Tailoring Conductive Metal Oxide Nanostructures under Harsh Environments

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論 文 内 容 の 要 旨
Thesis Summary

Every year a large amount of energy and resources are consumed to prevent failure of electronics from harsh environment, such as giant cooling system. Thus, electronics that capable for extreme condition aiming to solve this problem has attracted a lot interests, which is also called as harsh electronics. Recently, the emerging interests of harsh electronics is fueled by development of nanomaterials with unique properties. Among these materials, nanostructured ZnO is promising owing to its abundance and environment and biological affinity. Various nanostructured ZnO have been developed, like nanofilm, nanowire, nanorod and quantum dots. Among these nanomaterials, ZnO nanofilms based transparent thin film transistors (TTFTs) are considered possible candidates that meets demands of developing interactive electronics, such as flexible or wearable devices, flat panel displays, and system-on-glass. Previous studies showed optimized ZnO nanofilm resistivity of around 10^{-3} Ω·cm and can further achieve low resistivity as ~10^{-4} Ω·cm by heavily doping. However, while heavy doping improves properties of ZnO, it also causes instability due to relatively low crystallinity and undesired defects, which restrain its flexibility in device fabrication and application in harsh environment. For example, some sensors need to work at temperature higher than 200 ℃ for the best sensing performance, so long-term stability is important for practical application. Instability of oxides for anode has been a barrier in realization of long-term stable device in solar water-splitting area. Besides, dissolution of Zinc oxide in acid and basic solutions is another crucial issue that limit further application of oxide thin film in natural or physiological environment. Investigation of stability in harsh environment of oxide thin film is vast, as expected from their great significance, but researches about rational methods to improve stability without sacrificing electrical conductivity is still limited. In this thesis, we proposed a rational method to improve both thermal and chemical stability of

conductive doped ZnO nanofilms by a novel sequential annealing process. It is interesting that for ZnO nano film with optimized electrical properties only specific sequential annealing can improve thermal stability, while reversed treatment cannot. Based on this phenomenon we suggested that the finely compensation of defects and obtained less impurities lattice structure is attribute to appropriate strategy based on charge neutrality. We believe this thesis provided effective solution to instability problem of conductive ZnO nanostructure and offer a new prospective to defects compensation mechanism.