第 12 回 CSIS セミナー
第 83 回ナノ・スピン工学研究会
半導体スピントロニクス研究室講演会の開催について

日　時：　平成 27 年 11 月 26 日（木）16:40～17:40

場　所：　電気通信研究所　ナノ・スピン総合研究棟 4 階　401 号室

講　師：　Professor Claudia FELSER (Max Planck Institute of Chemical Physics for Solids, Dresden, Germany)

講演題目：**Topology – from the perspective of Materials science**

概　要：

Topological insulators (TIs) are a new quantum state of matter, which have attracted interest of condensed matter science. The concept of topology is well established in chemistry in the context of molecules. Remarkable is that topological insulators can be predicted by ab initio theory and even understood from a chemistôs perspective. Herein, a simple recipe based on bonds, bands, symmetry, and nuclear charge will be given to motivate a systematic search for new topologically nontrivial materials. The materials are small band gap insulators with robust gapless surface states. Starting with the theoretical prediction and experimental verification of two-dimensional TIs, the HgTe-based quantum wells, many new topological materials have been discovered. Currently known TI materials can be classified into two families, the HgTe relatives and the Bi_2Se_3 family.

Heusler compounds are a remarkable class of materials with more than 1,000 members and a wide range of extraordinary multifunctionalities [1] including tunable topological insulators (TI) [2] half-metallic high-temperature ferri- and ferromagnets [3], compensated ferrimagnets [4] multiferroic shape memory alloys, and with a high potential for spintronics, energy technologies and magnetocaloric applications. The tunabilty of this class of materials is exceptional and nearly every functionality can be designed. Therefore it is not surprising that we were able to design Heusler compounds with a band inversion and a non-trivial topology for multifunctional TI [2].

Many of these ternary zero-gap semiconductors in Heusler compounds (LnAuPb, LnPdBi, LnPtSb and LnPtBi) contain the rare-earth element Ln, which can realize additional properties ranging from superconductivity (for example LaPtBi) to magnetism (for example GdPtBi) and heavy fermion behavior (for example YbPtBi). These properties can open new research directions in realizing the quantized anomalous Hall Effect and topological superconductors. C1b Heusler compounds have been grown as single crystals and as thin films. The control of the defects, the charge carriers and mobilities can be optimized [5]. The band inversion is proven by ARPES [6]. Heusler compounds are similar to a stuffed diamond, correspondingly, it should be possible to find the ñhigh Zò' equivalent of graphene in a graphite-like structure or in other related structure types with 18 valence electrons and with inverted bands [7]. Dirac cones and Weyl points can occur at the critical points in the phase diagrams of TI. Weyl points, a new class of topological phases was predicted in NbP, NbAs and TaP [8]. We founds ultrahigh magneto resistance, mobilities and Fermi arcs in this class, proving their topological electronic state [9-11].

1. Tanja Graf, Stuart S. P. Parkin, and Claudia Felser, Progress in Solid State Chemistry 39 (2011) 1-50
2. S. Chadov, X. Qi, J. Kübler, G. H. Fecher, C. Felser, S.-C. Zhang, Nature Mater. 2010, 9, 541
3. M. Jourdan, A. Kronenberg, J. Minar, J. Braun, S. Chadov, B. Balke, A. Gloskovskij, M. Kolbe, H. J. Elmers, G. Schönhense, H. Ebert, C. Felser, and M. Kläui, Nature Com. 5 (2014) 3974
4. A. K. Nayak, et al.　C Nature Mat. 14　(2015) 679.
5. Chandra Shekhar, Siham Ouardi, Ajaya K. Nayak, Gerhard H. Fecher, Walter Schnelle, and Claudia Felser Phys. Rev. B 86 (2012) 155314,
6. ñUnusual Topological Surface States in Half-Heusler Compounds LnPtBi (Ln=Lu, Y)òZ. K. Liu, L. X. Yang, S. ï C. Wu, B. Zhou, Y. Zhang, S. ï K. Mo, Z. Hussain, Z. X. Shen3, B. H. Yan, Chandra Shekhar, C. Felser and Y. L. Chen, submitted
7. B. Yan, L. Müchler, C. Felser, Phys. Rev. Lett. 2012, 109, 116406
8. C. Shekhar, A. K. Nayak, Y. Sun, M. Schmidt, M. Nicklas, I. Leermakers, U. Zeitler, Y. Skourski, J. Wosnitza, W. Schnelle, H. Borrmann, W. Schnelle, J. Grin, C. Felser, B. Yan, Nature Physics 11 (2015) 645
9. ñLarge and unsaturated negative magnetoresistance induced by the chiral anomaly in the Weyl semimetal TaPò, Chandra Shekhar, Frank Arnold, Shu-ChunWu, Yan Sun, Marcus Schmidt, Nitesh Kumar, Adolfo G. Grushin, Jens H. Bardarson, Ricardo Donizeth dos Reis, Marcel Naumann, Michael Baenitz, Horst Borrmann, Michael Nicklas, Elena Hassinger, Claudia Felser, & Binghai Yan, preprint arXiv: 1506.0657
10. Lexian Yang, Zhongkai Liu, Yan Sun, Han Peng, Haifeng Yang, Teng Zhang, Bo Zhou, Yi Zhang, Yanfeng Guo, Marein Rahn, Dharmalingam Prabhakaran, Zahid Hussain, Sung-Kwan Mo, Claudia Felser, Binghai Yan, Yulin Chen, Nature Physics online, preprint arXiv:1507.00521
11. Z. K. Liu, L. X. Yang, Y. Sun, T. Zhang, H. Peng, H. F. Yang, Y. Zhang,　Y. F. Guo, P. Dharmalingam, Z. Hussain, S.ï K. Mo, M.Schmidt, C. Felser, B. Yan and Y. L. Chen, Nature Materials online DOI: 10.1038/NMAT4457

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