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Minimizing Unintended Background Signals Arising from Conventional Mounting Techniques in Sensitive Magnetometry

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Two-dimensional (2D) van der Waals materials have attracted considerable interest for nanoscale spintronic devices such as spin valves, spin-filter magnetic tunnel junctions, and magnetic field sensors. Understanding the intrinsic magnetism in these systems is essential, particularly as measurements often require ultra-sensitive magnetometry near detection limits, where artefacts and magnetic contamination can significantly affect results. Consequently, the reliability of magnetometric detection of ferromagnetism in such materials has been questioned. Here, we systematically investigate magnetic contamination introduced when Teflon or K-tape is used during sample placement for measurements and handling propose to mitigate or eliminate these artifacts. We present the temperature- and magnetic field-dependent magnetization data of 1T-TiSe$_2$ obtained following these procedures, which is diamagnetic in the temperature range of 5–300 K.

Keywords : 2D materials, van der Waals crystals, spintronics, background magnetic signals

1. Introduction

Nano-objects with a magnetic signal comparable to that of the diamagnetic substrates on which they are deposited pose new challenges to state-of-the-art magnetometry and its users. Magnetic property measurements are fundamental to condensed matter physics, with various commercial magnetometers available for such studies. With unrivalled sensitivity, superconducting quantum interference device (SQUID) magnetometers have long been proved suitable for the study of nano-versions of well understood materials, e.g., thin films or nanoparticles of magnetic materials and superconductors. However, when studying new materials exhibiting magnetic behaviour close to the limits of SQUID sensitivity, small magnetic contaminations and measurement artifacts must be carefully taken into account. Next, the Vibrating Sample Magnetometer (VSM), is widely used for measurements at low temperatures and high magnetic fields [1–3]. VSM operates by detecting the magnetic induction generated as the sample vibrates near detection coils [4], based on Faraday's law, which relates a time-varying magnetic flux to an induced electromotive force (emf) [5].

In commercially available VSM, the sample holders are made up of brass or quartz. The measurement system is calibrated for the same. However, experimentally, it is tricky to mount the sample on these sample holders such that the sample will be kept intact during the measurement, which involves mechanical motion and exposure to the extensive range of temperature and magnetic field variation. To obtain the correct contribution from only the sample, especially when the samples with magnetic moments of the order of 10^{-6} emu are under consideration, a background contribution of the sample mounting assemblies must also be thoroughly tested [6-8].

In this work, we present the study of magnetization responses of two most commonly used materials, Teflon tape and K-Tape, with the half-cylindrical quartz rod (paddle) of 4 mm diameter. The magnetization of these materials is studied with different sizes and centring conditions. Also, the presence of background contribution is thoroughly investigated and a protocol to reduce the same is tested. These studies will help to determine the appropriate background contribution of Teflon and K-tape while using them for sample mounting purposes during an investigation.

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Finally, we present the magnetization study of a system with an extremely low magnetic moment, diamagnetic TiSe$_2$ crystals. TiSe$_2$ does not have any unpaired electrons, so it is perfect diamagnetic in the Curie–Weiss sense. Earlier experiments show that bulk TiSe$_2$ exhibits weak, temperature-independent diamagnetism across the measured range (including 5-300 K) [9, 10]. This diamagnetism arises mostly from core-electron contributions with weak Landau diamagnetism of conduction carriers. Owing to its van der Waals layered, quasi-two-dimensional nature and intrinsically weak magnetic response, TiSe$_2$ serves as an ideal test system to demonstrate how even a nominally diamagnetic material can yield apparent magnetic signatures if unintended background or measurement artefacts are not carefully minimised in sensitive magnetometry experiments.

2. Experimental Details

We carried out the magnetic characterization of the sample holding materials using a Quantum Design Physical Property Measurement System (QD PPMS EverCool II). First, we studied the magnetic contributions of most commonly used Teflon tape and Kapton tape (K-Tape) for sample mounting in VSM and PPMS measurement systems. We carried out the magnetic moment measurements as a function of magnetic field in the range of 0-5 tesla as well as temperature in the range of 5-300 K. Fig. 1 shows the tapes placed around the quartz paddle as samples for the present experimental study.

3. Result and Discussion

3.1. Magnetic measurements of Teflon Tape

Teflon tape, a readily available diamagnetic material, was initially chosen for sample mounting with the expectation of yielding a small, temperature-independent background magnetic signal. A 3 cm × 1 cm strip was cut using standard laboratory scissors and affixed to the quartz paddle, as shown in Fig. 1(a). The tape was aligned such that its centre lay 35 mm from the base of the paddle, positioning it at the centre of the PPMS pick-up coil during measurements. This configuration was intended to characterize the background signal arising solely from the setup geometry, ensuring that even if the Teflon signal was below the detection threshold, a consistent reference would be available for comparison.

