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Pure Alkali-Halogen Plasma Generation using Alkali Salt for Ion Source

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Much attention has been focused on carbon nanotubes (CNTs) with nanometer-scale diameter and micrometer-order length from the point of view of new materials and their applications such as next-generation nanoelectronic devices. Pristine semiconducting single-walled CNTs (SWNTs) under a field-effect transistor configuration exhibit only a p-type transport property. Here, accommodation of various dopant atoms, molecules, and compounds is available for modifying the intrinsic electronic and mechanical properties of SWNTs. When the connection of rows of alkalimetal and halogen atoms inside SWNTs is attained, a resultant p-n junction is expected to yield rectifying properties which are predicted by the recent theoretical simulation. With this aim, an alkali-halogen plasma source consisting of alkali positive ions and halogen negative ions is developed, which are suitable for a substrate-bias control in the encapsulation process.

The alkali-halogen plasma is generated by a dc magnetron discharge under a uniform magnetic (B) field. Spiral and linear cathodes of tungsten wire heated by resistive heating are set at the central axis of a grounded cylinder, and they are negatively biased to form an electric field E perpendicular to B field lines. Alkali-salt vapor is introduced from an oven, filling the cylinder. Thermal electrons drift in the azimuthal (EXB) direction and the electrons collide with alkali salt, dissociating and ionizing it. As a result of this process, alkali positive ions, halogen negative ions, and electrons are produced. Thus, the dissociation and the ionization can be controlled by only the E field under a constant B field. A magnetic-filter region is situated at the exit of the cylinder and electrons are removed from the plasma. The electron emission, E and B fields, and the length of the magnetic-filter region are optimized, resulting in the alkali-halogen plasma with the ion density 10^8 cm^-3 at B = 0.2 T.