

## Angular momentum current probed via THz emission in Ni/Cr bilayer

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Laser-pulse induced THz emission in ferromagnetic metal (FM)/normal-metal (NM) bilayer film is widely studied from both scientific and technological points of view [1]. The THz emission is caused by the transient transverse charge current which is generated via the inverse spin-Hall effect for photo-induced transient spin current across FM/NM interface. Recently, several groups discussed the effect of not only spin but also orbital angular momentum current in the THz emission in FM/NM bilayers [2] (Fig. 1), whereas many issues remain to be addressed. Here we report THz emission in Ni/Cr bilayers with various Cr thickness  $t_{Cr}$  and discuss the effect of angular momentum current in this system. We deposited films with the following stacking structure using ultrahigh vacuum magnetron sputtering: fused silica glass sub. | Ni(5) | Cr( $t_{Cr}$ ) | Al(3) (thickness in nm). THz emission was measured via a THz time-domain spectroscopy (THz-TDS) with a Ti: Sapphire fs laser [3]. A pump laser pulse was linearly polarized, and emitted THz was detected via electro-optic sampling with a ZnTe crystal. Fig. 2 shows the THz emissions for  $t_{Cr} = 3$  nm applying the magnetic field  $H$  of about  $\pm 10$  mT. The THz signal was flipped with the sign of magnetic field, indicating the magnetic origin. The THz signal exhibited the maximum at  $t_{Cr} = 3$  nm and decreased with increasing  $t_{Cr}$ , which means that the THz emission originates from the conversions of spin and/or orbital angular momentum current induced by the pulse laser into transverse charge current [1]. We will discuss physics in detail in this presentation.

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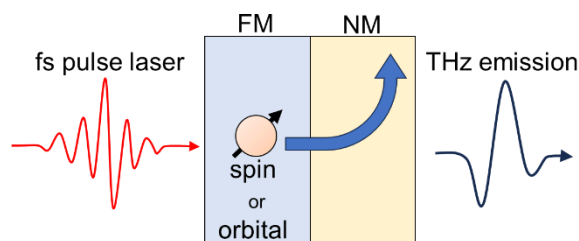


Fig. 1 schematics of the mechanism of THz emissions via the spin and orbital Hall effect.

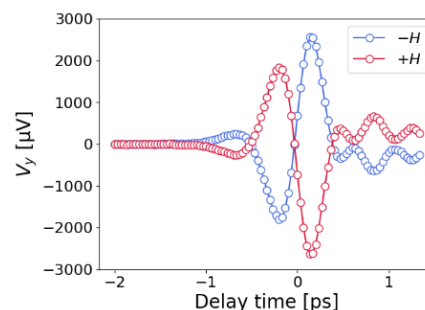


Fig. 2 THz emissions for a Cr thickness  $t_{Cr} = 3$  nm applied with positive (red) and negative (blue) magnetic fields of about 10 mT.