GP-Spin Seminar

June 12,2017
1:30pm-3:00pm

"Epitaxial ferromagnetic Heusler alloy/semiconductor hybrid structures for spintronic application"

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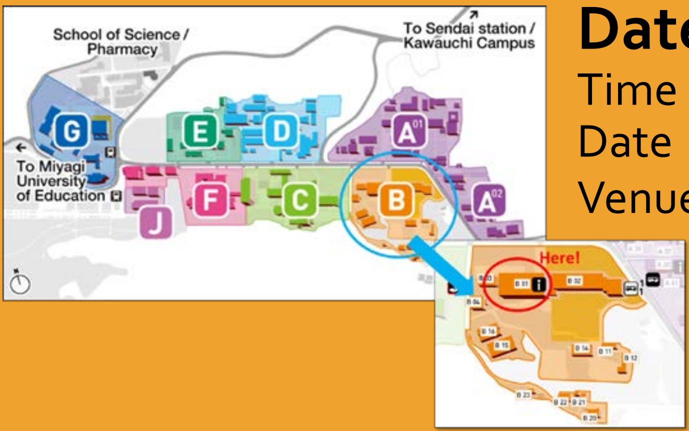

Date and Venue

Time 1:30pm-3:00pm
Date June 12, 2017
Venue Seminar room 407,
Education and Research Bldg(B01),
Material Science and Engineering,
Aobayama-Campus

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Epitaxial ferromagnetic Heusler alloy/semiconductor hybrid structures for spintronic application

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Semiconductor spintronics offers the possibility to develop hybrid devices that can perform the processing, communication, and storage of information within one chip. Furthermore, taking advantage of the electron spin as an additional degree of freedom entails the potential to increase the functional density in integrated circuits instead of scaling down the packing density by further reducing the size of single devices. Important building blocks of spintronic devices involve the generation, transport, detection, and manipulation of spin-polarized carriers in semiconductors. Particularly because of their potential for non-volatile memory applications, hybrid structures consisting of ferromagnetic (FM) metals and semiconductors (SC) are of major interest for semiconductor spintronics. Our investigations combine two mutually dependent directions. The first aims at a comprehensive understanding of the heteroepitaxial growth by molecular beam epitaxy (MBE) as well as the structural and magnetic properties of the ferromagnet/semiconductor hybrid system as a whole. The second one aims at identifying and understanding the mechanisms involved in spin transport which are relevant for spintronic device concepts.

The ability to inject, transport, manipulate, and detect spin-polarized carriers by purely electrical means is a prerequisite for most proposed spin-based semiconductor devices. Local spin valves are essential building blocks for such spintronic applications. We have demonstrated for the Co_2FeSi/GaAs hybrid system the all-electrical injection and detection of spins employing a lateral device structure by both spinvalve measurements and experiments utilizing the Hanle effect. Furthermore, a new spintronic device concept has been established for which a cascade of spin extraction instead injection events is utilized for the functionality as a nonvolatile reconfigurable current divider.

The preparation of fully crystalline thin film stacks consisting of a semiconducting channel sandwiched between two ferromagnetic layers constitutes a prerequisite for the engineering of a new device type. For the underlying device concept, the heights and shapes of the potential barriers formed at the interface between the ferromagnet and the semiconductor are crucial. However, the major obstacle for the realization of crystalline layer stacks of a semiconductor sandwiched between two ferromagnets is the considerable difficulty to overgrow metals with a fully crystalline semiconductor while preserving a good interface quality. Indeed, apart from the different crystal structures, ferromagnet and semiconducting materials generally have incompatible crystallization energies (larger for semiconductings compared to ferromagnets). As a consequence, chemical reactions are likely to occur during the growth of the semiconducting layer. In order to overcome the challenges with the semiconducting on ferromagnet growth, we have chosen solid-phase epitaxy as an approach where an amorphous film of Ge is deposited on Fe_3Si and then recrystallized slowly by thermal annealing.