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科学研究費助成事業　　研究成果報告書

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研究課題名（和文）コヒーレント磁気弾性強結合状態に基づく高効率スピン流生成手法の開拓

研究課題名（英文）Efficient spin current generation based on coherent magnetoelastic strong coupling state

研究代表者

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研究成果の概要（和文）：プロジェクト初期では、SAWキャビティデバイスの設計・製造に焦点を当て、スピン流生成の高効率化を目指した。SAWデバイス設計の最適化に成功し、音響キャビティの設置によりフォノンエネルギーの閉じ込め効率が2.09倍に向上。音響キャビティの共鳴周波数でSAWを励起すると、音響強磁性共鳴の励起効率が向上し、Cu/Bi2O界面のスピン流生成効率も改善された。音響キャビティ使用により、非相反性や非線形性も増大。後半では低ダンピング強磁性体CoFeB層を用いた共鳴実験でマグノン-フォノン結合強度が増大し、新たな強結合準粒子が確認された。これらの成果はセンシング技術の発展に寄与する。

研究成果の学術的意義や社会的意義
当プロジェクトで達成したSAWチップデバイスを用いた室温におけるマグノン-フォノン強結合の実証は従来になく、ハイブリッド波ベースの情報通信技術に大きな影響を与える。また、マグノン-フォノン結合準粒子は、マグノンとフォノンの両方の特性を活用し、大きな伝播長や長いコヒーレンス時間を持つ磁気弾性波デバイスの実現を可能にする。この研究成果は、Physical Review LettersとScience Magazineで高い注目を集め、その社会的・学術的意義が示されている。

研究成果の概要（英文）：At the beginning of the project, we concentrated on the design and fabrication of SAW cavity devices to increase the efficiency of spin current generation. we successfully optimized the design of the SAW devices and improved the confinement efficiency of phonon energy by 2.09 times by installing acoustic cavities. Excitation of SAWs at the resonant frequency of the acoustic cavity improved the excitation efficiency of acoustic ferromagnetic resonance and the efficiency of spin current generation at the Cu/Bi2O interface. Incorporation of the acoustic resonator also improved the non-collinearity and nonlinearity. In the second phase of the project, resonance experiments using a low-damping ferromagnetic CoFeB layer improved the magnon-phonon coupling strength, leading to the confirmation of a new strongly coupled quasiparticle. These findings advance the development of sensing technology.

研究分野：マグノニクス

キーワード：磁気弾性結合　強結合　スピン流　エデルシュタイン効果

様　式　C－１９、F－１９－１（共通）

１．研究開始当初の背景

The research into topics related to magnon-phonon coupling has experienced a resurgence, driven by the growing interest in transitioning the understanding of magnon-phonon interaction to technologies relevant to the information and communication sector. This is particularly true when phonons are in the forms of surface acoustic waves (SAWs), and magnons are the spin wave excitations in thin magnetic layers (few 10s of nanometers).

In our laboratory, a pivotal demonstration occurred in 2018, showcasing the generation of spin currents through the coupling of microwave surface acoustic waves (SAWs) with a ferromagnetic/nonmagnetic/oxide trilayer system [Physical Review B 97 (18), 180301(R) (2018)].

There is potential to extend these findings to fabricating cavity acoustic wave devices operating within a strong magnon-phonon coupling regime. In the strong coupling regime, efficient, protected, and coherent transfer of information occurs from excited magnon to phonon and vice versa, particularly in the magnon-phonon superposition state [Nature Physics 14, 500–506 (2018)]. Both magnons and phonons are bosonic particles, facilitating their coupling and the emergence of a quasiparticle analogous to exciton-polaritons [Rev. Mod. Phys. 82, 1489 (2010)]. The potential formation of novel quasiparticles in the strong coupling regime opens a new frontier in research, offering avenues to explore information processes within magnon-phonon interactions and address fundamental questions regarding the transition from classical to quantum realms.

２．研究の目的

We divide the research objectives of our projects into two parts:

- For the first part of our project, we aim to enhance spin current generation under acoustic FMR conditions by incorporating acoustic reflectors into our acoustic wave devices.

We aim to enhance the efficiency of the spin current generation by harnessing phononic energy that travels opposite to the direction in magnetic layers. This approach is projected to increase spin current generation from two to four times, facilitated by acoustic reflectors.

