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Synthesis and Characterizations of Graphene Growth by RF-PECVD on Thin Films at Low Temperatures

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***Abstract*— High temperature is crucial for supplying enough energy to the graphene growth by using CVD method. Plasma existence in CVD system is the alternative to lower the growth temperature and promote the graphene growth mechanism. This plasma energy helps in changing the hydrocarbon gas to reactive radicals. The radicals and ions bombard the substrate surface which resulting in a more active surface structure by speeding up the chemical reaction. Here, we report graphene growth on polycrystalline Cobalt (Co) and Nickel (Ni) films, respectively using our simplified set-up of RF-PECVD and characterize their structural properties.**

Keywords—Graphene growth, plasma CVD, Low temperature, graphene on metal

I. INTRODUCTION

As one of three-dimensional materials, graphene exhibits excellent electrical, mechanical, optical characteristics as potential materials for various applications [1]. In graphene production, growing graphene on metal was widely explored using CVD method [2]. However, high temperature needed during growth making the limitation to the low temperature substrate. Thus, with the aid of plasma energy, lower temperature growth can be achieved [3]. This method of Plasma Enhanced CVD is combines the high energy of plasma with the CVD system.

II. MATERIALS AND METHODS

A. Materials

There are two types of metal catalyst used, that is Nickel and Cobalt used in these experiments. 100nm of Ni and Co thin films were deposited on 100nm SiO_2/Si respectively. Meanwhile methane was utilized as carbon source to supply seeding for graphene formation. Graphene growth process was done with only one gas, acting as the carbon source for the graphene formation [4].

B. Methodology

PECVD system was setup in our C-electronic labs. The synthesis was conducted in vacuum condition at low pressure growth [5]. Two different plasma power conditions were applied to systems that are 0 W and 40 W. CH_4 with 120 sccm flow rate inserted onto the quartz tube for 5 min. The growth process is divided into 4 parts; cleaning, heating, growth and cooling process [6].

C. Characterizations

The as-grown graphene was characterized by using Raman Spectroscopy and X-ray Photoelectron Spectroscopy (XPS).

III. RESULTS AND DISCUSSION

A. Physical Characteristics

UniRAM Raman spectroscopy with 532 nm excitation laser was used to characterize structural and electronic properties of graphene [7].

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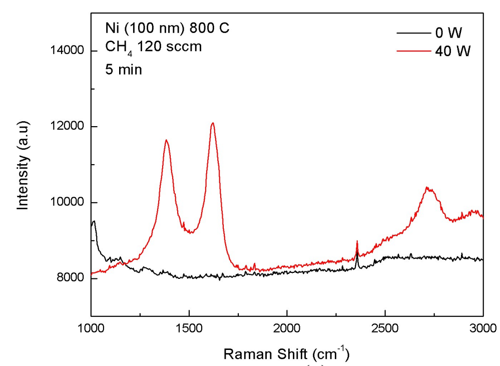

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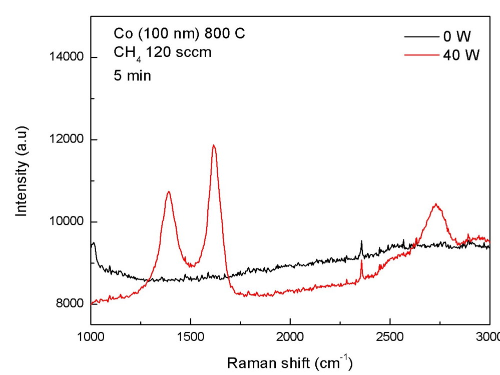


(b)

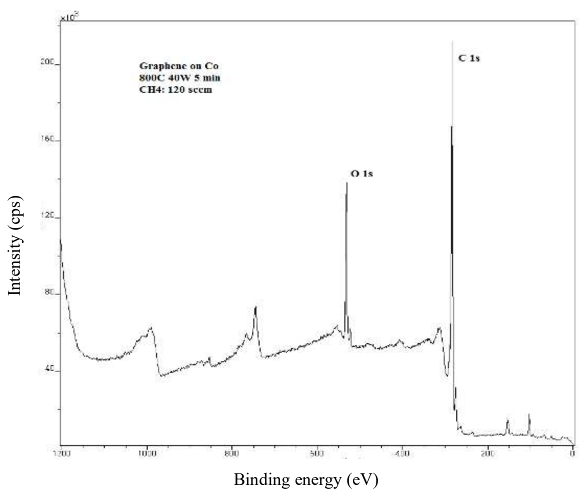
Fig 1: Comparison of Raman spectra at growth conditions 0W and 40W on (a) Co and (b) Ni films

Fig 1 (a) shows two Raman spectra; 40 W and 0 W of plasma power both in Ni. 3 strong peaks were observed in 40 W plasma power as the D, G and 2D band. From that we identify that multilayer graphene was produced [8]. Another Raman spectrum of 0 W conditions shows those 3 peaks absent on the sample. These results also take place for the growth on Co shows in Fig. 1(b).

These observations explained that plasma play a significant role in graphene growth for both Co and Ni samples. Plasma contributes to extra energy for methane decomposition in graphene formation on Co and Ni substrate [9].

B. X-ray Photoelectron Spectroscopy (XPS) Analyses

XPS analysis was done to observe the quality of graphene produce from the existent of carbon and oxygen element. Fig. 2 (a) shows that element of carbon higher that oxygen. The XPS C1s spectra of graphene consist of four peaks that correspond to sp2 carbon at 284.6 eV shown in Fig. 2(b)



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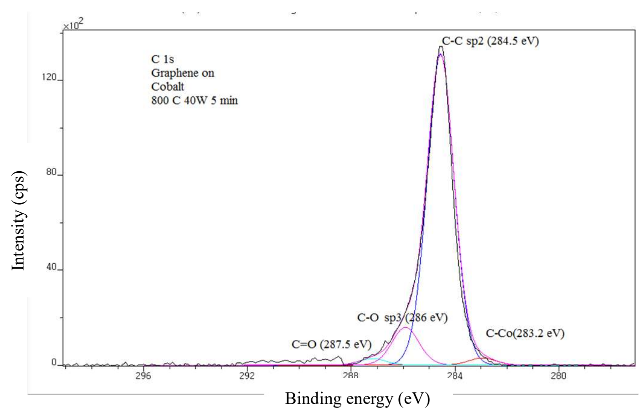

(b)

Fig. 2. XPS of graphene on Co films (b) C1s spectra of graphene on Co films

IV. CONCLUSIONS

From our study, it showed that plasma play a significant role in graphene growth. Plasma contributes to extra energy for methane decomposition in graphene formation on metal substrate. To improve the quality of graphene produced, it is crucial to study other parameters such as growing time, gas flow rate, type of metal and others. Thus in future, low temperature graphene growth can be conduct, enable graphene to growth on flexible substrate.

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