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Anisuzzaman, Mohammad

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モハマッド　アニスッザマン
氏名・(本籍・国籍)　Mohammad Anisuzzaman　(バングラデシュ)

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論文調査委員　（主　査）准教授　佐道泰造
　　　　　　　（副　査）教　授　浅野種正　　教　授　中島　寛

論　文　内　容　の　要　旨

Over the last fifty years, the performance of Si based microprocessors has been improved continuously through device shrinkage and improving device architecture. However, Si transistor performance is fundamentally limited by the carrier mobility. Furthermore, the Si transistor is shrunken into the nanometer scale where maintaining transistor operation becomes exponentially difficult. In these circumstances, implementation of high mobility semiconductors for next generation large-scale integrated circuits (LSIs) has become essential, and significant research efforts are being exerted for such ends.

The main purpose of this work is to develop orientation stabilized Ge-on-insulator (GOI) using the rapid melting growth (RMG) process. The previously reported work on the RMG method was focused on fabricating high-quality large-area Ge strips, e.g., achieving 3 μm x 1 cm strips with a thickness of 100 nm. However, till date no demonstration has been done on the nanofabrication of GOI using RMG. As a result, the nanofabrication process of GOI structures using the promising RMG method should be developed. It is expected that growth characteristics and crystal quality will have a significant dependence on the fabrication process and structural dimensions. Hence, the crystal characteristics should be extensively analyzed.

A major problem of the RMG technique is the rotation of crystal orientation along the strip length in the growth of (111) oriented Ge in <112> crystallographic direction. Recent development in Ge transistors has shown that the electron mobility shows a strong dependence on crystal orientation. It was demonstrated that the effective electron mobility in a (111) Ge channel is 1.5 times higher than that in (100) oriented channel. Therefore, it is important to obtain orientation stabilized (111) GOI.

Under such background, a formation technique of orientation stabilized GOI has been developed for realization of next-generation LSIs. This dissertation consists of five chapters. Contents of respective chapters are briefly described below.

Chapter 1 summarizes the background, the objective, as well as an outline of this study.

In chapter 2, the nanofabrication process of GOI by RMG and the crystal characteristics of (100) oriented Ge nano-strips are presented. Here, dependence of the growth characteristics and crystal quality on Ge strip dimensions is discussed. It is demonstrated here that thickness reduction of Ge strips tends to produce orientation instability. It is also shown that narrowing of strips is effective in suppressing the unstable growth. It is found that narrowing of Ge strips can improve growth characteristics, thereby growth of high crystal quality thin GOI structures becomes possible.

Chapter 3 presents the results of the effort to obtain orientation stabilized growth of GOI from (111) seed. In this work, the knowledge of orientation stabilization by narrowing of strips, as learned from the work on (100)-GOI nanofabrication, was employed. Successful stabilization of crystal orientation in thick (100 nm) and thin (50 nm) (111)-oriented GOI strips with any growth directions by strip-narrowing has been demonstrated. Here, a strong dependence on growth direction is also found. Crystal characteristics are presented in detail in order to understand the cause of orientation instability and how stability is obtained by narrowing.

Chapter 4 is the detailed analysis of crystal characteristics of rapid-melting grown Ge in order to find the physical process of rotation and the reasons behind the observed effects of thinning and narrowing of strips. Here, various propositions on the explanation of the process are examined. A comprehensive model to explain the process based on introduction of local-strains by Si-diffusion and relaxation of the local-strains at strip-edges is presented in this chapter.

The concluding remarks are given in Chapter 5.

論 文 審 査 の 結 果 の 要 旨

本研究は、急速溶融法を用いた絶縁膜上のGe成長における回転機構について詳細な検討を行い、次世代高性能デバイスの実現に有用と期待される極薄Ge結晶膜の高品位形成を実現したもので、電気電子工学上価値ある業績である。