マテリアル先端リサーチインフラ利用報告書
ARIM User's Report

【Release：2025.06.16】　【Update：2025.11.28】

課題データ / Project Data

課題番号 Project Issue Number	23JI0008
利用課題名 Title	磁性薄膜の表面構造解析
利用した実施機関 Support Institute	北陸先端科学技術大学院大学 / JAIST
機関外・機関内の利用 External or Internal Use	外部利用/External Use
ARIM半導体基盤PF 関連課題 Related to ARIM-SETI	指定なし / No Designation
横断技術領域 Cross-Technology Area	計測・分析/Advanced Characterization
重要技術領域 Important Technology Area	量子・電子制御により革新的な機能を発現するマテリアル/Materials using quantum and electronic control to perform innovative functions
キーワード Keywords	原子間力顕微鏡/Atomic Force Microscope (AFM),走査プローブ顕微鏡/ Scanning probe microscope,スピントロニクス/ Spintronics

利用者と利用形態 / User and Support Type

利用者名（課題申請者） User Name (Project Applicant)	Bera Sambhunath
所属名 Affiliation	BML Munjal University School of Engineering &Technology
共同利用者氏名 Names of Collaborators Excluding Supporters in the Hub and Spoke Institutes	
ARIM実施機関支援担当者 Names of Supporters in the Hub and Spoke Institutes	伊藤暢晃
利用形態 Support Type	技術代行/Technology Substitution

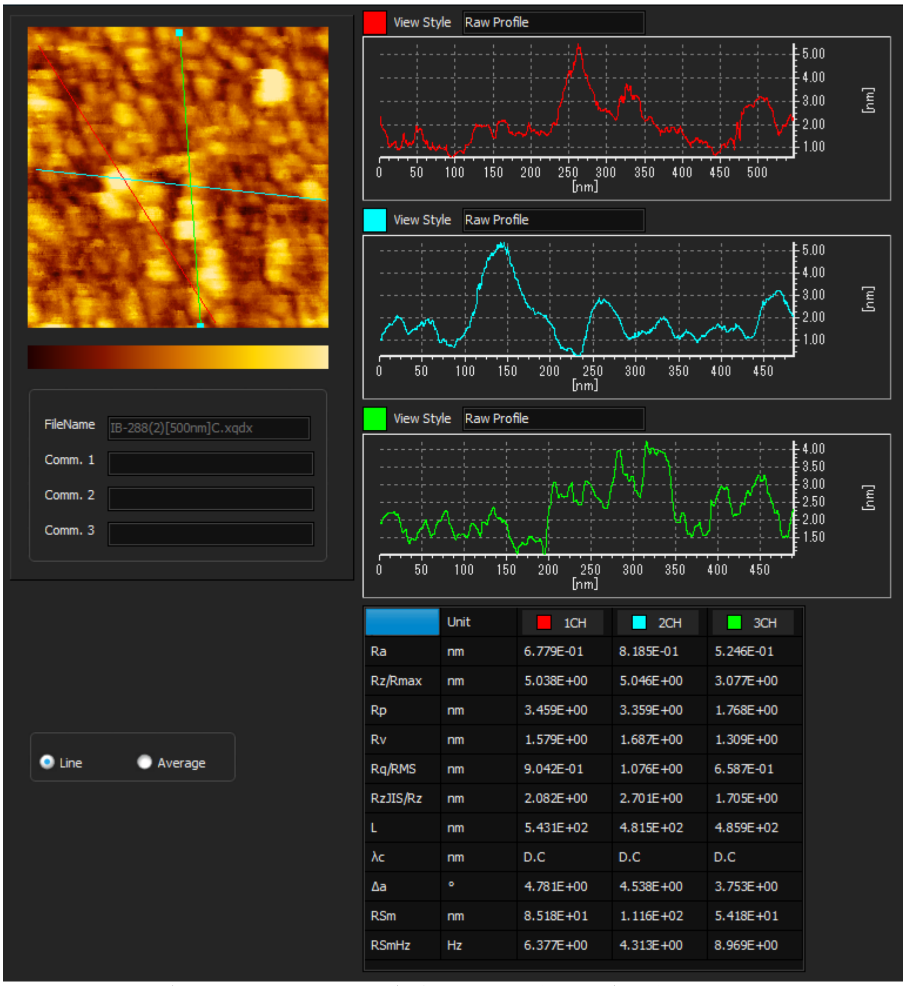
利用した主な設備 / Equipment Used in This Project

