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

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課題データ / Project Data

課題番号 Project Issue Number	24UT1069
利用課題名 Title	Light-matter coupling in hybrid 2D material photonic devices
利用した実施機関 Support Institute	東京大学 / Tokyo Univ.
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	加工・デバイスプロセス/Nanofabrication
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	導波路、フォトニック結晶、キャビティ、SOI、LINbO3,電子線リソグラフィ/ EB lithography,ダイシング/ Dicing,フォトニクス/ Photonics,スパッタリング/ Sputtering

利用者と利用形態 / User and Support Type

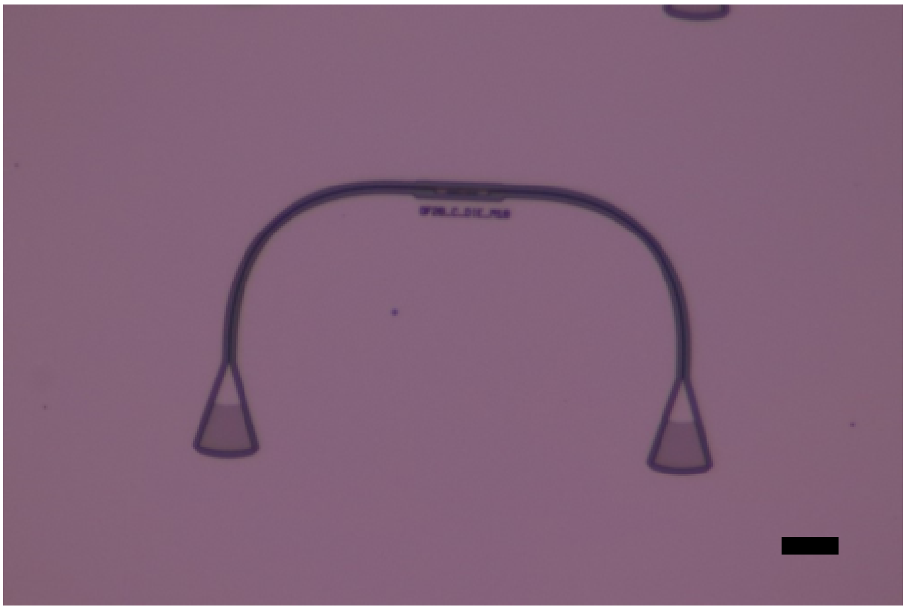
利用者名（課題申請者） User Name (Project Applicant)	Fong Chee Fai
所属名 Affiliation	理化学研究所加藤ナノ量子フォトニクス研究室
共同利用者氏名 Names of Collaborators Excluding Supporters in the Hub and Spoke Institutes	Yuichiro K. Kato
ARIM実施機関支援担当者 Names of Supporters in the Hub and Spoke Institutes	
利用形態 Support Type	機器利用/Equipment Utilization

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

利用した主な設備 Equipment ID & Name	UT-503：超高速大面積電子線描画装置 UT-600：汎用ICPエッチング装置 UT-604：高速シリコン深掘りエッチング装置 UT-900：ステルスダイサー UT-702：川崎ブランチECRスパッタリング装置

報告書データ / Report

概要（目的・用途・実施内容） Abstract (Aim, Use Applications and Contents)	We use the Takeda cleanroom to fabricate photonic structures such as waveguides, photonic crystal and cavities on various substrates such as silicon, silicon nitride and lithium niobate. The photonic nanostructures are then used for light-matter coupling with 2D materials
実験 Experimental	We began by spin-coating an electron-beam resist onto the chosen substrate, such as silicon-on-insulator (SOI), silicon nitride, or lithium niobate. Using electron beam lithography, we defined the photonic nanostructure patterns onto the resist, followed by resist development. For lithium niobate, an additional sputtering step is required to deposit a layer of chromium as hard mask for the subsequent etching step. The patterns were then transferred to the substrate using inductively coupled plasma etching. After removing the remaining resist, additional processing steps, such as wet etching with hydrofluoric acid for substrates with a silicon dioxide layer, were performed as needed to create air-suspended nanophotonic structures or other desired geometries.
結果と考察 Results and Discussion	We successfully fabricated photonic nanostructures, including waveguides and photonic crystals, on a variety of substrates such as silicon, silicon nitride, and lithium niobate. Fig.1 shows a nanobeam photonic crystal cavity with grating couplers. Fig.2 shows a grating photonic crystal cavity with grating outcouplers for use with fiber in- and out-coupling. The optical properties of these structures were confirmed through photoluminescence and laser transmission measurements. The waveguide modes and cavity resonances, typically in the near-infrared regime, enable efficient light-matter coupling with van der Waals materials that are optically active in the same wavelength range. The flexibility in substrate choice allows for tailoring the nanophotonic structures to specific material and application requirements.
図・表・数式 1 Figures, Tables and Equations 1	 Fig.1 Nanobeam photonic crystal cavity with grating couplers fabricated on SOI substrate. Scale bar represents 10 microns.

図・表・数式 2 Figures, Tables and Equations 2	 Fig.2 Grating photonic crystal cavity with grating outcouplers for use with fiber in- and out-coupling. Structures are fabricated on an SOI substrate. Scale bar represents 10 microns.
その他・特記事項（参考文献・謝辞等） Remarks(References and Acknowledgements)	C.F. Fong was partly supported by RIKEN SPDR fellowship. This work was supported in part by JSPS KAKENHI (JP22K14623, JP20H02558, JP23H00262 and JP24K17627).

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)	Chee Fai Fong, Self-Aligned Hybrid Nanocavities Using Atomically Thin Materials, *ACS Photonics*, **11**, 2247-2254(2024). DOI: 10.1021/acsphotonics.3c01927
口頭発表、ポスター発表および、その他の論文[1] Oral Presentations etc.	C. F. Fong, D. Yamashita, N. Fang, S. Fujii, Y.-R. Chang, T. Taniguchi, K. Watanabe, Y. K. Kato, ” Dielectric environment engineering with 2D materials for hybrid nanocavities” , Fundamental Optical Processes in Semiconductors (FOPS) 2024, Newfoundland, Canada (July 25, 2024).
口頭発表、ポスター発表および、その他の論文[2] Oral Presentations etc.	C. F. Fong, D. Yamashita, N. Fang, S. Fujii, Y.-R. Chang, T. Taniguchi, K. Watanabe, Y. K. Kato, “Demonstration of hybrid photonic crystal nanocavity using atomically thin van der Waals flakes,” The 14th International Conference on Metamaterials, Photonic Crystals and Plasmonics (META 2024), Toyama, Japan (July 16 2024).
特許出願件数 Number of Patent Applications	0件
特許登録件数 Number of Registered Patents	0件