Fabrication of anti-reflection structures and carbon nanofibers using only ion beam irradiation to glassy carbon

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During our experiments with oxygen ion beam irradiation to glassy carbon (GC) surface we learned that the irradiated surface possessed anti-reflection (AR) property. Thus, we carefully chose irradiation conditions and examined relationship between irradiated morphology of GC surface and degree of AR effect. Our previous study reported that oxygen ion beam energy of 500 eV forms the finest pitch of conical AR structures, and that an irradiation time of more than 24 min can fabricate conical AR structures with heights more than 250 nm. The irradiated GC surface with this condition indicates anti-reflection property over the visible light range; furthermore, with this surface it is possible to prevent oblique incident angle reflection [1]. In this paper, optimization of oxygen gas flow rate and argon ion beam irradiation effect was studied.

For this work, mirror finished GC (Tokai Carbon Co., Ltd) was used as specimen. For oxygen and argon ion beam irradiation, an EIS-200ER (ELIONIX Co.) equipped with electron cyclotron resonance (ECR) was used. Ion beam irradiation was carried out at ion beam energy of 500 eV, irradiation time of 45 min, and microwave power of 100 W at room temperature. Then oxygen gas flow rates were varied from 1.4 to 3.0 sccm. Figure 1 shows the SEM images after oxygen ion irradiation. Figure 2 shows relative reflectance of irradiated GC surface at almost visible light range. These results shows oxygen gas flow rate of 2.0 sccm is optimum condition, and oxygen gas flow rate is very sensitive parameter for fabrication of AR structures. This reason is believed that amount of oxygen neutral radicals was varied with changing the gas flow rate.

Tanemura *et al.* reported that room-temperature growth of a carbon nanofiber (CNF) on the tip of conical carbon protrusions using argon ion beam irradiation [2]. However, conical protrusions were formed by sputtering with a seed supply method, so that this process was complicated. On the other hand, we have been obtained conical protrusions (AR structures) by only oxygen beam irradiation to glassy carbon. Therefore, argon ion beam irradiation of AR structures which was fabricated by oxygen ion beam irradiation at GC was carried out. Figure 3 shows SEM images growth of CNFs at top of conical structure. Argon ion irradiation condition was ion beam energy of 1000 eV, irradiation time of 15 min, and microwave power of 100 W at room temperature. In conclusion, CNFs have formed using two step ion beam irradiation method, and this process is very effective to fabricate of CNF.

[1] J. Taniguchi et al., *J. Nanosci. Nanotechnol., in press.*

[2] M. Tanemura et al., *Appl. Phys. Lett.* **84** (2004) 3831.

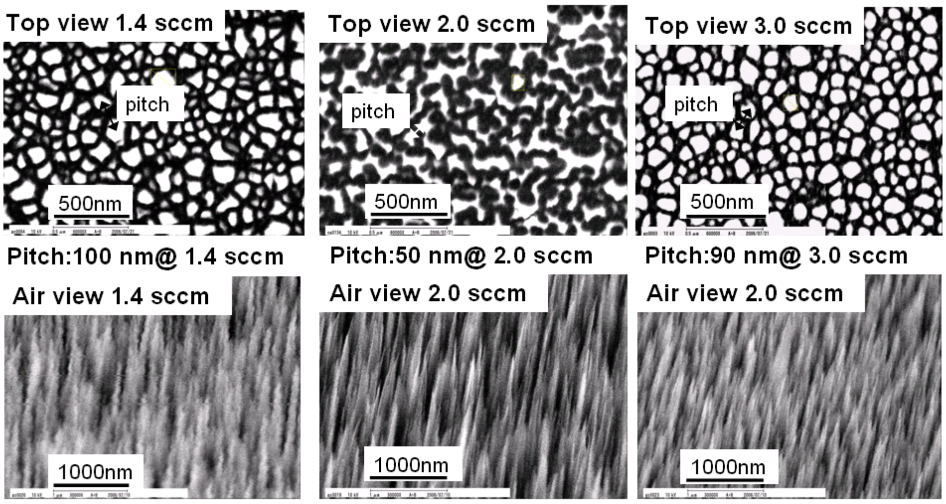


Fig 1: SEM images of GC surface after oxygen ion irradiation at various oxygen gas flow rate (1.4, 2.0, 3.0 sccm).

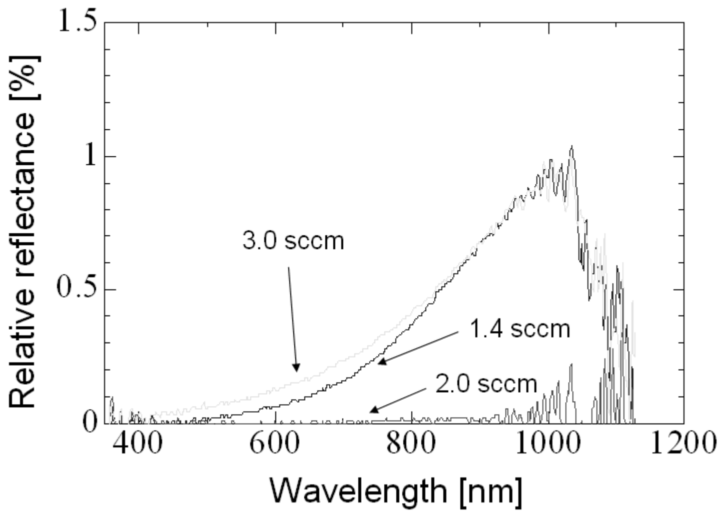
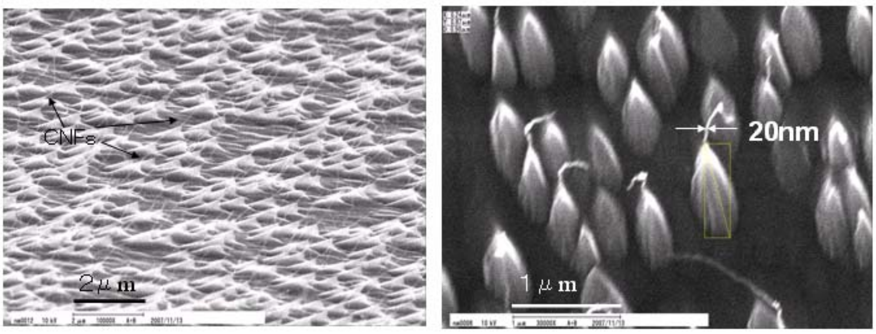


Fig 2: Relative reflectance of irradiated GC surface with various oxygen gas flow rates (1.4, 2.0, 3.0 sccm) at almost visible light range.



(a) SEM image of 45 tilted angle view of CNFs (b) SEM image of enlarged view of CNFs

Fig 3: SEM images growth of CNFs after argon ion beam irradiation.