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Synthesis and Optical and Magnetic Properties of Diluted Magnetic Semiconductor $Zn_{1-x}Mn_xO$ Hollow Spherical Structures

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A [illegible] $Z_{1-x}M_xO$ [illegible] Mn^{2+} [illegible] Zn^{2+}. Ra [illegible] (520−530 $^{-1}$) [illegible] $^6A_1(G)$ [illegible] $^4E(G)$. T [illegible] M [illegible].

I. Introduction

S [illegible] ZO [illegible] GaN [illegible],[1] ZO [illegible] [2−5] E [illegible] V-,[6] C-,[7] N-,[8] F-,[9] C-,[10] [illegible] M [illegible] [11−16] ZO [illegible]. A [illegible] ZO [illegible], M [illegible] Mn^{2+} (0.66 [illegible]) [illegible] Zn^{2+} (0.60 [illegible]).[4,5,13]

D [illegible] 5 [illegible], M [illegible] ZO [illegible] [11] [illegible] [12] [illegible] [13] [illegible] [14] [illegible] [15−18] U [illegible] M [illegible] ZO [illegible] [14] [illegible] [16] [illegible] [13] T [illegible] M [illegible] ZO [illegible]. A [illegible] [19] P [illegible] ZO [illegible] (≥750 °C)[20a,] [illegible] M ZO [illegible] [5] T [illegible]

[illegible] M [illegible] ZO [illegible].

I [illegible] $Z_{1-x}M_xO$ [illegible] S [illegible] (Z) [illegible] ($MnC_2O_4 \cdot 4H_2O$) [illegible] 420 [illegible] 650 °C, [illegible] 600−700 °C. W [illegible] 30 [illegible] (∼500 °C) [illegible] (600−700 °C) [illegible] M- [illegible] Z [illegible] Z [illegible]. W [illegible] M- [illegible] ZO [illegible] M [illegible] 650 °C [illegible] M [illegible].

II. Experimental Details

$Z_{1-x}M_xO$ [illegible] F [illegible] 1a. Z (99.99% [illegible]) [illegible] $MnC_2O_4 \cdot 4H_2O$ [illegible] (99.99% [illegible]) [illegible] 2 [illegible] S (100) [illegible] 30 [illegible] T [illegible]

* C [illegible] Fa : +86-21-54747552. E- a : @ [illegible]

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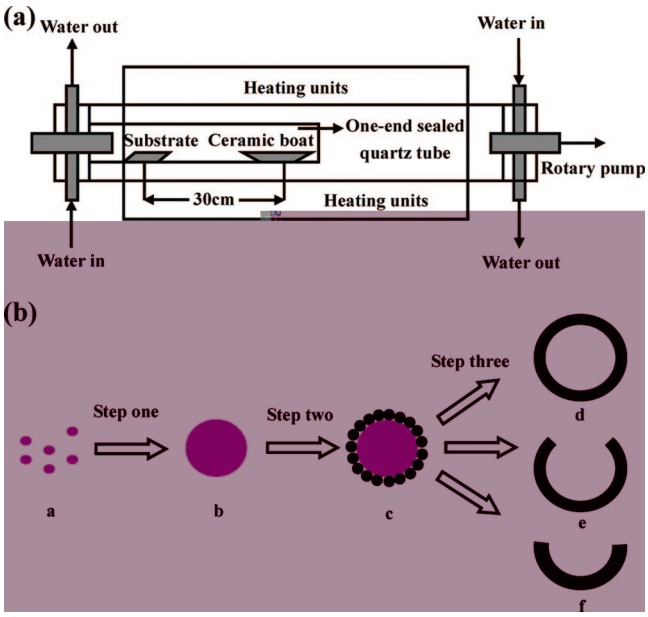

Figure 1. (a) S a a a a a a a a , Z 1−xM xO a , , . ( ) S a , a a Z 1−xM xO a , , : a, M Z ; , M Z a a , a ; , a a a M Z O a a ; (b) Z 1−xM xO a 600 °C, ( ) Z 1−xM xO , , a 650 °C, a ( ) Z 1−xM xO , , a 700 °C.

a a a , a , . A a, , a a a a , a a a a , - a , a a a a a , 600, 650, a 700 °C, , a a 10 , / . A a a a a , , a a a a , , a , a , a a , 2 . F a , a a a , 30, 60, 120, a 180 , , , a a , a . D a , a , , a , S , a a , a a a , 500 °C. T S , a , a a a , a a a , a , a a .

