中文摘要

有機自旋電子學是一利用有機材料為媒介來傳播自旋極化訊號之新興研究領域。在本研究中我們指出利用氧電漿處理有機層之表面可增加有機自旋閥之磁阻效能；相對的，有機自旋閥中之有機材料若未經由氧電漿處理，則無法顯現出磁阻效應。X 光電子能譜伴隨深度剖析量測結果顯示有機層經由氧電漿處理後，只會在介面深度小於 2 奈米處形成衍生之氧化層，並不會對此深度以下之有機層造成影響；本實驗結果提供一可行之介面性質改善方案，並成功增加有機自旋閥之磁阻效能。

金屬與有機層接觸所形成之介面性質對於有機自旋電子元件效能具有極大之影響；為了釐清介面電子結構與元件效能兩者之關連，我們在苝四甲酸二酐(PTCDA)有機自旋閥元件(鐵磁/有機半導體/鐵磁 之三層結構)中有機半導體與鐵磁之介面加 0.6 奈米厚的未完全氧化之氧化鋁層，並利用 X 光電子能譜及近邊 X 光吸收精細結構能譜來探測其介面性質。加入未完全氧化之氧化鋁層的元件在室溫下具有 13.5%的磁阻效應，而未加入未完全氧化之氧化鋁層的元件則不具任何磁阻效應。近邊 X 光吸收精細結構能譜指出，不論苝四甲酸二酐直接接觸鐵磁材料或未完全氧化之氧化鋁層，皆具有一規則排列之平面結構。X 光電子能譜顯示當有機半導體直接接觸鐵磁層，在介面處容易造成電子結構混雜之效應，並會減低自旋電子注入有機層之效率；在有機半導體與鐵磁層之介面加入未完全氧化之氧化鋁層，此一電子結構混雜之效應被有效的降低，因而提高了自旋電子注入有機層之效率。本研究提供了包含電子結構及分子排列規則的系統化資訊，將有助於新穎有機自旋電子元件之研究與設計。

以一層或少層碳原子所購成之石墨烯材料，由於其所具有的π電子所構成之特殊電子結構特性，乃是新穎電子元件的特定選擇。另一方面，以此石墨烯材料為基底所購成之多層結構，在經由質子束照射及氫化處理後可呈現出鐵磁性質，對於自旋電子元件之應用亦具有令人期盼之潛力。為了更進一步了解質子束照射對於此一以石墨烯材料為基底構成之材料中的電子結構之作用，我們利用具有兩百萬電子伏特(2 MeV)能量之質子束照射生長於碳化硅(SiC)上之石墨烯；並利用同時具有元素及空間解析能力之光電子發射顯微鏡(PEEM)與掃描式光電子能譜顯微鏡(SPEM)進行空間解析之圖譜研究。光電子發射顯微鏡指出石墨烯在質子束

照射後之區域，其排列會顯得較為無序，同時會伴隨著 sp^3 形式的電子結構形成；掃描式光電子能譜顯微鏡顯示石墨烯經由質子束照射後仍具有穩定之電子結構，而其底下之碳化硅電子結構則被嚴重破壞。此結果加上原子力顯微鏡(AFM)所觀察到的形貌變化，指出石墨烯/碳化硅系統中的電子結構在質子束照射後的變化，並不是直接由照射時的質子所造成，而是經由質子束照射在碳化硅層所形成之氫氣泡膨脹並上浮後逐漸破壞而成。藉由調整質子照射時間，我們可控制質子注入的多寡，因而調控石墨烯/碳化硅系統的結構及電子特性，並可進一步應用在以石墨烯為基底之電子元件與自旋電子元件中。

Abstract

Organic spintronics is the new emerging field of research, where organic semiconductor (OSC) materials are applied as a medium to transport spin-polarized signals. In the present work, we report an enhanced magnetoresistance (MR) in organic spin valve with oxygen plasma-treated pentacene (PC) spacer. The spin valve containing PC without the treatment shows no MR effect, whereas those with moderately plasma-treated PC exhibit MR ratios up to 1.64% at room temperature. X-ray photoelectron spectroscopy with depth profiling is utilized to characterize the interfacial electronic properties of the plasma-treated PC spacer which shows the formation of a derivative oxide layer. The results suggest an alternative approach to improve the interface quality and in turn to enhance the MR performance in organic spin valves.

The interface formed between the metal and the OSC layers is the key to the performance of OSC-based spintronic device. To elucidate the relationship between interfacial electronic properties and device performance, we report interfacial characterization of organic spin valves (OSVs) with a thin organic semiconductor (OSC) spacer of 3,4,9,10-perylene-teracarboxylic dianhydride (PTCDA) dusted with partially oxidized alumina at the OSC/ferromagnet (FM) interfaces. Up to 13.5% magnetoresistance (MR) is obtained at room temperature with these PTCDA-based OSVs. Near Edge X-ray Absorption Fine Structure (NEXAFS) spectroscopy results show that the PTCDA molecules form a well-ordered in-plane structure with their molecular plane mostly parallel to the substrate surface. X-ray Photoelectron Spectroscopy (XPS) measurements reveal interfacial electronic interaction between PTCDA and FM; while the application of a thin dusted AlO_x layer at the PTCDA/FM interfaces prevents the electronic hybridization and preserves effective spin injection from FM into the OSC spacer. The systematic information of interfacial properties provided by the work, including electronic structure and molecular

orientation at the OSC/FM interface, is crucial and helpful to the design of future organic spintronic devices.

Graphene-based materials, formed by one or a few crystalline monolayers of carbon atoms, are promising candidates for electronic devices because of their unusual electronic properties based on the π electrons. Ferromagnetic ordering of such graphene based material generated by energetic proton beam implentation or hydrogenation get intense interest due to its potential application for scientific studies and spintronic devices. To investigate the impact of the proton irradiation on the electronic structure of graphene-based system, few layers of graphene grown on SiC (graphene/SiC) were irradiated by 2 MeV energetic proton beam. Space-resolved NEXAFS spectroscopy reveals disoriented domain of the graphene with sp^3-formed hybidization formed at the irradiated area due to the irradiation. Space-resolved XPS spectra show that the graphene is stable upon proton irradiation, whereas the electronic structure of SiC is destroyed dramatically. These results, along with the morphology measured by AFM, suggest that the electronic structure change may be induced by the structure reconstruction which is caused by the hydogen blisters and made by the implanted proton, rather than caused directly by the proton irradiation itself. The ability to locally manipulate the structure and properties of EG/SiC system using focused ion beam could open up a new route to engineering EG/SiC system which is potential for graphene-based electronics and spintronics.