Chemical Vapor Deposition Synthesis of Graphene from Alcohol

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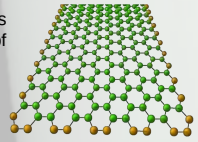
Introduction

➢ **Graphene** is a 2D sheet of sp^2-hybridized carbon.



Right: Graphene molecular structure

➢ Graphene synthesis methods: Mechanical exfoliation, oxidation of graphite, liquid-phase exfoliation and epitaxial growth such as chemical vapor deposition (CVD).

Above: Graphene field-effect transistors

➢ Why CVD? Higher quality Larger quantity

Above: SEM image of crumpled graphene

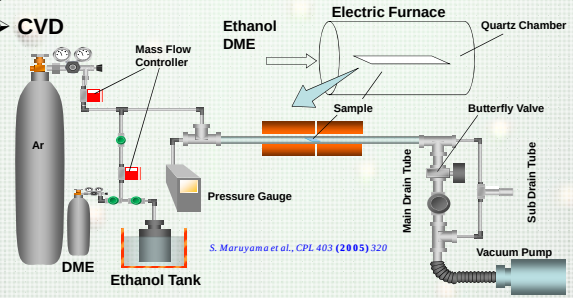
➢ Why Alcohol? High purity carbon source.

➢ Potential applications include: Graphene transistors, ultracapacitors, solar cells and flexible displays.

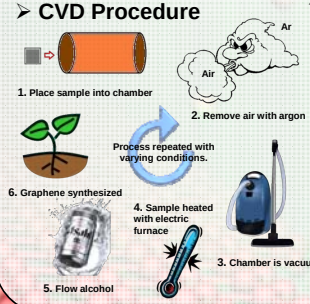
S. Maruyama et al (2010). Y. Lin al., *NanoLett.* (2009). A. Geim et al., *Nano Lett.* (2005).

Experimental

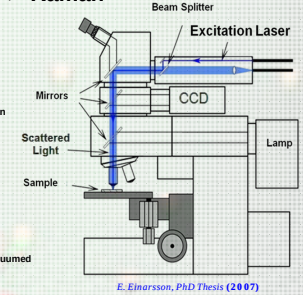
➢ **CVD**



➢ **CVD Procedure**



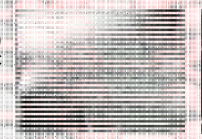
➢ **Raman**



Results

➢ **CVD synthesis of graphene from EtOH on Ni foil**

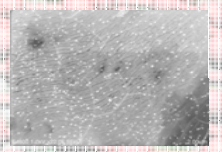
Optimal Conditions:
EtOH(CH_3-CH_2-OH)
Temperature: 900°C
Pressure: 300 Pa
CVD Time: 5 Min



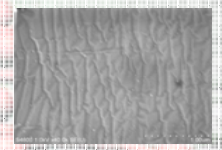
Below: Raman spectroscopy of the Ni Foil after having gone under CVD reaction.

Above: Photograph of the Nickel foil before undergoing CVD reaction.

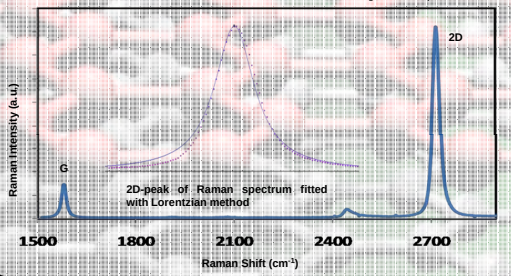
Above: Photograph of Nickel foil after undergoing CVD reaction. Note the color changes. This sample is much darker.



Above: SEM image of crumpled graphene on Ni substrate (x22.0k).