- In the second phase of our project, we confront the challenge of unequivocally demonstrating magnon-phonon strong coupling. Notably, hybrid magnon-phonon quasiparticles are expected to exhibit properties distinct from individual magnons or phonons within the strong coupling regime. They represent a novel entity combining the characteristics of both bosonic quasiparticles. Furthermore, we would like to demonstrate that magnon-phonon coupling can lead to strong nonreciprocity, resulting from the time-reversal symmetry breaking of magnons and the emergence of chirality in both magnons and phonons. These strong nonreciprocities enable directional propagation, which aids in noise isolation.

３．研究の方法

(1) The first challenge of our project is the design and fabrication of our surface acoustic wave (SAW) devices to enhance spin current generation. In standard SAW devices, the interdigital transducers (IDTs) produce bi-directional SAWs (see Figure 1a, top), and half of the phonon energy is lost, dissipating in the opposite direction to the magnetic layer location. Thus, minimizing the losses of phononic energy in our transfer mechanism is crucial. We can reduce the phonon losses by adding acoustic reflectors to the ends of our IDTs. If the distance between reflectors and IDTs is adequately engineered, we can obtain constructive wave interference and increase the phonon coupling to our magnetic layer (see Figure 1a, bottom). By collecting the waves traveling in the opposite direction of our magnetic film, we can expect enhancements of two to four times if the SAW generation is symmetric. Furthermore, an acoustic analog of optical Bragg mirrors forming an optical cavity can increment the magnon-phonon coupling, which is relevant to the challenge in the second part of our project.

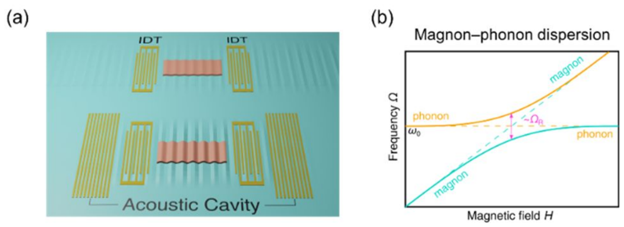

Figure 1. (a) Schematic illustration of surface acoustic wave device (SAW), without (top) and with (bottom) acoustic cavity. (b) Avoided crossing or anticrossing at the intersection between the magnon and phonon dispersions.

Our SAW devices, designed with acoustic reflectors, underwent initial testing through simulation using COMSOL Multiphysics software. Subsequently, we proceeded with fabrication utilizing electron beam lithography and electron beam evaporation techniques. To validate the functionality of the SAW devices, we employed a Vector Network Analyzer (VNA), which measures SAW transmission by assessing scattering parameters S_{21} and S_{12}.
The main objective of the second phase of the project is to demonstrate the strong magnon-phonon coupling conclusively. To achieve this, we must employ a distinct measurement approach. A key indicator of strong coupling is the occurrence of avoided crossing or anticrossing of energy dispersions of the quasiparticles, such as magnons and phonons, involved in the coupling. In our specific case, this manifests as an avoided crossing at the intersection between the magnon and phonon dispersions (refer to Fig. 1b). Our methodology involves simultaneous scanning of the excitation frequency of our SAW device and the external magnetic field, utilizing an acoustic cavity device and a magnetic layer. The strength of the coupling is directly related to the size of the gap observed at the avoided crossing.
The experimental demonstration of enhanced nonlinearities is another crucial aspect of our research project. Within the strong coupling regime, we anticipate observing characteristic nonlinear behaviors, including Suhl instabilities, which are a kind of parametric instabilities of ferromagnetic spin waves. Experimentally, Suhl instabilities manifest as the spontaneous generation of half-harmonic and second-harmonic spin waves. We investigate the harmonic generation of our strongly coupled magnetoelastic waves using Brillouin light scattering spectroscopy (BLS) under externally applied magnetic fields.

(2) Problems Encountered in Conducting the Research and Measures to Cope with Them

As is well-known, the COVID-19 pandemic disrupted many lives, including research activities. Although we managed to achieve, to a large extent, the objectives of our research project, we suffered delays due to the COVID-19 pandemic. The most significant issue was delays in delivering a cryostation and complementary equipment for Brillouin light scattering measurements. While waiting for the delivery of the equipment, we investigated various magnetic materials with low magnetic damping. CoFeB was found to be the best option for our magnon-phonon strong coupling experiments (see research achievements section).