利用した主な設備 Equipment ID & Name	JI-012：大気中原子間力顕微鏡

報告書データ / Report

概要（目的・用途・実施内容） Abstract (Aim, Use Applications and Contents)	Magnetic multilayers are being used in spintronics, magneto-optics, sensor technology etc. Their applications are based on the exclusive magnetic properties which are easily variable by the element content, individual layer thicknesses, crystal structure, annealing, ion irradiation etc. Both magnetic as well as structural properties in multilayers can get greatly influenced by the interfaces between different layers Magnetic Si/Cr/$SmCo_5$/Pt/CoFeB/Al & Si/$SmCo_5$/Cr/Pt/CoFeB/Al multilayers are exchange spring magnetic system in which $SmCo_5$ is hard magnetic & CoFeB is soft magnetic. Pt & Cr in between $SmCo_5$ & CoFeB has been used as a diffusion barrier layer to reduce the intermixing between two magnetic layers. AFM study shows smooth surface for both the sample with rms roughness less than 1 nm.
実験 Experimental	Magnetic multilayers have been deposited on Si(100) substrate by using ion beam sputtering deposition technique at room temperature. There is a hexagonal target holder in the deposition chamber so that one can mount six different targets at a time. Cr, $SmCo_5$, Pt foil, CoFeB, and Al targets were placed on five faces of the hexagonal target holder. We have deposited Si/Cr/SmCo5/Pt/CoFeB/Al & Si/SmCo5/Cr/Pt/CoFeB/Al magnetic multilayers. Internal structure of the multilayer samples has been investigated using x-ray reflectivity technique at BML University, India. Magnetic properties were studied using vibrating sample magnetometry technique at Delhi University, India. Surface topography study was performed using Atomic Force Microscopy at JAIST, Japan. Correlations between structure and magnetic properties of the magnetic multilayers has been investigated
結果と考察 Results and Discussion	Individual layer thickness, density, and roughness of the two multilayers were calculated very precisely using x-ray reflectivity analysis. VSM study confirms that samples are magnetic anisotropic with easy axis along in-plane direction and hard axis along out-plane direction. Coercivity, remanences, and saturation magnetization has been determined form the hysteresis loops. Surface topography of the multilayer samples have been characterized by using Atomic force Microscopy (AFM) technique, to determine the surface roughness of multilayer samples. The morphology of the multilayer sample is calculated over the area of approximately (0.5 x 0.5) μm. Three channels has been measured in a selective area which are shown in CH1(red),CH2(blue) and CH3(green); the surface has a root-mean-square roughness of 0.9 nm, 1 nm and 0.7 nm respectively. The line profile of the AFM images exposes the maximum & minimum height of particles on the surface of film which was measured as 5 nm.

図・表・数式 1
Figures, Tables and Equations 1



AFM image (500 X 500 nm2) (bottom figure) of Cr/SmCo5/Pt/CoFeB/Al multilayer sample with line profile

その他・特記事項（参考文献・謝辞等） Remarks(References and Acknowledgements)	

成果発表・成果利用 / Publication and Patents

DOI（論文・プロシーディング）[1] DOI (Publication and Proceedings)	Gourav Sharma, Structure & magnetic properties of Cr/SmCo5/Pt/CoFeB multilayer thin films, *Physica B: Condensed Matter*, **722**, 418047(2026). DOI: https://doi.org/10.1016/j.physb.2025.418047
口頭発表、ポスター発表および、その他の論文 Oral Presentations etc.	
特許出願件数 Number of Patent Applications	0件
特許登録件数 Number of Registered Patents	0件