6th Asia-Pacific Conference on Plasma Physics, 9-14 Oct, 2022, Remote e-conference

Atmospheric Pressure Cold Plasma: From Nanotechnology to Decontamination

Rajib Kar[1,2], Namita Maiti[1,2]
[1] Laser & Plasma Technology Division, Bhabha Atomic Research Centre, Mumbai, India-400085
[2] Homi Bhabha Natinal Institute, Anushaktinagar, Mumbai-400094
e-mail (speaker): rajibkar.ph@gmail.com / rajibkar@barc.gov.in

Atmospheric pressure cold plasma has gained worldwide attention of researchers for their exciting applications in different fields. Nowadays, these plasma sources are being used in researches ranging from plasma medicine to material processing **[1, 2]**. Primarily, three different types of atmospheric pressure cold plasma sources are the most popular ones. Namely, (a) atmospheric pressure plasma jet (APPJ), (b) dielectric barrier discharge (DBD) and (c) hollow cathode (HC) type of discharges **[1]**. The first two types of discharges are the most popular ones and normally get maximum attention for different applications. On the other hand, HC type of discharges are less explored in comparison. HC type of devices produce a unique opportunity of cold plasma production over large area in atmospheric pressure for different applications. The heart of this type of plasma device is the live electrode with grooves. For hollow cathode principle to work, both side of these grooves must be held at equal potential at an instant while the dimension of the groove should ideally be lesser than the electron-neutral mean free path **[3]**. In that case, stray electrons present inside the groove can gain energy from the applied alternating field and generate a breakdown for plasma creation. The device described here, has got an electrode which has spiral shaped groove inside the electrode having width of 250 μm. By changing composition and ratio of plasma forming gases judiciously we have used this device for generation of vertically aligned carbon nanotubes (CNTs) with intra-molecular junctions and later used it successfully for etching of Ta (a surrogate material for Pu).

Importance and future prospect of CNTs need no introduction but it is important to note that traditional radioactive decontamination methods cause secondary radioactivity and enhances a chance of accidental exposure to the personnel. Thus, there are ongoing researches for finding a potential alternative and atmospheric pressure cold plasma based chemical etching is one of those promising alternatives but major challenge remains in development of a large area atmospheric pressure plasma source which HC probably can solve **[4]**.

During experiment, a gas mixture of $He/H_2/C_2H_2$ was used with an Inconel acted as the substrate as well as ground electrode for the generation of CNTs. For etching, Inconel was replaced with Ta and a suitable gas mixture of $He/ CF_4/O_2$ was used for etching.

References
[1] Rajib Kar *et al.* Trans. Ind. Nat. Ac. Eng. **5**, 327 (2020).
[2] Bikash Sharma et al. Mat. Today Comm. 16, 178 (2018).
[3] H. Barankova et al. Appl. Phys. Lett. 76, 285 (2000).
[4] Rajib Kar *et al.* Handbook of Environmental Materials Management, Springer, 1-27 (2020)

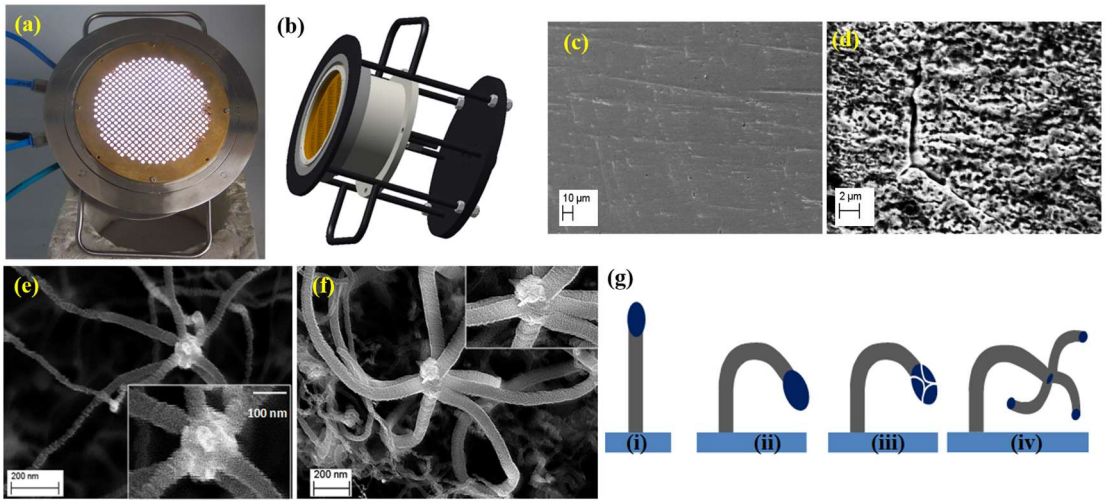

Figure1: (a) Photograph of hollow cathode device, (b) 3-D schematic of the device, SEM image of Ta substrate (c) before etching and (d) after etching by He/CF4/O2 plasma, (e) & (f) FESEM images of CNTs with intramolecular junctions, (g) production of these intramolecular junctions by catalyst splitting.