(3) Research plan/methods implemented through changes to the original plan for use of research funds

Our research plan/methods have been implemented without significant changes to the original plan. Due to the COVID-19 pandemic, we experienced a delay in our Brillouin light scattering (BLS) measurement plan. However, the delays did not affect the main objectives of the project, and presently, we are completing the BLS measurements and preparing a scientific manuscript with the obtained data.

(4) The status of the response to the items pointed out at the time of the interim assessment

In the interim assessment, we received a very positive report, with no significant issues identified in our research project.

４．研究成果

(1) We have successfully designed and fabricated our surface acoustic wave (SAW) devices. Figure 2(a) shows the comparison of the absorption power of SAW P_{SAW} of our SAW devices with (blue circle) and without (red square) the acoustic cavity. We observe an enhancement factor of 2.04, proportional to the enhancement of acoustic ferromagnetic resonance excitation. Figure 2(b) shows the output voltage resultant of the spin-to-charge conversion and compares the SAW devices with (blue circles) and without (red square) acoustic cavity. We observe a significant enhancement of spin current generation with our acoustic cavity device. We do a SAW power dependence excitation to obtain an estimation of the enhancement factor. Figure 2(c) shows the power dependence of acoustic spin pumping for SAW devices with (blue circles) and without (red square) acoustic cavities. From this plot, we can deduce enhancement factors of 2.96 at a low power range (<75mW) and 1.6 at a high power range (>75mW). **These results demonstrate that, as we proposed in the main objective of our project's first half, it is possible to enhance the spin current generation by minimizing the phonon losses with acoustic cavities; for further details, see our related publication [Appl.**

Phys. Lett. 116, 252404, Editor's suggestion (2020)].

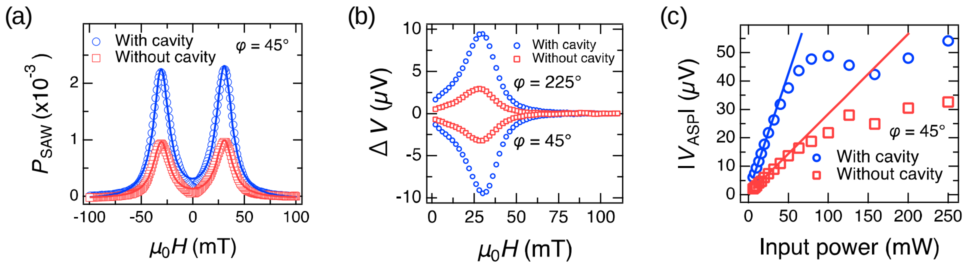

Figure 2. (a) SAW power absorption at resonance condition for ferromagnetic resonance (FMR) driving of a Ni layer. (b) Detected electric voltage when 10 mW of RF power is applied to IDT 1 and an external in-plane magnetic field in angles of 45^0 and 225^0 is applied. Data are taken from samples with acoustic cavities (blue circles) and without (red squares) acoustic cavities. (c) Input RF power of IDT 1 dependence of electric voltage at an angle of 45^0 of an external magnetic field applied to samples with (blue circles) and without (red squares) acoustic cavity.

The relevance of nonlinearity in our project motivated another critical study, a nonreciprocal phenomenon. In an independent experiment on high-quality CoFeB films, we found a nonlinear SAW absorption behavior as large as 100%. Please note that the devices do not use acoustic cavities in this experiment. The obtained result is very relevant to our project; however, it is a development not foreseen in the original research plan, and more details will be given in the next section of this document. Details can also be consulted in our related publication [Science Advances 6 (32), eabb1724 (2020)].

Following the original objectives of the first half of our project, we have demonstrated (i) the enhancement of spin current generation by minimizing the phonon losses using acoustic cavities and (ii) the study of asymmetries in the magnon-phonon coupling, such as nonreciprocal phenomena and nonlinearities. The results have been reported as high-impact publications, which the journal editors and RIKEN institute have highlighted.

