ENHANCING THE PERFORMANCES OF TRADITIONAL B-MINIMUM ECR ION SOURCES WITH MULTIPLE DISCRETE-FREQUENCY MICROWAVE RADIATION[1]

G. D. Alton, F. W. Meyer, Y. Liu, J. R. Beene, D. Tucker[2]

The performances of ECR ion sources, in terms of high-charge-state yields and intensities within a particular charge state, can be enhanced by increasing the physical sizes of the ECR zones in relation to the sizes of their plasma volumes. The creation of a large ECR plasma "volume" permits coupling of more power into the plasma, resulting in the heating of a much larger electron population to higher energies, the effect of which is to produce higher charge state distributions and higher intensities within a particular charge state than possible in present forms of the ECR source. The ECR plasma "volumes" of traditional B-minimum ECR sources can be increased by injecting broadband microwave radiation (multiple-discrete frequency, variable frequency, or broad-bandwidth frequency microwave radiation) derived from standard klystron, gyrotron, or TWT technologies (frequency domain). To demonstrate that the frequency domain technique can be used to enhance the performance of a traditional B-minimum ECR ion source, comparative studies were made to assess the relative performances of the ORNL Caprice ECR ion source, in terms of multiply-charged ion beam generation capabilities, when excited with high-power, single frequency or multiple-discrete frequency microwave radiation, derived from standard klystron and/or TWT technologies. These studies demonstrate that the charge-state populations for Ar^{q+} and Xe^{q+} move toward higher values when excited with two and three discrete-frequency, microwave power compared to those observed when single-frequency microwave power is used. For example, the most probable charge state for Xe is increased by one charge-state unit while the beam intensities for charge states higher than the most probable are increased by factors of ~ 3 compared to those observed for single frequency plasma excitation. The results of these measurements along with details on the modifications to the injection system required to couple the microwave radiation into the plasma volume of the Caprice source will be presented in this report.

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[2] Lambda Technologies, Inc., Raleigh, NC.