

for the film with the intermediate anisotropy are in good agreement with our BLS data.

In summary, we performed BLS and MOKE studies of strained Pt/Co/Pt films. We demonstrated that the strain strongly influences the DMI in the system. Application of  $\pm 0.1\%$  in-plane deformations varies the DMI constant from 0.1 to 0.8 mJ/m<sup>2</sup>. Moreover, strong DMI anisotropy appears under compressive strain. The DMI constant perpendicular to the strain direction changes sign while the constant along the strain direction does

not. The magnetic film with the DMI of opposite sign along directions perpendicular to each other is suitable for realization of skyrmions with an antivortex domain wall. The strain used in the present work is less than what can be achieved in a hybrid FE/FM system. This opens the way to manipulate the DMI and eventually the skyrmions with a voltage via the strain-mediated magneto-electric coupling.

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- <sup>1</sup> N. Nagaosa and Y. Tokura, *Nature Nanotechnology* **8**, 899 (2013).
- <sup>2</sup> A. Fert, N. Reyren, and V. Cros, *Nature Reviews Materials* **2**, 17031 (2017).
- <sup>3</sup> K. Everschor-Sitte, J. Masell, R. M. Reeve, and M. Klaui, *Journal of Applied Physics* **124**, 240901 (2018).
- <sup>4</sup> G. Finocchio, F. Bttnr, R. Tomasello, M. Carpentieri, and M. Klaui, *Journal of Physics D: Applied Physics* **49**, 423001 (2016).
- <sup>5</sup> A. Soumyanarayanan, M. Raju, A. L. Gonzalez Oyarce, A. K. C. Tan, M.-Y. Im, A. P. Petrovic, P. Ho, K. H. Khoo, M. Tran, C. K. Gan, F. Ernult, and C. Panagopoulos, *Nature Materials* **16**, 898 (2017).
- <sup>6</sup> W. Jiang, P. Upadhyaya, W. Zhang, G. Yu, M. B. Jungfleisch, F. Y. Fradin, J. E. Pearson, Y. Tserkovnyak, K. L. Wang, O. Heinonen, S. G. E. te Velthuis, and A. Hoffmann, *Science* **349**, 283 (2015).
- <sup>7</sup> A. Hrabec, J. Sampaio, M. Belmeguenai, I. Gross, R. Weil, S. M. Cherif, A. Stashkevich, V. Jacques, A. Thiaville, and S. Rohart, *Nature Communications* **8**, 15765 (2017).
- <sup>8</sup> J. Sampaio, V. Cros, S. Rohart, A. Thiaville, and A. Fert, *Nature Nanotechnology* **8**, 839 (2013).
- <sup>9</sup> G. Yu, P. Upadhyaya, X. Li, W. Li, S. K. Kim, Y. Fan, K. L. Wong, Y. Tserkovnyak, P. K. Amiri, and K. L. Wang, *Nano Letters* **16**, 1981 (2016).
- <sup>10</sup> F. Buttner, I. Lemesh, M. Schneider, B. Pfau, C. M. Gunther, P. Helsing, J. Geilhufe, L. Caretta, D. Engel, B. Kruger, J. Viehhaus, S. Eisebitt, and G. S. D. Beach, *Nature Nanotechnology* **12**, 1040 (2017).
- <sup>11</sup> L. Wang, Q. Feng, Y. Kim, R. Kim, K. H. Lee, S. D. Pollard, Y. J. Shin, H. Zhou, W. Peng, D. Lee, W. Meng, H. Yang, J. H. Han, M. Kim, Q. Lu, and T. W. Noh, *Nature Materials* **17**, 1087 (2018).
- <sup>12</sup> Y. Liu, N. Lei, W. Zhao, W. Liu, A. Ruotolo, H.-B. Braun, and Y. Zhou, *Applied Physics Letters* **111**, 022406 (2017).
- <sup>13</sup> J. Wang, Y. Shi, and M. Kamlah, *Phys. Rev. B* **97**, 024429 (2018).