Now, let us describe the research achievements of the second half of our project. The most essential research achievement in our project is presented in Figure 3. Starting with Figure 3(a), we observe the experimental data of SAW transmission spectra of two phonon modes moving across a 10 nm thick CoFeB layer in an acoustic cavity device: one mode with frequency around 6.59 GHz with relatively more substantial amplitude (bright yellow) than another mode at lower frequency, 6.56 GHz, with weaker amplitude (dim orange). The dispersions of the phonon modes in Figure 3(a) are primarily constant and linear and are only absorbed by the CoFeB layer when the external in-plane magnetic field is around 30mT; at this magnetic field value, the phonon energy is absorbed to excite spin waves (magnons). Figure 3(b) shows the theoretical model reproducing our experimental data for the case when the CoFeB layer is 10 nm thick. In the SAW transmission measurements with a 10 nm thick CoFeB, the coupling of magnons and phonons is still out of the strong coupling regime. However, as we commented in the original proposal, the coupling strength g in these experiments is directly proportional to the number of participating spins; therefore, by increasing the thickness of our magnetic layer, we can expect a proportional increase in coupling strength. Figure 3(c) shows the data of similar SAW transmission measurements with a 20 nm thick CoFeB layer. SAW transmission data now shows a deviation or bending on the phonon dispersion as the applied external magnetic field approaches the resonance condition with magnons around 30mT. The response of the phonon dispersion to the external magnetic field indicates the strong coupling between magnons and phonons and the formation of a new hybrid quasiparticle. In other words, now, phonons behave partially as magnons and can feel the influence of external magnetic fields. And, in principle, the opposite is also true: magnons behave partially like phonons. Figure 3(d) shows the theoretical model reproducing our experimental data for the case when the CoFeB layer is 20 nm thick. As envisioned in the original proposal, achieving magnon-phonon strong coupling opens transcendent opportunities to develop hybrid wave-based devices and new sensing technologies and explore various physical phenomena at the border between classical and quantum mechanics. Figures 3(e) and 3(f) show the data and theoretical model of similar SAW transmission measurements, now with a 30 nm thick CoFeB layer. It is evident the more significant avoided crossing or anticrossing in the phonon dispersion indicates an even larger coupling strength. The strong coupling between magnons and phonons results from increasing the coupling strength g and reducing the energy losses of magnons and phonons. As mentioned, the magnon losses are caused by magnetic damping, an intrinsic property of magnetic materials. At the same time, the use of acoustic cavities reduces the phonon losses in our SAW devices. Therefore, to demonstrate that this is the case, we also measure the SAW transmission with a 30 nm thick CoFeB layer but without an acoustic cavity. The data for this measurement is shown in Figure 3(g). The data shows the linear and constant dispersion of two phonon modes unaffected by the external magnetic field, further demonstrating the relevance of using acoustic cavities to reduce the phonon losses in our devices.

The achievement in our project of strong magnon-phonon coupling with a SAW on-chip device at room temperature is the first of its kind worldwide, with a large impact on hybrid wave-based information and communication technologies. A hybrid magnon-phonon quasiparticle can exploit the combined properties of both magnon and phonons to create magnon devices with larger propagation lengths or hybrid wave devices with longer coherent times. As tangibles to demonstrate the impact and relevance of our research achievement, we refer to our publication in Physical Review Letters [Phys. Rev. Lett. 132, 056704 (2024)], selected as the Editors' suggestion, and we also refer to the highlights of our work in Science Magazine [1st of March 2024, vol. 383, issue 6686, page 961].

