CHAPTER 1

Introduction

Low-energy ion beam bioengineering has recently emerged as a very potential new technique for biological mutation and gene transfer to benefit agriculture, horticulture and microbiology. In the technique, energetic ion beam bombards biological organisms in vacuum to induce direct mutation of the genetic substances or changes in microstructure of a cell envelope for subsequent gene transfer. In order to realize effective and appropriate ion bombardment of the biological materials for the application purposes, ion range in the materials must be known. For mutation, the ion range must reach the genetic substance inside the cell. If cells are directly exposed to ion beam, the ion range should be at least equal to the thickness of the cell envelope which is mainly composed of the cell wall. If tissues of organs (such as seeds) are bombarded, the ion range should be great enough to penetrate the coat of the cells. For gene transfer, the ion range is more delicate. In this treatment, normally cells are directly bombarded, and thus the ion range should be limited within the cell envelope. Any ion energy which leads to the ion range beyond the above-described criteria may cause death of the cell, which is definitely not expected. Ion range, more exactly speaking, ion penetration depth in materials partly depends on ion sputtering, the more sputtering the deeper the penetration. Although ion sputtering of conventional solid materials has been well studied, ion sputtering of biological materials has been found many special features such as considerably high sputtering yields. A basic reason has been attributed to especially porous structure of the biological materials. However, many features on this issue still remain unknown of unclear, particularly on quantification of the sputtering yields. Thus, investigation on ion beam induced surface sputtering of biological materials such as cell envelope and seed coat is fundamentally necessary. Secondary Ion Mass Spectrometry (SIMS) can play its advantageous role in this study. SIMS can *in-situ* detect what elemental species, compounds and clusters and how many are emitted during low-energy ion bombardment. From this information, partial and total sputtering yield can be estimated and hence the sputtering loss of the surface can be further calculated.

Today SIMS is widely used for analysis of trace elements in solid materials, especially semiconductors and thin films. Paul and Steinwedel (Paul and Steinwedel, 1953) developed the quadrupole analyzer in 1953. Mass separation is achieved solely with electric fields. It is a path-stability spectrometer where the “quality” determining the stability of the ion paths is the specific charge. An ideal quadrupole analyzer consists of four long hyperbolic cylinders in a square array with the inside radius of the array equal to the smallest radius of curvature of hyperboles. The main advantages of quadrupole analyzers are compact size, high transmission rate and opportunity for fast scanning (Van Bramer, 1998).