$(Zn_{1-x}Mn_x)GeP_2$ 계 상온 강자성 반도체 제조

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Room-temperature ferromagnetism in $(Zn_{1-x}Mn_x)GeP_2$ semiconductors

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1. 서론

The substitution of magnetic ions such as Mn^{2+}, Cr^{2+}, and Fe^{2+} into non-magnetic semiconductors generates peculiar structural, electronic, electrical, optical, and magnetic properties. In the early work [1], II-VI semiconductors such as CdTe, CdSe, ZnSe, and ZnTe were widely studied since 2^+ magnetic ions can occupy the group-II cation sites of the host lattices. Concerning the magnetic properties, these systems usually showed antiferromagnetic (AFM) or spin glass ordering. III-V dilute magnetic semiconductors (DMSs) such as (InMn)As [2] and (GaMn)As,[3,4] exhibited ferromagnetism. Here we report on the discovery of room-temperature FM ordering in electrically insulating $(Zn_{1-x}Mn_x)GeP_2$ and an antiferromagnetic(AFM) to ferromagnetic(FM) transition at a temperature around 47 K.

2. 실험방법

For single and polycrystal $(Zn_{1-x}Mn_x)GeP_2$ preparation, we used high-purity (99.999%) zinc (Zn), germanium (Ge), manganese phosphide (Mn_3P_2), and phosphorus (P) powders as starting materials with a particle size of < -200 mesh to maximize the surface area and thereby enhance the reaction kinetics. First, the powders were weighed and loaded into thick walled quartz ampoules. Then the ampoules were evacuated (<10^{-6} Torr) and sealed. After encapsulation, the sealed ampoule was mixed loaded into a vertical furnace, and heated slowly to form single-phase $(Zn_{1-x}Mn_x)GeP_2$. For single crystal growth, the temperature was slowly cooled at 0.5 °C/h to a point below the melting temperature (1022 °C for $ZnGeP_2$) and thereafter at 100 °C/h.

3. 실험 결과 및 고찰

We have observed a room-temperature ferromagnetism in chalcopyrite $(Zn_{1-x}Mn_x)GeP_2$ with $T_C = 312$ K. We have also observed that at temperatures below 47 K, samples for x = 0.056 and 2.0 show a transition to the antiferromagnetic (AFM) state, so that ferromagnetism is well defined to be present between 47 K and 312 K. The observation that the AFM phase is most stable at low temperatures is consistent with the predictions of full-potential linearized augmented plane wave (FLAPW) total energy calculations and has consequences for other chalcopyrite materials.

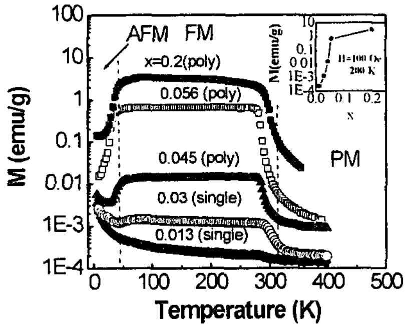

Fig. 1 Logarithmically-scaled temperature dependent magnetization (M) of $(Zn_{1-x}Mn_x)GeP_2$ for different composition, x, in a 100 Oe magnetic field. Single and poly represent single and poly crystals, respectively. M vs x was plotted in the inset.

4. 결론

It is plausible that this and related materials can replace the Mn doped III-V systems and open the way to room temperature spintronic devices.

5. 참고문헌

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