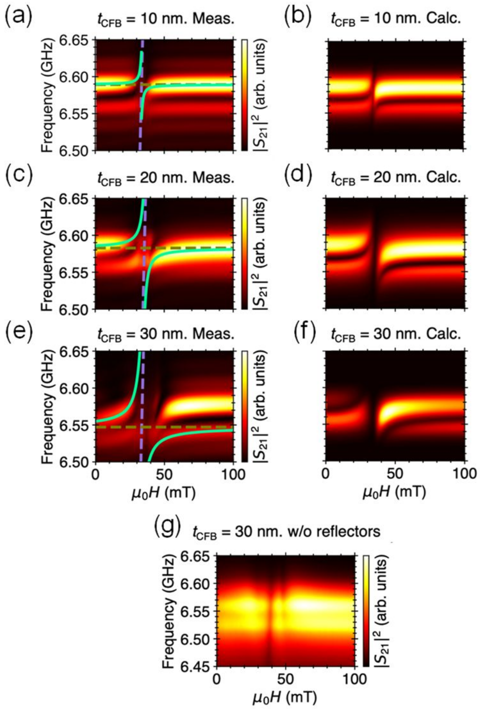

Figure 3. SAW transmission experiment and theoretical model on a 10 nm (a, b), 20 nm (c, d), and 30 nm (e, f) thick CoFeB layer in a device with an acoustic cavity. (g) SAW transmission experiment on a 30 nm thick CoFeB layer in a device without an acoustic cavity.

(2) Research results obtained from new developments that were not foreseen in the original research plan

As it turns out, studies of magnon-phonon coupling had more to offer than we initially foreseen in the original research plan. In the following, we list other relevant results.

- In an experiment on high-quality CoFeB films, we found a nonlinear SAW absorption behavior as large as 100%. Details of this research results were published in **Science Advances 6 (32), eabb1724 (2020)**, and were covered in the news by Phys.org.
- In another set of experiments, we explored the coupling of SAW with ferromagnetic layers under out-of-plane external magnetic fields and the consequent spin current generation. This work was published in **Advanced Materials Interfaces, 2201432 (2022)**.
- We also explored the possibility of modifying the coupling between magnons and phonons by experimentally defining an artificial periodic landscape in superlattices. Details of this work can be obtained in the related publication in **Phys. Rev. Lett., 131, 176701 (2023)**.
- We demonstrate acoustically driven spin-wave resonance in a crystalline antiferromagnet, chromium trichloride, via SAW irradiation. The work was published in **Phys. Rev. Lett. 131, 196701 (2023)**, it was selected as Editor's suggestion, and feature article in APS Physics magazine.

５．主な発表論文等

〔雑誌論文〕　計14件（うち査読付論文　14件／うち国際共著　8件／うちオープンアクセス　4件）

１．著者名 Y. Hwang, J. Puebla, K. Kondou, C. Gonzalez-Ballestero, H. Isshiki, C.Sanchez Munoz, L. Liao, F. Chen, W. Luo, S. Maekawa, & Y. Otani	４．巻 132
２．論文標題 Strongly Coupled Spin Waves and Surface Acoustic Waves at Room Temperature	５．発行年 2024年
３．雑誌名 Physical Review Letters	６．最初と最後の頁 056704-1~5
掲載論文のDOI（デジタルオブジェクト識別子） 10.1103/PhysRevLett.132.056704	査読の有無 有
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 該当する

１．著者名 T. Lyons, J. Puebla, K. Yamamoto, R. Deacon, Y. Hwang, K. Ishibashi, S. Maekawa, & Y. Otani	４．巻 131
２．論文標題 Acoustically Driven Magnon-Phonon Coupling in a Layered Antiferromagnet	５．発行年 2023年
３．雑誌名 Physical Review Letters	６．最初と最後の頁 196701-1~6
掲載論文のDOI（デジタルオブジェクト識別子） 10.1103/PhysRevLett.131.196701	査読の有無 有
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 －

１．著者名 L. Liao, J. Puebla, K. Yamamoto, J. Kim, S. Maekawa, Y. Hwang, Y. Ba, & Y. Otani	４．巻 131
２．論文標題 Valley-Selective Phonon-Magnon Scattering in Magnetoelastic Superlattices	５．発行年 2023年
３．雑誌名 Physical Review Letters	６．最初と最後の頁 176701-1~6
掲載論文のDOI（デジタルオブジェクト識別子） 10.1103/PhysRevLett.131.176701	査読の有無 有
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 －

１．著者名 Y. Hwang, J. Puebla, K. Kondou, C. Sanchez Munoz, & Y. Otani	４．巻 92
２．論文標題 Nonlinear Acoustic Spin Pumping Caused by Temperature-Dependent Frequency Shifts of Surface Acoustic Waves	５．発行年 2023年
３．雑誌名 Journal of the Physical Society of Japan	６．最初と最後の頁 094702-1~5
掲載論文のDOI（デジタルオブジェクト識別子） 10.7566/JPSJ.92.094702	査読の有無 有
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 該当する

