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Ferrite Engineering for Oxide Electronics

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Recently, many a number of researches have been studied for the development of magnetic semiconductors owing to their potential applications in the spintronic devices. Ferrite related materials such as wustite (FeO), hematite (Fe_2O_3), magnetite: spinel-ferrites (Fe_3O_4), garnet-ferrite ($M_3Fe_5O_{12}$) [1,2] and other related ferrites are promising systems because of their probabilities of bandgap engineering, which lie well within the visible-IR spectrum, as well as their low costs, electrochemical stabilities, and environmental compatibilities.

Despite the numerous studies on these materials, there is few articles on p-type spinel ferrites. So far, two p-type semiconductors that are generally recognized as exceptional are Fe_2MoO_4 [3] and Fe_2TiO_4 [4]. However, they show paramagnetic or weak ferromagnetic behaviors at room temperature. Furthermore, no one has succeeded in growing films of these p-type systems. These problems pose severe barriers to the practical application of these materials. The fabrication of p-type ferrite films would pave the way for the creation of an entirely magnetic p-n junction [5] that can form the basic building block for a spintronic arithmetic and logic unit. Such a magnetic p-n junction has never been achieved despite considerable recent efforts in the field of spintronics. The chief obstacle to fabricating a magnetic p-n junction is the difficulty in controlling the carrier type in magnetic semiconductors. In this article, we have demonstrated artificial control of conduction types (p-type and n-type) in the spinel ferrite films in the Ge-substituted Fe_3O_4 ($Ge_xFe_{3-x}O_4$) for the first time. [6]

In addition, photo-electrochemical (PEC) properties are also discussed in the α-Fe_2O_3 films. We have demonstrated that enhanced photocurrent in Rh-substituted α-Fe_2O_3 thin films grown by a pulsed laser deposition. This is important research field for solar cells and/or water cracking technologies. The Rh-substituted α-Fe_2O_3 ($Fe_{2-x}Rh_xO_3$; $0.0 \leq x \leq 2.0$) thin films were grown on α-Al_2O_3(110) substrates with a Ta-doped SnO_2 electrode layer by pulsed laser deposition. Highly oriented epitaxial films with pure corundum structures were successfully fabricated over the entire compositional range. The optical absorption spectra of the films indicate narrowing of the bandgap with increasing Rh content. Consequently, the photoelectrochemical performance was improved in the Rh-substituted films. We found that the optimum Rh content lies at around x=0.2, where the photocurrent is significantly enhanced over a wavelength range of 340–850 nm. The bandgap of the films decreased with increasing Rh content. The PEC efficiency was significantly enhanced in the films with lower Rh contents, in the visible and NIR regions. The findings of this research are expected to be useful in the development of the solar fuel conversion systems based on alpha-Fe_2O_3. [7]

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