Refined Beams of Neutral Free Radicals Produced by the Method of Photo-Deionization of Negative Ion Beams

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In order to further develop artificial metastable materials for quantum devices and nano-electromechanical systems it has become indispensable in recent years to ingeniously utilize selective surface reactions of neutral free radicals for the device processing. The problem encountered in the experimental study of a chemical reaction between a neutral free radical and a well-characterized material surface is how to supply a sufficient-flux purified beam of momentum-controlled neutral free radicals onto the surface. The beam, moreover, should be a steady-flux continuous one more useful for thin-film growth application than a pulsed one. Although many approaches to produce neutral beams have been developed in the fields of experimental chemistry, heating of plasmas for controlled thermonuclear fusion, and experimental simulation of low-earth orbit phenomena, efficient production of the steady-flux refined beam of neutral free radicals (RBNR) has not been realized yet. In order to overcome the difficulty we have proposed several experimental production approaches such as the method of photo-dissociation of energetic compound beams (PDECB) [1-4] and the method of photo-deionization of negative ion beams (PDINIB) [5-8].

We have been developing a trial surface-processing apparatus utilizing RBNR produced by the PDINIB method. When we apply RBNR to thin film growth, a steady-flux beam obtained using a CW laser is more useful than a pulsed beam. However, the power of an available CW laser is generally much weaker than the peak power of a pulsed laser. Thus, development of a multiple-pass photo-deionizer (MPDI) to enhance the photo-neutralization efficiency has been a key point to realize a practical steady-flux PDINIB apparatus. The rate of neutral free radical production by our trial PDINIB apparatus is estimated in Ref. 7 based on ion-current difference measurement by laser intensity modulation (ICD).

In the present study, we could improve the S/N ratio and the spatial resolution of the ICD measurement system 40 times and 7 times, respectively. This improved monitoring system was used for measurements of the spatial profile of the neutral-beam flux under various conditions of the neutral-beam production. At NGC2009 & CSTC2009, we will discuss the beam-profile controllability of the trial PDINIB apparatus based on the experimental results.

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