１．著者名 J. Puebla, Y. Hwang. S. Maekawa, & Y. Otani	４．巻 120
２．論文標題 Perspectives on spintronics with surface acoustic waves	５．発行年 2022年
３．雑誌名 Applied Physics Letters	６．最初と最後の頁 220502-1~9
掲載論文のDOI（デジタルオブジェクト識別子） 10.1063/5.0093654	査読の有無 有
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 －

１．著者名 Y. Hwang, J. Puebla, K. Kondou, & Y. Otani	４．巻 9
２．論文標題 Voltage Signals Caused by Surface Acoustic Wave Driven Ferromagnetic Resonance Under Out‐of‐Plane External Fields	５．発行年 2022年
３．雑誌名 Advanced Materials Interfaces	６．最初と最後の頁 2201432～2201432
掲載論文のDOI（デジタルオブジェクト識別子） 10.1002/admi.202201432	査読の有無 有
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 －

１．著者名 K. Yamamoto, M. Xu, J. Puebla, Y. Otani, & S. Maekawa,	４．巻 545
２．論文標題 Interaction between surface acoustic waves and spin waves in a ferromagnetic thin films"	５．発行年 2022年
３．雑誌名 J. Magn. Magn. Mater.	６．最初と最後の頁 168672-1~10
掲載論文のDOI（デジタルオブジェクト識別子） 10.1016/j.jmmm.2021.168672	査読の有無 有
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 －

１．著者名 F. Chen, X. Ge, W. Luo, R. Xing, S. Liang, X. Yang, L. You, R. Xiong, Y. Otani, & Y. Zhang,	４．巻 15
２．論文標題 Strain-induced Megahertz Oscillation and Stable Velocity of an Antiferromagnetic Domain Wall	５．発行年 2021年
３．雑誌名 Phys. Rev. Applied.	６．最初と最後の頁 014030-1~8
掲載論文のDOI（デジタルオブジェクト識別子） 10.1103/PhysRevApplied.15.014030	査読の有無 有
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 該当する

1．著者名 J. Puebla Y. Hwang K. Kondou & Y. Otani	4．巻 534
2．論文標題 Progress in spinconversion and its connection with band crossing	5．発行年 2021年
3．雑誌名 Ann. Phys. (Berlin)	6．最初と最後の頁 2100398-1~9
掲載論文のDOI（デジタルオブジェクト識別子） 10.1002/andp.202100398	査読の有無 有
オープンアクセス オープンアクセスとしている（また、その予定である）	国際共著 該当する

1．著者名 K.Yamamoto, W. Yu, T. Yu, J. Puebla, M. Xu, S. Maekawa, & G. Bauer	4．巻 89
2．論文標題 Non-reciprocal Pumping of Surface Acoustic Waves by Spin Wave Resonance	5．発行年 2020年
3．雑誌名 Journal of the Physical Society of Japan	6．最初と最後の頁 11372-1-5
掲載論文のDOI（デジタルオブジェクト識別子） 10.7566/JPSJ.89.113702	査読の有無 有
オープンアクセス オープンアクセスとしている（また、その予定である）	国際共著 該当する

1．著者名 M. Xu, K. Yamamoto, J. Puebla, K. Baumgaertl, B. Rana, K. Miura, H. Takahashi, D. Grundler, S. Maekawa, & Y. Otani	4．巻 6
2．論文標題 Nonreciprocal surface acoustic wave propagation via magneto-rotation coupling	5．発行年 2020年
3．雑誌名 Science Advances	6．最初と最後の頁 1724-1-5
掲載論文のDOI（デジタルオブジェクト識別子） 10.1126/sciadv.abb1724	査読の有無 有
オープンアクセス オープンアクセスとしている（また、その予定である）	国際共著 該当する

1．著者名 Y. Hwang, J. Puebla, M. Xu, A. Lagarrigue, K. Kondou, & Y. Otani	4．巻 116
2．論文標題 Enhancement of acoustic spin pumping by acoustic distributed Bragg reflector cavity	5．発行年 2020年
3．雑誌名 Applied Physics Letters	6．最初と最後の頁 252404-1-5
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オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 該当する

