Transparent Oxide Semiconductors

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Transparent conductive oxides (TCOs) and transparent oxide semiconductors (TOSs) have a long history since 1950s. The material design concept for TCOs looks almost established, i.e., ionic oxides p-block metals with an electronic configuration of $(n\text{-}1)d^{10}ns^{0}$ and a spatial spread of ns orbitals which is enough to have large overlap with neighboring metal ns orbitals irrespective of intervening oxygen ion[1]. Concretely, most of the TCOs have been realized in the material systems of In_2O_3-SnO_2-CdO-Ga_2O_3-ZnO. Materials based on light metal oxides such as Al_2O_3 and SiO_2 have not been regarded as the candidates of TCOs. In 2002, we[2] reported high electronic conductivity in 12CaO•7Al_2O_3 (C12A7) which had been a typical insulator and this discovery was followed by transparent conductivity in cubic $SrGeO_3$ in 2011.[3] These two materials are TCOs realized by a new material design concept.

As for TOS, the striking advances are seen in transparent amorphous oxide semiconductors (TAOS) in science and technology due to strong demand for active layer materials in thin film transistors (TFTs). Amorphous In-Ga-Zn-O (IGZO) TFTs, which was first reported in late 2004,[4] has adopted to drive high resolution displays of new iPad and 55inch OLEV-TV [5] . This is a first mass production of TOS family. The major reasons for this adoption are high electron mobility (an order of larger than that of a-Si:H) and easy fabrication process. A major advance in TOS-TFTs is realization of p-channel TFTs and subsequent fabrication of C-MOS using ambipolar SnO. [6]

In this talk, I review these progresses viewed from electronic state of these materials.

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