

Spin-photonics with semiconductors and metallic thin films

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A study of inducement and manipulation of magnetic orders in industrially important semiconductors has its root in the epitaxial growth of III-V-based magnetic semiconductors [1]. Since the demonstration of light-induced magnetic phase transition in the (In,Mn)As/GaSb system [2], the author has been elaborating the concept of spin-photonics through various experiments which demonstrate hybrid functionality based on both light and spins [3]. The aim of spin-photonics is presently three folds; firstly, expand opportunity of fundamental research and its applications with a new class of nanostructures; secondly, pursue ultra-fast manipulation of magnetization beyond the limit encountered by application of a magnetic field pulse [4]; and thirdly, study advantages of using spin and light as new physical states that would be useful for the future information technology. In this presentation, I will review recent experimental results which are relevant to the concept of spin-photonics.

As for experimental results with semiconductor-based ferromagnetic materials, I will review (i) ultra-fast inducement of magnetic moments with circular-polarized light [5], (ii) optically induced precession of magnetization in (Ga,Mn)As [6-8] with linearly polarized light, including the study of an angular momentum flow in metal/(Ga,Mn)As hybrid structures [9], and (iii) low power, all-optical switching of magnetic domains in (Ga,Mn)As microbars [10].

Optical manipulation of M in metallic systems is another important subject which we have started in 2009 in collaboration with NHK STRL. Our choice of material was ferrimagnetic $\text{Gd}_{0.3}\text{Fe}_{0.7}$ thin films with out-of-plane M . Our interest has been to pursue photo-induced precession with low-power optical excitation as well as demonstration of spin-based optical buffer memory [11,12]. Interestingly, precessional motion of M has been achieved with the pump power of $10 \mu\text{J}/\text{cm}^2/\text{pulse}$ or lower [13], which has been two to three orders of magnitude smaller than previous studies [14]. Dynamic control of precessing M with two laser pulses has also been achieved. Recent progress with Co/Pd multi-layer system will also be discussed, through which we again emphasize the low-power control of M with ultra-short laser pulses [15].

Opportunity and impact of introducing magnetization M in optical systems, as exemplified by spin-optical buffer memory, will also be discussed.

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