SEMICONDUCTOR MATERIAL EVALUATION BY MEANS OF SCHOTTKY CONTACTS

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I. SCOPE OF THE PAPER

The large variety of possible application of semiconductor devices -- from high current, high voltage to microwave devices, from integrated optoelectronics -- is to a large extent due to the fact that semiconductors can be doped to a desired type and magnitude of conductivity. This is done by incorporating impurities whose energy levels in the forbidden gap are close to valence or conduction band and which are therefore completely ionized at normal temperatures of device operation. These levels are called shallow levels. The first part of this paper will discuss the principal methods for the evaluation of the concentration and local distribution of these shallow levels by means of Schottky contacts.

Simultaneously or independently during material or device processing another type of impurities can be incorporated with energy levels deep in the forbidden gap. These levels are called deep levels. Generally, deep levels are not fully ionized but their charge state can be influenced by electrical or magnetic fields, optical illumination and temperature variations during device operation. It is this change in charge state that may have deleterious effects on mobility, conductivity, device behaviour under dc bias, efficiency and life-time of optoelectronic devices. The second part of this paper will concentrate on a discussion of the methods by which the concentrations and the energy levels of "deep impurities" can be evaluated by means of Schottky contacts.
This diagnosis of deep levels is one step towards a thorough therapy of the semiconducting patient. It is a necessary step in our aim at completely healing the semiconductor of the "deep level malady".

II. INTRODUCTION

At semiconductor surfaces or at interfaces between a semiconductor and another solid, deviations from the bulk equilibrium values of charge and potential distributions are expected [1].

Energetic levels different from those in the semiconductor bulk are generated by a number of reasons: the interruption of the periodicity of the crystal lattice at the surface or interface; the adsorption of atoms and molecules from the ambient; the chemical reaction between the semiconductor and the ambient (including solids); work function differences between the semiconductor and a solid. If the surface or interface levels are charged (surface or interface charges) their charge has to be compensated by a charge of opposite polarity but of the same magnitude. This is the principle of charge neutrality which is a very effective tool for the calculation of the surface properties. Under zero bias conditions the surface or interface charges are compensated by charges in the semiconductor bulk close to the surface. These compensating charges can be:

a) majority carriers accumulated near the surface;

b) ionized donors or acceptors unneutralized by mobile charge carriers;