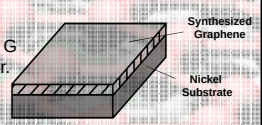


Below: SEM image of crumpled graphene on Ni substrate (x40.0k). **Graphene crumpled due to Ni expansion from high temperature.**



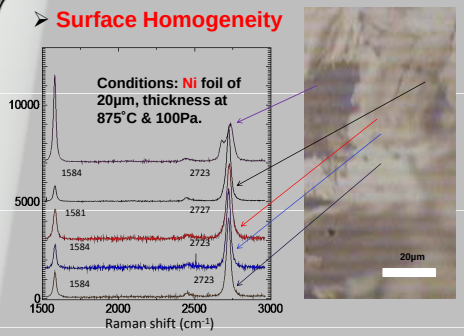
➢ **Discussion**

1. Graphene has a 2D & G peak ratio of 4.5 or greater.
2. Graphene's 2D-peak can be fitted with a single Lorentzian.
3. Both conditions were met as shown on the diagram to the left, we confirm the growth of graphene on Ni foil.



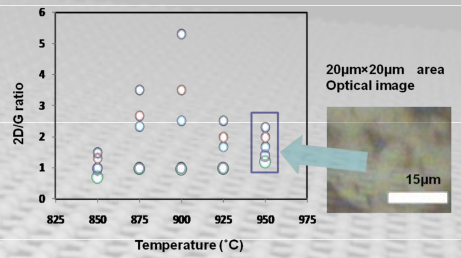
Results Cont'd

➢ **Surface Homogeneity**



➢ **A Dilemma: Homogeneity & Quality**

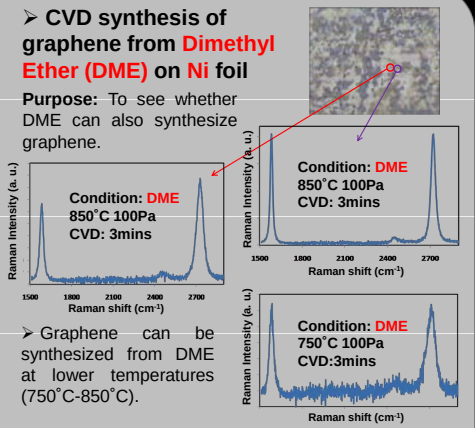
1. We selected 5 points randomly on 5 samples of different temperatures and mapped out the relationship between 2D/G ratio and temperature.



2. Quality graphene obtained at 875˚C and 900˚C.
3. Best surface homogeneity at 850˚C and 950˚C.
4. Difficult to synthesize both quality and homogeneous graphene.

➢ **CVD synthesis of graphene from Dimethyl Ether (DME) on Ni foil**

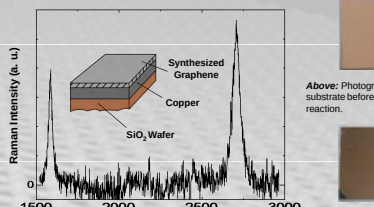
Purpose: To see whether DME can also synthesize graphene.



➢ Graphene can be synthesized from DME at lower temperatures (750˚C-850˚C).

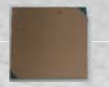
➢ **CVD synthesis of graphene from EtOH on Cu foil**

Purpose: To see whether changing the substrate to Cu would allow us to produce graphene.



Above: Raman shift of copper sample after undergoing CVD. We confirm the growth of graphene on Copper.

Above: Photograph of the Copper substrate before undergoing CVD reaction.



Above: Photograph of Copper substrate after undergoing CVD reaction. Note the color changes. This sample is much darker.

Conclusion

➢ We are capable of reproducing results of CVD synthesis of graphene on Nickel substrates with both ethanol and dimethyl ether as well as Copper substrates with ethanol.

➢ When using Nickel foil, high quality graphene can be obtained at 875˚C and 900˚C.

➢ When using Nickel foil, surface homogeneity is better achieved at 850˚C and 950˚C.

➢ Copper substrates can be used for graphene synthesis; however, surface homogeneity is difficult to achieve.

➢ Graphene can be synthesized from DME at lower temperatures than ethanol (750˚C-850˚C).

Acknowledgements

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Poster Background, J. Warner et al., *Nature Nanotechnology, Vol 4.* (2009)