Silicon and Germanium spintronics

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In this presentation, I will first review the recent advances in silicon and germanium spintronics. This field of research aims at combining the carrier charge and spin in the same device made of silicon and germanium in order to add new functionalities to nowadays microelectronic devices [1,2]. The first proposal for a semiconductor-based spintronic device was made in 1990 by Datta and Das: they introduced the concept of spin transistor [3]. Since then, huge effort has been devoted to succeed in the very first step to the development of such a device: electrical spin injection in semiconductors. Indeed many obstacles had to be overcome before creating a non-equilibrium spin population into Si or Ge conduction or valence bands [4]. In this talk, I will discuss about these different issues and show how we could circumvent most of them to achieve spin injection in n-Si and n-Ge at room temperature. In particular, we clarify the exact role of interface states in the spin injection mechanism [5,6,7] and show a clear transition from spin accumulation into interface states to spin injection in the Si and Ge conduction bands. For this purpose, we have grown a CoFeB/MgO spin injector on Silicon-On-Insulator (SOI) and Germanium-On-Insulator (GOI). We observe a spin signal amplification at low temperature due to spin accumulation into interface states [8,9]. At 150 K, we find a clear transition to spin injection in the channel up to room temperature: the spin signal is reduced down to a value compatible with spin diffusion model. In this regime, we could also demonstrate the spin signal modulation by applying a back gate voltage and by spin-pumping at the ferromagnetic resonance of the CoFeB layer which are clear manifestations of spin accumulation in the Si and Ge channels. Finally by setting a temperature difference between Ge and CoFeB we could thermally induce a spin accumulation in Ge due to the tunnelling spin Seebeck effect [10,11].

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