The red solid circles in Fig. 2(a) represent the magnetic response of the Teflon tape measured at 300 K. Two key observations can be drawn from this data. First, the setup yields a clearly measurable signal from the Teflon tape. Second, the signal includes an unexpected constant, field-independent negative component (opposite to the applied magnetic field), in addition to the anticipated diamagnetic behaviour. As this response is physically unrealistic for a purely diamagnetic material like Teflon, the measurements were repeated using the ‘automatic centring’ feature of the PPMS. In this option, the sample is placed for maximum signal automatically. With this option enabled, the system positioned the sample at 29.94 mm from the base, as opposed to the earlier manual placement at 35 mm. The resulting M(H) data from this corrected alignment is shown by the black open circles in Fig. 2(a). Notably at high fields both curves show anticipated diamagnetic behaviour. The magnetic susceptibility, obtained from the slope, is $(-5.14 \pm 0.08) \times 10^{-10}$ emu/Oe and $(-4.97 \pm 0.04) \times 10^{-10}$ emu/Oe from automatic positioning and manual positioning conditions, respectively.

Figure 2(b) displays the magnetization as a function of temperature M(T) measured at an applied field of 5 kOe. While a purely diamagnetic material is expected to exhibit temperature-independent magnetization, however the data reveal distinct anomalies. A pronounced peak appears near 50 K, and a sharp increase in magnetization is observed below 10 K. These features are likely to be extrinsic in origin. Teflon, being microporous, can adsorb molecular oxygen, which is known to exhibit a peak in its paramagnetic response around 50 K [11, 12], likely explaining the anomaly at that temperature. Additionally, Mari and Brossard [13] have reported that polychloro-

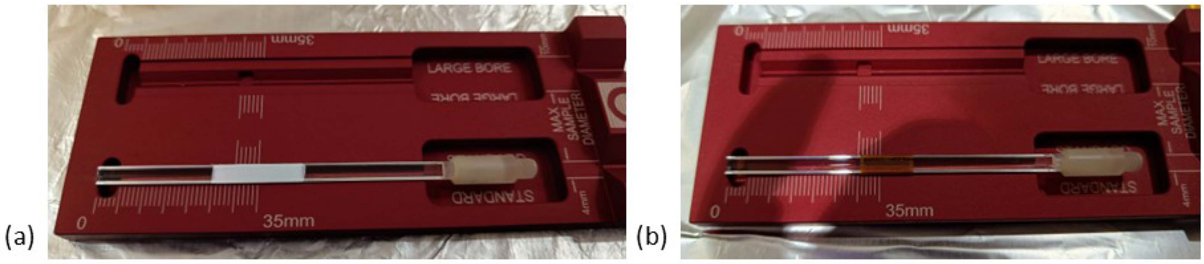

Fig. 1. (Color online) (a) Teflon tape (3 cm × 1 cm) (b) K-Tape (0.5 cm × 1 cm) mounted on quartz paddle.

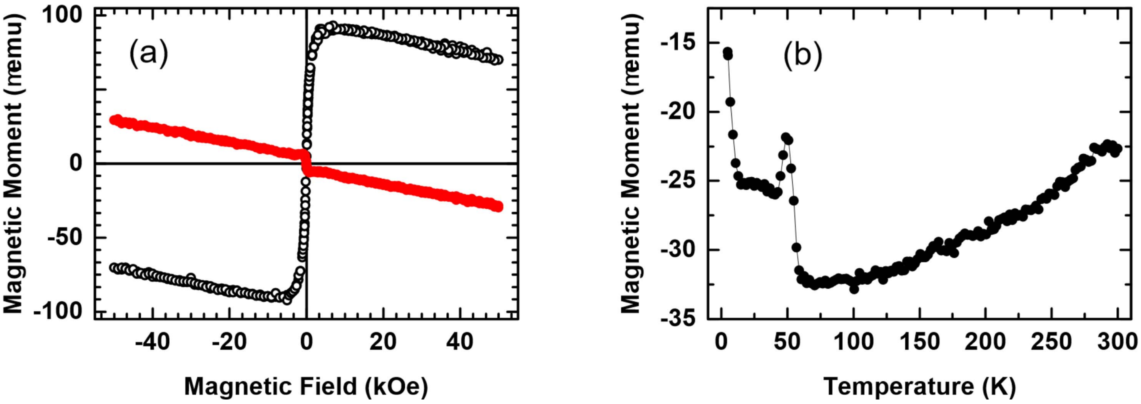

Fig. 2. (Color online) (a) Comparison of M-H response of the same Teflon tape at room temperature with manual centring (solid red circles) and auto-centring (open black circles) conditions (b) M-T response of Teflon tape with centring 35 mm with the magnetic field of 5 k Oe.

trifluoroethylene (PCTFE), a fluoropolymer similar to PTFE, shows enhanced paramagnetic behaviour at low temperatures, which could contribute to the observed low-temperature upturn. Furthermore, Ma et al. [14] have identified ferromagnetic components in Teflon, attributed to carbon-based dangling bonds or defects introduced during mechanical deformation processes such as stretching, which are often unavoidable during sample preparation.

