Ion irradiation effects in antimonide films


Universidade Federal do Rio Grande do Sul

Semiconductors are commonly implanted or irradiated with heavy ions to increase the number of defects in the matrix and enhance specific electrical and optical properties. For high energy irradiations (tens of MeV), the formation of ion tracks is well known and can be observed for a variety of materials, while ion energies around hundreds of keV can yield amorphization of crystalline substrates. A very peculiar effect is observed upon ion irradiation of antimonides, in the nuclear or electronic stopping power regime: the formation of a porous, sponge-like structure with nanometric dimensions. The effective surface area of the material is greatly increased, producing structures suitable for gas sensing or bolometry. Only a few semiconductors can be rendered porous by ion irradiation alone.

Here we show the ion irradiation effects on binary and ternary compound films containing In, Al, Ga and Sb grown by molecular beam epitaxy and magnetron sputtering. The first stages of porosity in InSb irradiated with 17 MeV Au ions were investigated by transmission electron microscopy, revealing the formation of pores before amorphization. The atomic composition and structure of porous GaSb and InSb were probed as a function of film thickness and irradiation fluence. The ion irradiation effects on the films were characterized by Rutherford backscattering spectrometry, scanning electron microscopy and x-ray diffraction analysis. The surface chemical components and the electronic state of surface atoms were investigated by means of x-ray photoelectron spectroscopy. X-ray absorption near edge spectroscopy provided information about oxidation state of atoms at the surface of the porous materials. In addition, the formation of porous structures in antimonides due to ion irradiation was simulated using the Cellular Potts Model for wet foams, providing information about parameters not easily accessible by experiments and enabling a better understanding of the mechanisms responsible for such changes.