

Foreword

The DX center is a defect present in Gallium Arsenide and related alloys when these materials are doped with n-type impurities. This defect has been detected as soon as an electrical characterization had been performed in GaAlAs because its concentration is of the same order of magnitude than the doping concentration. However, it is only recently that it has been recognized that the DX center is also introduced by donor impurities in GaAs. In that case the associated energy level is not localized in the forbidden gap of the material, but resonant, i.e. above the bottom of the conduction band.

The optical and electrical characteristics of the DX center soon demonstrated that this defect apparently behaves as a deep defect, i.e. a defect for which the electron-phonon interaction plays a large role. Hence the label DX to designate the center which was then assumed to be a complex involving a donor D and an intrinsic unknown defect X.

The interest for the DX center is twofold: fundamental and technological. For physicists, the DX center exhibits peculiar properties which clearly indicate that it belongs to a new class of defect which had not yet been encountered. Now that it is established that the DX center is nothing but the substitutional donor impurity, the physicists have to understand and justify how such an impurity which generally gives rise to a shallow effective-mass state can also produce in some materials an additional deep level. One of the properties of the DX center which is particularly challenging for the physicists is its so-called metastable character. A metastable state is a second state of the defect having the same electronic occupancy than the stable state. This type of phenomenon is also encountered for several other defects which are apparently more complicated and one can hope that its understanding will be easier to get in the case of the DX center, and thus be a help to understand it in other cases.

The identification of the DX center is also interesting for the technologists now that heterostructures based on the GaAs-GaAlAs system are increasingly used to realize high performance devices. As any deep level, the DX center traps free electrons, thus reducing the free carrier concentration provided by the donor impurities and their mobility. In GaAs where the DX level is resonant, it limits the doping efficiency at high level. Moreover, because of its metastable character, it induces persistent non equilibrium phenomena which induce hysteresis effects of the electrical characteristics of devices.

It is therefore important to know the possible means to eliminate such a defect and the ways towards its suppression go through its identification. The understanding of the physical processes which lead to its existence will allow to select the alloys (nature, composition and quality - ordered or disordered) and the new materials, such as superlattices, to be used in devices.

The aim of this book is to provide a comprehensive view of the important properties of this defect at a time where the European Economic Community has decided to support a basic program (ESPRIT) on this question. Up to now the DX center has been the subject of one review by D.V. Lang (in *Deep Centers in Semiconductors*, edited by S.T. Pantelides, Gordon and Breach, New York, 1986) which gives the state of knowledge obtained in 1980. Since then many new types of experiments have been performed and new data have been acquired which shine a different light on the subject. However, the numerous presentations which are currently made at various international conferences (on GaAs and related compounds, semi-insulating III-V materials, etc.), probably because too often given by same group, do not reflect this trend.

In this book leading specialists have been invited to present their own view on the subject. Only one group declined the invitation probably because they have enough occasions to do so in conferences. No attempt is made to propose an unified picture. It is to the reader to make his own. In addition to chapters devoted to the properties of the DX center, the book contains several chapters dedicated to the properties of the materials in which it exists because they are useful for the understanding of the DX properties themselves. However, the book does not contain general reviews on GaAs and GaAlAs because recent, excellent ones already exist in the Journal of Applied Physics by J.S. Blakemore and S. Adachi (53, R123, 1982, and 58, R1, 1985, respectively).

In conclusion, the book is intended for the specialists who study or use GaAs and related alloys. It regroups the today knowledge and understanding of the DX center, the defect which dominates the electronic properties of these materials and limit their use in devices.

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