1．著者名 J. Puebla, J. Kim, K. Kondou, & Y. Otani	4．巻 1
2．論文標題 Spintronic devices for energy-efficient data storage and energy harvesting	5．発行年 2020年
3．雑誌名 Communications Materials	6．最初と最後の頁 0022-5-1-9
掲載論文のDOI（デジタルオブジェクト識別子） 10.1038/s43246-020-0022-5	査読の有無 有
オープンアクセス オープンアクセスとしている（また、その予定である）	国際共著 該当する

1．著者名 P. Jorge, M. Xu, R. Bivas, K. Yamamoto, S. Maekawa, & Y. Otani	4．巻 53
2．論文標題 Acoustic ferromagnetic resonance and spin pumping induced by surface acoustic waves	5．発行年 2020年
3．雑誌名 Journal of Physics D: Applied Physics	6．最初と最後の頁 264002-1~7
掲載論文のDOI（デジタルオブジェクト識別子） 10.1088/1361-6463/ab7efe	査読の有無 有
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〔学会発表〕　計20件（うち招待講演　8件／うち国際学会　17件）

1．発表者名 J. Puebla, T. Lyons, K. Yamamoto, R. Deacon, Y. Hwang, K. Ishibashi, S. Maekawa, Y. Otani,
2．発表標題 Acoustically driven magnon-phonon coupling in a layered antiferromagnet
3．学会等名 APS March Meeting, Minneapolis, USA, Mar. 2024.（招待講演）（国際学会）
4．発表年 2024年

1．発表者名 Y. Hwang, J. Puebla, K. Kondou, C. Gonzalez-Ballestero, H. Isshiki, C. Sanchez Munoz, L. Liao, F. Chen, W. Luo, S. Maekawa, Y. Otani,
2．発表標題 Strong coupling between spin waves and surface acoustic waves,
3．学会等名 APS March Meeting, Minneapolis, USA, Mar. 2024.（国際学会）
4．発表年 2024年

1．発表者名 L. Liao, J. Puebla, K. Yamamoto, J. Kim, S. Maekawa, Y. Hwang, Y. Ba, & Y. Otani,
2．発表標題 Valley-selective phonon-magnon scattering in magnetoelastic superlattices,
3．学会等名 5th International Workshop on Spintronic Memory and Logic, SML, Beijing, China, Oct. 2023.（国際学会）
4．発表年 2023年

1．発表者名 Y. Hwang, J. Puebla, K. Kondou, C. Gonzalez-Ballestero, C. Sanchez Munoz, H. Isshiki, L. Liao, F. Chen, W. Luo, S. Maekawa, Y. Otani,
2．発表標題 Observation of the coupled magnon-phonon mode splitting in a surface acoustic wave cavity device,
3．学会等名 JEMS 2023, Madrid, Spain, Aug. 2023.（国際学会）
4．発表年 2023年

1．発表者名 Y. Otani
2．発表標題 Spin conversion research towards novel spintronic functionalities
3．学会等名 MML 2023, Seoul, Korea, Jul. 2023.（招待講演）（国際学会）
4．発表年 2023年

1．発表者名 Y. Hwang, J. Puebla, K. Kondou, K. Yamamoto, S. Maekawa, & Y. Otani,
2．発表標題 Strongly coupled surface acoustic waves and spin waves in a ferromagnetic thin film,
3．学会等名 MML 2023, Seoul, Korea, Jul. 2023.（国際学会）
4．発表年 2023年

１．発表者名
J. Puebla, Y. Otani,

２．発表標題
Resonant absorption of surface acoustic waves in magnetic thin films

３．学会等名
Workshop on Interdisciplinary Spin Physics, Sendai, Japan, Jun. 2023.（招待講演）（国際学会）

４．発表年
2023年

１．発表者名
J. Puebla, Y. Otani,

２．発表標題
Magnon-phonon coupling in a layered antiferromagnet,

３．学会等名
INTERMAG 2023, Sendai, Japan, May 2023.（招待講演）（国際学会）

４．発表年
2023年

１．発表者名
Y. Hwang, J. Puebla, K. Kondou, K. Yamamoto, S. Maekawa, & Y. Otani,

２．発表標題
Observation of Coupled Magnon-Phonon Mode Anticrossing in a Two-Port Surface Acoustic Wave Resonator,

