Solar energy is a promising source of power for solution of energy and environmental problem of the world. Fabricate of low cost solar cell - one of the most difficult task in photovoltaic research society. Various semiconductor materials have been used to fabricate solar cells that convert sunlight into electricity. Among them, silicon based solar cells are dominated in the market that are expensive, and thus not practical to use for daily life. One of the attractive alternatives is the application of carbon based solar cell that can be fabricated from hydrocarbon precursors which is cheap, abundant and non-toxic.

For application of graphene in different devices, it is needed to synthesis high quality of graphene as well as easy process is also highly desirable. Different methods are using for growing graphene on various substrate, like; thermal chemical vapour deposition (CVD), micromechanical cleavage or chemical exfoliation of graphite, thermal decomposition of SiC. Among various methods, thermal CVD has been a main method to synthesize of graphene in everywhere, however it requires high temperature (above ~1000°C), catalyst films, post-transfer and additional catalyst removal process are needed. For leaving this complicated graphene synthesis process, direct growth of graphene without using any other catalyst is very attractive.

In this work, we synthesized graphene directly (without using catalyst) on silicon substrate by microwave (MW) surface wave plasma (SWP) CVD using hydrocarbon as a source gas at low temperature (550°C). MW SWP CVD is a promising plasma source among the various types of existing plasma sources for the deposition of graphene thin film. Unlike other plasma sources SWP has an advantage that it does not corrode ions on the substrate surface. We believed that the direct synthesis of graphene on silicon is possible due to high radical density of MW-SWP CVD.

Moreover, we demonstrated graphene/silicon (G-Si) schottky junction solar cells. Current-voltage (I-V) characteristics under dark and illumination are shown in Figure 1. It showed photovoltaic behaviour with maximum open-circuit voltage ($V_{oc}$) 0.409 V; short circuit current density ($J_{sc}$) 17.038 mA/cm², fill factor (FF) 0.623 and conversion efficiency ($\eta$) 4.348 % are obtained. Compared to conventional Si solar cells, the fabrication process is greatly simplified, just graphene synthesized directly on n-type crystalline Si wafer at low temperate.

![Figure 1: Current-voltage characteristics of the graphene/silicon (G-Si) schottky junction solar cells under dark and light illumination (AM 1.5, 100 mW/cm²).](image-url)