T , a , , Z 1−xM xO a , , a a a , a (FE-SEM; P XL30FEG) a a a , a 5 V, , , a - (HRTEM) (JEOL JEM-2100F), a X- a a (XRD) B /D8 D a GADDS , a C Kα , (λ = 1.5406). E , X- a (EDX) a a a a , FE-SEM a a a a a (SAED) a , HRTEM a , - . T -Ra a a a , , a , (PL) a a - a , a J Y La RAM HR800UV -Ra a , a A + (514.5) a a H −Cd (325.0) a a , . T a a a a a a (PPMS-12). T a a a a (EPR) a a B EMX-8/2.7 - - a a a a , .

III. Results and Discussion

Pa a− F , 2 a FE-SEM a a - a , a 600, 650, a 700 °C 120 . T EDX a a a a a a M a x = 1.26%. I a a a a a , , a a a a a , a a a . W a a a , , a a 600 °C a a a . W a a a , , a a a a a 650 °C a a a 700 °C. T , a , , a a a a , , M 1.26% a 700 °C 30, 60, a 180 , . Pa − F , 2 a , a - a , a 700 °C a a . I , a , , , a a a a . TEM a , a a a , , a , a a a , , . F , 2 a TEM a , a a , , , a 650 °C 120 M 1.26%. T , a a - a a a , a a , a a a a a a . F , 2 a HRTEM a M a a a a a a F , 2 a a , a . T a , a , 0.26 , [0002] a a , Z O. I a a a a a , a a , a [0001] a . T , SAED a , a F , 2 a a . O a a a a a , , , Z O ,[20] , , a , a a a , a F , 1 . I , Z a M a , a , M Z - a , S , a . I , , a M Z a a a a a M Z O a a a M Z a , a , a . I , M Z a , a a , M Z O a a . I , , a a a , a , . W , a a , , a Z (a , 420 °C), M Z O a Z a a a a Z a . A 600 °C a , , a Z a , a a a , , a a a (F , 2a). T , a Z a a a : a a M Z O a a a , a a , a , a M Z O a . T , , a , a , , , a a , a a , , , a , a , . T , , a a (F , 2) (F , 2) a a , .

T a , a a a a − F , 2 , a , a , a . L M Z O , -

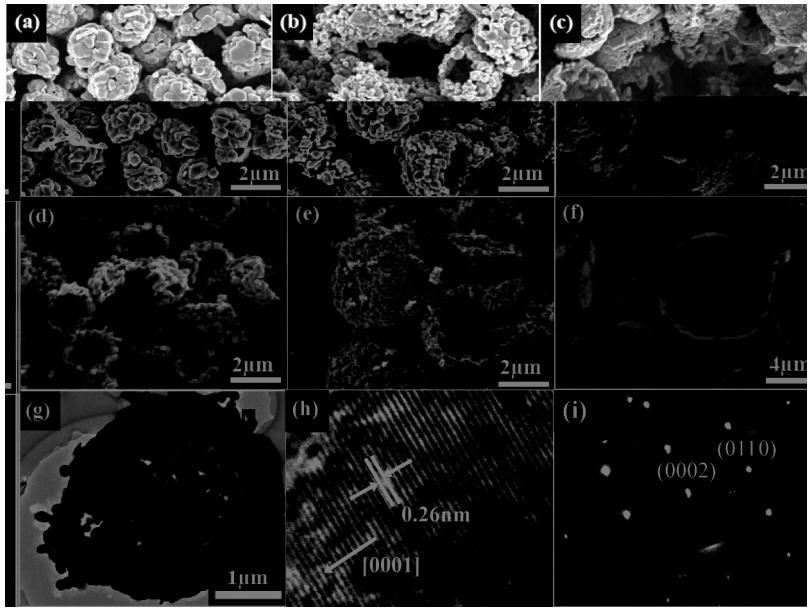

Figure 2. (a–) FE-SEM a Z $_{1-x}$M $_x$O a , , $x = 1.26\%$, 120 a 600, 650, a d 700 °C, . (d–) FE-SEM a Z $_{1-x}$M $_x$O a , , $x = 1.26\%$, a 700 °C 30, 60, 180 , . (–) TEM a , HRTEM a [d a a d a d a d a , , a a ,], a d d , SEAD a Z $_{1-x}$M $_x$O a , , $x = 1.26\%$, a 650 °C 120 .

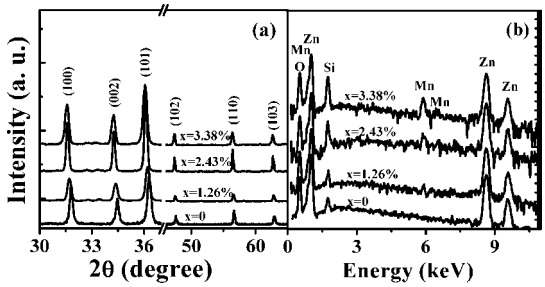

Figure 3. (a) XRD a a d ( ) EDX a , d d Z O a d Z $_{1-x}$M $_x$O a , , a 650 °C 120 M $x = 1.26\%$, 2.43%, a d 3.38%, . T EDX a a -2 , a a .