３．学会等名
INTERMAG 2023, Sendai, Japan, May 2023.（国際学会）

４．発表年
2023年

１．発表者名
L. Liao, J. Puebla, J. Kim, Y. Hwang, & Y. Otani

２．発表標題
Nonreciprocal Surface Acoustic Wave Propagation Enabled by Out-of-Plane Magnetization,

３．学会等名
INTERMAG 2023, Sendai, Japan, May 2023.（国際学会）

４．発表年
2023年

１．発表者名 Y. Hwang, J. Puebla, C. S. Munoz, K. Yamamoto, K. Kondou, S. Maekawa, & Y. Otani
２．発表標題 音響共振器による表面弾性波の非線形励起及びマグノン・フォノン結合への影響
３．学会等名 日本物理学会　第77回年次大会
４．発表年 2022年

１．発表者名 J. Puebla
２．発表標題 Magnon-phonon coupling in the presence of acoustic cavities,
３．学会等名 Workshop on Spintronics SPIN 2022, Bariloche, Argentina, Nov. 2022（国際学会）
４．発表年 2022年

１．発表者名 Y. Otani, J.Puebla, Y. Hwang, & K.Kondou,
２．発表標題 Magnon-phonon coupling in spintronics
３．学会等名 ICMFS-2022, Okinawa, Japan, Jul. 2022（招待講演）（国際学会）
４．発表年 2022年

１．発表者名 Y. Hwang, J. Puebla, K. Kondou, K. Yamamoto, C. S. Munoz, A. Lagarrigue, S. Maekawa, & Y. Otani
２．発表標題 Enhancement of spin current generation by magnon-phonon coupling using acoustic cavity
３．学会等名 ICMFS-2022, Okinawa, Japan, Jul. 2022（国際学会）
４．発表年 2022年

1．発表者名
J. Puebla, M. Xu, Y. Hwang, K. Yamamoto, S. Maekawa & Y. Otani

2．発表標題
Latest Strides on Magnon-Phonon Coupling (acoustic): Spin current, Nonreciprocity and Nonlinearity

3．学会等名
The 15th Joint MMM-INTERMAG Conference, Jan. 2022（国際学会）

4．発表年
2021年

1．発表者名
Y. Hwang, J. Puebla, M. Xu, A. Lagarrigue, K. Kondou & Y. Otani

2．発表標題
Enhancement of Acoustic Spin Pumping by Acoustic Distributed Bragg Reflector Cavity

3．学会等名
INTERMAG 2021, Online, April 2021（国際学会）

4．発表年
2021年

1．発表者名
大谷 義近

2．発表標題
機能的スピン変換現象

3．学会等名
分子研研究会「エネルギー科学の最前線：階層横断的な理解に向けて」 2022年3月.（招待講演）

4．発表年
2021年

1．発表者名
J. Puebla, Y. Otani

2．発表標題
Magneto-rotation devices and spin current generation in the presence of acoustic cavities

3．学会等名
2021 MRS Fall meeting, Online, Dec. 2021（招待講演）（国際学会）

4．発表年
2021年

１．発表者名 J. Puebla, M. Xu, Y. Hwang, K. Yamamoto, K. Baumgaertl, A. Lagarrigue, B. Rana, K. Kondou, K. Miura, H. Takahashi, D. Grundler, S. Maekawa & Y. Otani
２．発表標題 Nonreciprocity via magneto-rotation coupling and acoustic spin pumping in presence of acoustic cavities
３．学会等名 5th Symposium for The Core Research Clusters for Materials Science and Spintronics, Oct. 2021（招待講演）
４．発表年 2021年

１．発表者名 M. Xu, K. Yamamoto, J. Puebla, K. Baumgaertl, B. Rana, K. Miura, H. Takahashi, D. Grundler, S. Maekawa & Y. Otani,
２．発表標題 Acoustic-magnetic rectifier in anisotropic magnets,
３．学会等名 International workshop in Spintronics, Ollantaytambo, Peru, Oct. 2019（国際学会）
４．発表年 2019年

〔図書〕　計0件

〔産業財産権〕

〔その他〕

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７．科研費を使用して開催した国際研究集会

〔国際研究集会〕　計0件

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