

## Masataka Hasegawa

AIST, 1-1-1 Higashi, Tsukuba, Ibaraki, 305-8565, Japan

hasegawa.masataka@aist.go.jp

# High-throughput synthesis of graphene by plasma CVD and its commercialization

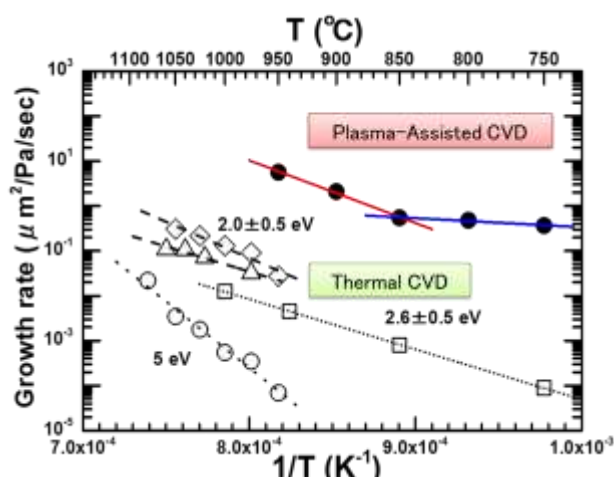
It is necessary to establish high-quality and high-throughput graphene synthesis technique for the practical application of graphene transparent films. In this talk development of high-throughput plasma-enhanced CVD for high quality graphene and its commercialization will be discussed.

The plasma CVD is characterized by high-growth rate graphene atomic membrane compared with conventional thermal CVD (fig.1), which is suitable for the high-throughput production for the industrial use [1,2,3]. We have achieved a graphene membrane with a transmittance of 95% (two-layer) for visible light and sheet resistance of  $130\Omega$  (gold chloride doped) in A4 size by developing an original plasma CVD method. The grain boundary and residual strain in graphene synthesized by plasma CVD with high-growth rate is analyzed by scanning transmission electron microscopy (STEM) and Raman spectroscopy [4]. The connection between the grains of graphene by high-throughput synthesis was confirmed. The compressive strain remained in graphene, which affects electrical conductivity, was observed. (fig.2). We have established a start-up company for the commercialization of high-throughput synthesized graphene.

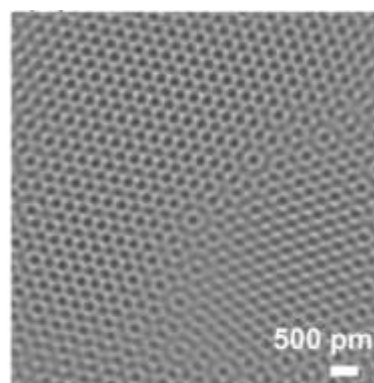
## References

- [1] R. Kato, K. Tsugawa, M. Ishihara, T. Yamada, Y. Okigawa, M. Hasegawa, Carbon **77** (2014) 823-828. .
- [2] Y. Okigawa, R. Kato, M. Ishihara, T. Yamada, M. Hasegawa, Carbon **82** (2015) 60-66.
- [3] R. Kato, S. Minami, Y. Koga, M. Hasegawa, Carbon **96** (2016) 1008-1013.
- [4] R.Kato, Y. Koga, K. Matsuishi, M. Hasegawa, Japanese Journal of Applied Physics **56** (2017) 030307-1-5.

## Figures



**Figure 1:** Temperature dependence of graphene growth rate for thermal CVD and plasma-assisted CVD which are normalized by CH<sub>4</sub> partial pressure.



**Figure 2:** Grain boundary of graphene synthesized by high-throughput plasma CVD