, a d a 700 °C 30 (F , , 2 d), d a , a a a a a M d d Z O a - a a d. S a d, d a 700 °C, , , a , M d d Z a a a , a d M d d Z , d a a d , . W a , M - d d Z a a d d a d , M - d d Z O a a a d d d M d d Z O a a , a d , a a a a d a , d , , a a d a d F , , 2.

XRD a d EDX a , a d , , a d a d Z $_{1-x}$M $_x$O a , , d M d a 650 °C 120 . W , , d d Z O d, d , d a , d a a . I , d d F , , 3a a XRD a d (100), (002), (101), (102), (110), a d (103) a a a a Z O a d , a d a d J C P d D a S a d a d . T , d HRTEM a a d, , Z O , , . T a a a a d a a , a M , M d , a , a a , , , a M $^{2+}$, , , , d a Z $^{2+}$ a d a a a , a . T a a , d , , a a , (∼500 °C) a a a (600−700 °C) a d a M - a d d . M , d a a M XRD a M d d a a a d a , a , , d a , a a a a a a a a d a a a d, M $^{2+}$ (0.66) a , a a Z $^{2+}$ (0.60).[13] U , S , a, a a a *a*-a a d *c*-a a a a a 3.243 a d 5.204 , d d Z O 3.261 a d 5.225 M d d Z O a , , M $x = 3.38\%$, . T d , EDX a a F , , 3 . T d a a a -2 , a a . T , d a a a - a d Z $_{1-x}$M $_x$O a , , a d Z , M , a d O , a S , a S , a . F a a M Z EDX a, a d a a M (x=[M]/([Z] + [M]) Z $_{1-x}$M $_x$O a , , $x = 0$, 1.26%, 2.43%, a d 3.38%, .

F , , 4 a , Ra a a , d d Z O a d Z $_{1-x}$M $_x$O a , , d M d a 650 °C 120 . T a a d , a a , d 437 $^{-1}$ a a , d a a E$_2$(,) d Z O. I a d , a a d a a Ra a a a , Z O.[21,22] T E$_2$(,) d a , a d a a , a , , , d a, HRTEM a d XRD a . I , d d Z O a E$_1$[, , d a - a (LO)] d a a a ∼580 $^{-1}$. W a M , E$_1$(LO) d , . I a Ra a , , Z O, a d d a d a d a

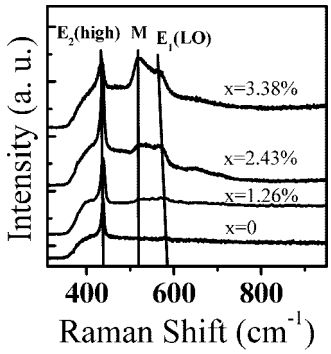

Figure 4. R a, Ra a a , d d Z O a d Z 1−xM xO a , , , a 650 °C 120 M x = 1.26%, 2.43%, a d 3.38%, .

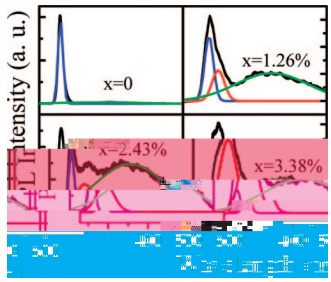

Figure 5. R a, PL a , d d Z O a d Z 1−xM xO a , , , a 650 °C 120 M x = 1.26%, 2.43%, a d 3.38%, .

M a , d 520−530 −1 d M d d Z O a . I a a , d a d , , d a M 2+ a .[23−25] F F , , 4, , a a a d a a E2(,) a a 0 ∼1.0 M x = 0 3.38%, , , , a a d a d, d , d, a M d . I , d, d a , a, Ra a a d d a a d a d Z 2M O4 a 663 −1,[26] . ., - d a a Z 1−xM xO a , , . T , a a XRD , d F , , 3a a d a d , .

