carbon Composite Electrode

After that, the mold will be tested to produce electrodes from carbon composite that can be seen on figure 6 and figure 7.

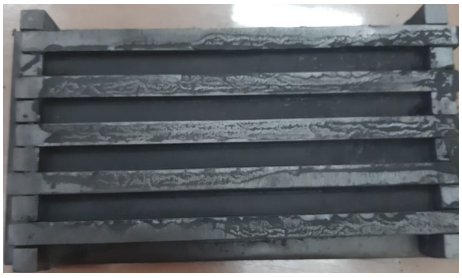

Figure 6: Carbon Composite Electrode at The Mold

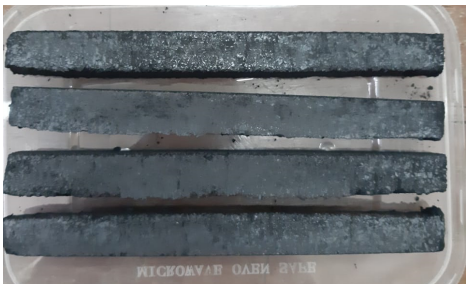

Figure 7: Carbon Composite Electrodes

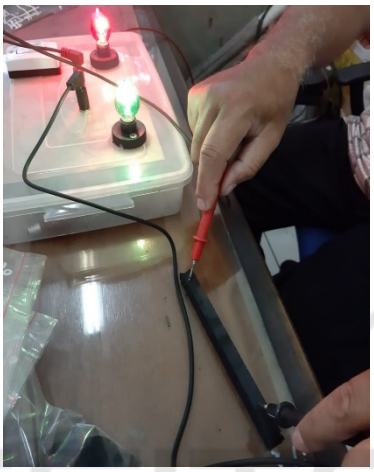

Figure 8: Conductivity Test for The Carbon Composite Electrode

Figure 9: Electrochemical Exfoliation with Carbon Composite Electrodes

Figure 10: The Result of Electrochemical Exfoliation with Carbon Composite Electrodes

Figure 8 show the result of the conductivity test carbon composite electrode that can turn on the lamp, so this electrode have electrical conductivity. The result of initial test that using carbon composite electrode for synthesis graphene with electrochemical exfoliation method can be seen at figure 9 and figure 10. It was proven that the carbon-carbon composite made of coconut shell and tar was successful in acting as anode and cathode, and the exfoliating carbon layer on the anode and cathode succeeded in forming graphene.

4 CONCLUSION

Mold of the composites carbon electrode can be made from material ST 37 which have thick 5 mm. The mold prove can produce 4 electrodes, each electrode have dimension 15x1x1 [cm]. The carbon-carbon composite made of coconut shell and tar was successful in acting as anode and cathode, and the exfoliating carbon layer on the anode and cathode succeeded in forming graphene.

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