- <sup>14</sup> A. V. Sadovnikov, A. A. Grachev, S. E. Sheshukova, Y. P. Sharaevskii, A. A. Serdobintsev, D. M. Mitin, and S. A. Nikitov, *Phys. Rev. Lett.* **120**, 257203 (2018).
- <sup>15</sup> Y. Shi and J. Wang, *Phys. Rev. B* **97**, 224428 (2018).
- <sup>16</sup> Y. Sun, Y. Ba, A. Chen, W. He, W. Wang, X. Zheng, L. Zou, Y. Zhang, Q. Yang, L. Yan, C. Feng, Q. Zhang, J. Cai, W. Wu, M. Liu, L. Gu, Z. Cheng, C.-W. Nan, Z. Qiu, Y. Wu, J. Li, and Y. Zhao, *ACS Applied Materials and Interfaces* **9**, 10855 (2017).
- <sup>17</sup> B. Dieny and M. Chshiev, *Rev. Mod. Phys.* **89**, 025008 (2017).
- <sup>18</sup> Y. Nii, T. Nakajima, A. Kikkawa, Y. Yamasaki, K. Ohishi, J. Suzuki, Y. Taguchi, T. Arima, Y. Tokura, and Y. Iwasa, *Nature Communication* **6**, 8539 (2015).
- <sup>19</sup> K. Shibata, J. Iwasaki, N. Kanazawa, S. Aizawa, T. Tanigaki, M. Shirai, T. Nakajima, M. Kubota, M. Kawasaki, H. S. Park, D. Shindo, N. Nagaosa, and Y. Tokura, *Nature Nanotechnology* **10**, 589 (2015).
- <sup>20</sup> T. Koretsune, N. Nagaosa, and R. Arita, *Scientific Reports* **5**, 13302 (2015).
- <sup>21</sup> C. Baraduc, T. Srivastava, M. Schott, M. Belmeguenai, Y. Roussign, A. Bernand-Mantel, L. Ranno, S. Pizzini, S. M. Chrif, A. Stashkevich, S. Auffret, M. Chshiev, and H. Ba, *Proceedings, Spintronics XI* **10732** (2018).
- <sup>22</sup> A. V. Davydenko, A. G. Kozlov, A. G. Kolesnikov, M. E. Steblyi, G. S. Suslin, Y. E. Vekovshinin, A. V. Sadovnikov, and S. A. Nikitov, *Phys. Rev. B* **99**, 014433 (2019).
- <sup>23</sup> S. Tacchi, R. E. Troncoso, M. Ahlberg, G. Gubbiotti, M. Madami, J. Åkerman, and P. Landeros, *Phys. Rev. Lett.* **118**, 147201 (2017).
- <sup>24</sup> L. Landau and E. Lifshitz, *Theory of Elasticity (Volume 7 of A Course of Theoretical Physics)* (Pergamon Press, 1970).
- <sup>25</sup> K. Di, V. L. Zhang, H. S. Lim, S. C. Ng, M. H. Kuok, J. Yu, J. Yoon, X. Qiu, and H. Yang, *Phys. Rev. Lett.* **114**, 047201 (2015).
- <sup>26</sup> J.-H. Moon, S.-M. Seo, K.-J. Lee, K.-W. Kim, J. Ryu, H.-W. Lee, R. D. McMichael, and M. D. Stiles, *Phys. Rev. B* **88**, 184404 (2013).
- <sup>27</sup> L. Sun, R. X. Cao, B. F. Miao, Z. Feng, B. You, D. Wu, W. Zhang, A. Hu, and H. F. Ding, *Phys. Rev. Lett.* **110**, 167201 (2013).
- <sup>28</sup> C. Eylich, W. Huttema, M. Arora, E. Montoya, F. Rashidi, C. Burrowes, B. Kardasz, E. Girt, B. Heinrich, O. N. Mryasov, M. From, and O. Karis, *J. Appl. Phys.* **111**, 07C919 (2012).
- <sup>29</sup> A. Fert and P. M. Levy, *Phys. Rev. Lett.* **44**, 1538 (1980).
- <sup>30</sup> L. Camosi, S. Rohart, O. Fruchart, S. Pizzini, M. Belmeguenai, Y. Roussigne, A. Stashkevich, S. M. Cherif, L. Ranno, M. de Santis, and J. Vogel, *Phys. Rev. B* **95**, 214422 (2017).
- <sup>31</sup> H. Sohn, M. E. Nowakowski, C. yen Liang, J. L. Hockel, K. Wetzlar, S. Keller, B. M. McLellan, M. A. Marcus, A. Doran, A. Young, M. Klaui, G. P. Carman, and a. R. N. C. Jeffrey Bokor, *ASC Nano* **9**, 4814 (2015).
- <sup>32</sup> M. Donahue and D. Porter, *OOMMF User's Guide Version 1.0* (National Institute of Standards and Technology, Gaithersburg, MDs, 1999).