

# Topotactic Mutual-Exchange Growth of Magnetic Zintl Phases from III–V Semiconductors

Man Suk Song

Department of Semiconductor, Dong-A University, Busan, Republic of Korea  
\*email: mssong@dau.ac.kr

The synthesis of advanced materials with controlled composition, structure, and functionality continues to expand the field of materials science. Here, a topotactic mutual-exchange growth method is presented, transforming III-V semiconductor nanowires and thin films into exotic magnetic Zintl compounds via molecular beam epitaxy (MBE). This unique mechanism involves solid-state exchange of Europium (Eu) and Indium (In), forming single-crystalline Zintl phases while preserving the original semiconductor lattice motifs. Wurtzite InAs nanowires are topotactically converted into  $\text{Eu}_3\text{In}_2\text{As}_4$  nanowires, exhibiting antiferromagnetic transitions and classified as  $C_2T$  axion insulators with chiral hinge modes and Dirac surface states. Zincblende InAs(Sb) nanowires similarly convert to  $\text{Eu}_5\text{In}_2\text{As}_6$ , featuring distinct antiferromagnetic phases around 7 K and 16 K, classified as antiferromagnets as well as potential altermagnets for spintronic applications. This growth mechanism has been extended to thin-films and has enabled the exploration of new combinations of Zintl compounds using other III-V semiconductor materials, such as GaAs and InP. Furthermore, this topotactic mutual-exchange approach offers new avenues for designing magnetic, thermoelectric, and topological materials, significantly advancing applications in spintronics, quantum computing, and electronics.

## Reference

- [1] Song, M. S., et al. Topotaxial mutual-exchange growth of magnetic Zintl  $\text{Eu}_3\text{In}_2\text{As}_4$  nanowires with axion insulator classification. *Nat. Nanotechnol.* **19**, 1796–1803 (2024).
- [2] Song, M. S., et al. Topotactic growth of Zintl phase  $\text{Eu}_5\text{In}_2\text{As}_6$  nanowires with antiferromagnetic behavior. *Nano Lett.* **25**, 7292–7297 (2025).