Dopability, Intrinsic Conductivity, and Nonstoichiometry of Transparent Conducting Oxides

National Rene able Energ Laborator , Golden, Colorado 0401, US

(7 2006, 23 2007)

In$_2$O$_3$ O , -
, . W -
H, W
( ) („ ”) *H* *n*- W ,
H 2

μ^0

O_2 , W . ., 2 μ_{In},

3 μ

0. 4 V In$_2$O$_3$ 0.73 O,

3.50 V 3.45 V W

. 24 ( ). W -

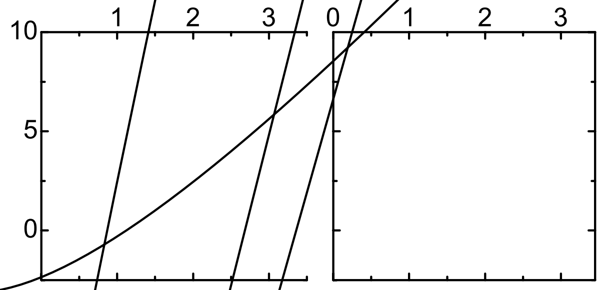
H_D E_F, μ $-E_D$ E_H, qE_F, $\sum \pm \mu^0$, μ,

E_D E_H , - -

, , q .

μ_{In}, μ_{Zn}, μ_{Sn}, μ_{Al},

μ_O ( ) ( )



1100 4, - V_O (. 1).

E trinsic donors do lead to degenerate doping. . 3, Sn_{In} In_2O_3 Al_{Zn} O H E_F M , , . W 1% In_2O_3, (O_2), . ., (. 2). (T_a 1073 K) 30, - $p(O_2) \gtrsim 10^{-6}$ atm, 30 $p(O_2)^{-1/8}$ (. 2). . 3, O_i - - $p(O_2)$, 1 V E_F M . O, 1% , . 2. $p(O_2)$, , W , V_{Zn} . $p(O_2)^{-1/4}$ $p(O_2) \geq 10^{-6}$ atm (. 2), -

($E_F < E_C$). - V_{Zn} E_F^N M , . 13,15, O. O , . ., n 10^{17} cm^{-3} (T_g 1423 K) 31, , . 31, V_{Zn} , c. V_{Zn} 2×10^{15} cm^{-3} $p(O_2)$ 1 atm .

Large eq ilibri m o gen de cienc . In_2O_3 O (≲1%) O- - 4,8, , , O , . O - V_O, In_2O_3 O (. 1). In_2O_3, O 2×10^{20} cm^{-3} 0.4% O T 1673 K (. 1,), O 1% . 4 . O, V_O 4×10^{19} cm^{-3} (0.1%) T 1373 K (. 1) - , . 5. V_O - O - O 8, c. V_O 10^{17} cm^{-3} O 32.

E cited O acancies can lead to (persistent) photocond cti it . V_O O . 14, 16, V_O^0 , - a_1^2 , . , a_1^0 , , 16 . M O In_2O_3, . ., O 20, a_1^0 . , F - (V_O) , In_2O_3 O.

Coe istence of coloration and cond cti it . - . In_2O_3 ( ) 4 O ( ) 5, . O , (. ., - V_O^0 V_O e), , V_O^0 V_O e V_O V_O^2 e , 1.8 1.6 In_2O_3 ( ), 2.8 2.4 V O 16.

,
V_O (. 1),
In_2O_3 O,
33
In_2O_3.
10^{17} 10^{19} cm^{3} 4,5,7
,