W , PL a Z 1−xM xO a , , . F , , 5 d a a, PL a , d d Z O a d d d Z O d a 650 °C 120 d M . W a a a a a , , a (UV) a a ∼386 . T a , M d , d a , a , , d a, .[27,28] H , , a a a d UV a d a M . A , a Ga a , a d , a PL a a, 330 700 , a d a a a a , d 417 a a M d d a , , a, d a a d a , .[29−32] S a a d , a a d UV a a , d a Z .[33] S XRD , d a a d a Z , a d, d a a d EDX , , , , a a Z O ∼1, a , d fl, a Z . U , , , a d a [$I_{d d a}$ /I_{UV}] d d a (a d a d ,) Z O UV a

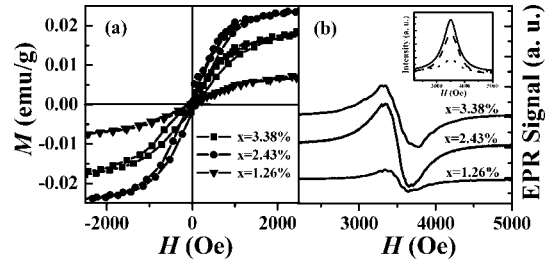

Figure 6. (a) R a, a (*M*−*H* ,) a d ( ) EPR a Z 1−xM xO a , , , a 650 °C 120 M x = 1.26%, 2.43%, a d 3.38%, . T a , a , a EPR , a , d, a d, a d d , a - a d a M x = 2.43%, 3.38%, a d 1.26%, .

(a d a ,) a a , M x, a a a a, $I_{d d a}$ /I_{UV} a 0 ∼5 x = 0 3.38%. M a a a .[32] a a , a d d→d a , M 2+ M d d Z O , , , M Y4 , d (Y a a) a d a d a , d , , d a $^6A_1$(G) a d d a ^{4}E(G) 2.97 V (, a 417). T , a , d d a a d→d a M 2+ , , d a $^6A_1$(G) d a ^{4}E(G). I a d, a d a, $I_{d d a}$ /I_{UV} d d→d a M 2+ a M a d d a a , a a d a M 2+ Z O a .

T d , (a d a , , F , , 5) , a d a a d a a , a d , d , a a a d , d , d a a d a , a a a Z O.[17,34] F F , , 5 , d d Z O a a , , , a d d a , a , a d Z O , a a a . T , , a d M d d Z O a , , a a , d , a a d, d M 2+ a a . T a , a d Z O UV a a ∼0.02 ∼1.50 x = 0 3.38%, d a , a M d , , , a a , a a . T , a Ra a a a a d a , a d, d a M d , .

W a , a a Z 1−xM xO a , , . T a a a, d a a, a d d, d a 650 °C 120 . F , , 6a a a (*M*) , a d (*H*) (*M*−*H*) , M d d Z O a , , d a , 0 ∼ ±2500 O . I , d d a a a a a 300 K a H_C ≈ 70 ± 5 O . S M - a d d , a M O, M O2, a d M 2O3 a a a M 3O4 a 45 K,[35] a a, a - Z 1−xM xO a , , a a , d a - d d , a d a, a a d a M 2+ a . T a a M d d Z O ,[14] a d ,[16] a d a a ;[25] , M d d Z O a

a a . C a

, a a - a a a a a a a a , a - a a a a a a a a a a a a a .

I $M-H$ a a a M ($x = 3.38\%$) a a a a a . T a a a a a M a Z O M Z O a a a a M , a a a M $^{2+}$ a a a .[36] T , Z O a a M , M $^{2+}$ a Z $^{2+}$ a , a a M $^{2+}$ a a a a a M $^{2+}$. T a M a a a a a a M 2.43%. F M a a a a a a a a a a a a . M a.[14] a a a M a a a M $^{2+}$ a 2.2% M . W a a a a Z $_{1-x}$M $_x$O a a M a . F , a a a a a a a Z O 2.43% M ~0.024 , (0.122 μ_B/M). T a a a a a ~5 μ_B/M a M $^{2+}$, a a a a a a a a a M $^{2+}$.[17,23]

EPR a a M $^{2+}$ a . F 6 a a EPR a . I a a a EPR a , a M $^{2+}$ Z .[13,37] F a a EPR a a (F 6), a a a a 2.43% M a a a . T a a a a a a a a F 6a.

IV. Conclusions

I a , a a a a a a Z $_{1-x}$M $_x$O a a a a . T a a Z a M C $_2$·4H$_2$O a a a S a 30 a a . T a a a a a a 600−700 °C, a a a a Z M Z O a a a a M - a a a (a 500 °C). F , a a a a a a a a a a a a M a a a M Z a a . T a a a - a a a a a a a a a a a a . W a TEM, EDX, XRD, Ra a , a PL a a a a a a a a M Z O a a a a a M $^{2+}$ a a a a . A a a a a a a a , a a a a M a . T a a a a a a a a a a a a Z O a a a .

Acknowledgment. T a Na a S F a C a a 10734020 a 10674094, Na a Ma Ba R a P 2006CB921507, Na a M E a P a IRT0524, a S a a M a K P 08XD14022.

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