3.2. Magnetic measurements of Kapton Tape (K-Tape)

We then investigated the magnetic properties of Kapton tape (K-tape), another candidate material for sample mounting. K-tape consists of a polyimide [15] with adhesive layers typically derived from silicone or acrylic formulations [16], and it is generally considered to be diamagnetic [15, 17]. A strip of K-tape measuring 3 cm × 1 cm (identical to Teflon) was cut using standard laboratory scissors and affixed to the quartz paddle, centred at 35 mm from the base. The auto-centring procedure determined an optimal position of 29.03 mm. To evaluate the influence of sample positioning—similar to the earlier analysis with Teflon tape—magnetization versus field M(H) measurements were performed at room temperature using above both the auto-centred position and the manual placement on the quartz rod. The corresponding results are presented in Fig. 3(a).

From Fig. 3(a), it can be observed that the K-Tape shows the diamagnetic behaviour at higher fields. The linear fit at higher magnetic fields gives the diamagnetic susceptibility of $(-1.46 \pm 0.01) \times 10^{-9}$ emu/Oe and $(-1.23 \pm 0.01) \times 10^{-9}$ emu/Oe for manual and auto-centring conditions, respectively. Here, a para / ferromagnetic-like behaviour at lower fields is observed. This is similar to auto-centering positioning case of Teflon. The temperature

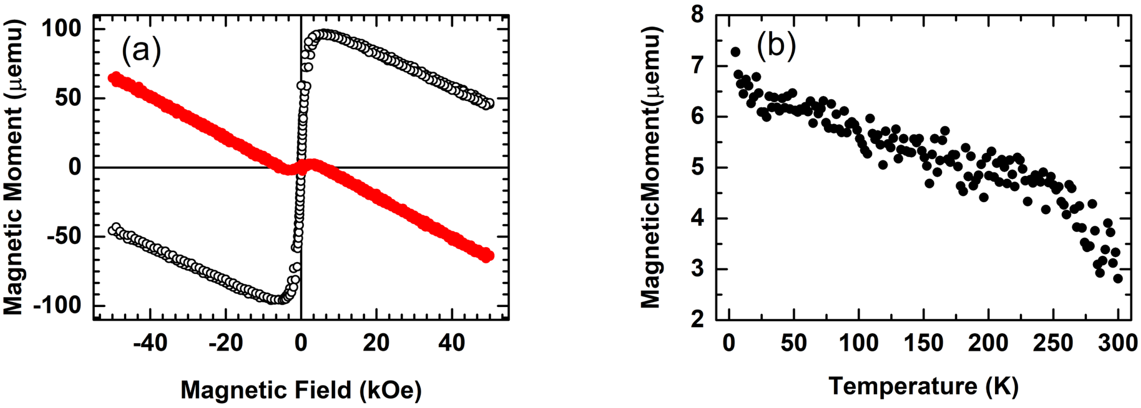

Fig. 3. (Color online) (a) Comparison of M-H response of K-tape at room temperature with manual centring (solid red circles) and auto-centring (open black circles) conditions (b) M-T response of K-tape with auto-centring condition (c) M-T response of K-tape with manual centring condition, both with the applied magnetic field of 5 kOe.

dependent magnetization M(T) response of K-tape measured under auto-centring conditions is shown in Fig. 3(b). The magnetic susceptibility remains positive throughout the temperature range, indicating that para / ferromagnetic contributions from unknown sources dominate the overall magnetic response.

Standard laboratory tools such as scissors and tweezers are typically made from stainless steel, often AISI 420 martensitic stainless steel, which is commonly used for scissor blades. This material is known to exhibit clear ferromagnetic behaviour, characterized by significant coercivity and remanent magnetization [18], and may transfer magnetic contaminants to samples during handling [19]. To eliminate such sources of contamination, non-magnetic scissors fabricated from a copper–titanium alloy and plastic tweezers were employed in the next set of the sample mounting process. Additionally, environmental dust—especially in laboratory environments—can introduce magnetic impurities that adhere to sample surfaces. Jickells et al. have reported the presence of magnetic particles in airborne dust in such settings [20]. To minimize this effect, approximately 1 mm was trimmed from all edges of the Kapton tape using non-magnetic scissors, effectively removing any surface-bound contaminants [21]. Since the measured magnetic moment is directly proportional to the amount of material present, reducing the sample size offers a practical approach to suppressing background signals [15]. Consequently, a smaller K-tape sample (0.5 cm × 1 cm), as shown in Fig. 1(b), was selected for further measurements.

The magnetic field dependence of magnetization, M(H), for the carefully prepared Kapton tape sample is shown in Fig. 4(a). The data reveal a significant suppression of non-diamagnetic contributions at low fields, indicating a marked reduction in para/ferromagnetic-like behaviour at room temperature. For comparison, a similarly sized K-tape sample, i.e., 0.5 cm × 1 cm was cut using standard laboratory scissors, and the M(H) measurement was repeated. The results, presented in Fig. 4(b), clearly demonstrate the presence of para-/ ferromagnetic signals in the sample prepared with regular scissors. Both curves show diamagnetic like behaviour at high fields. Now these curves are from the two different pieces of the tape, linear fits to the high-field region show

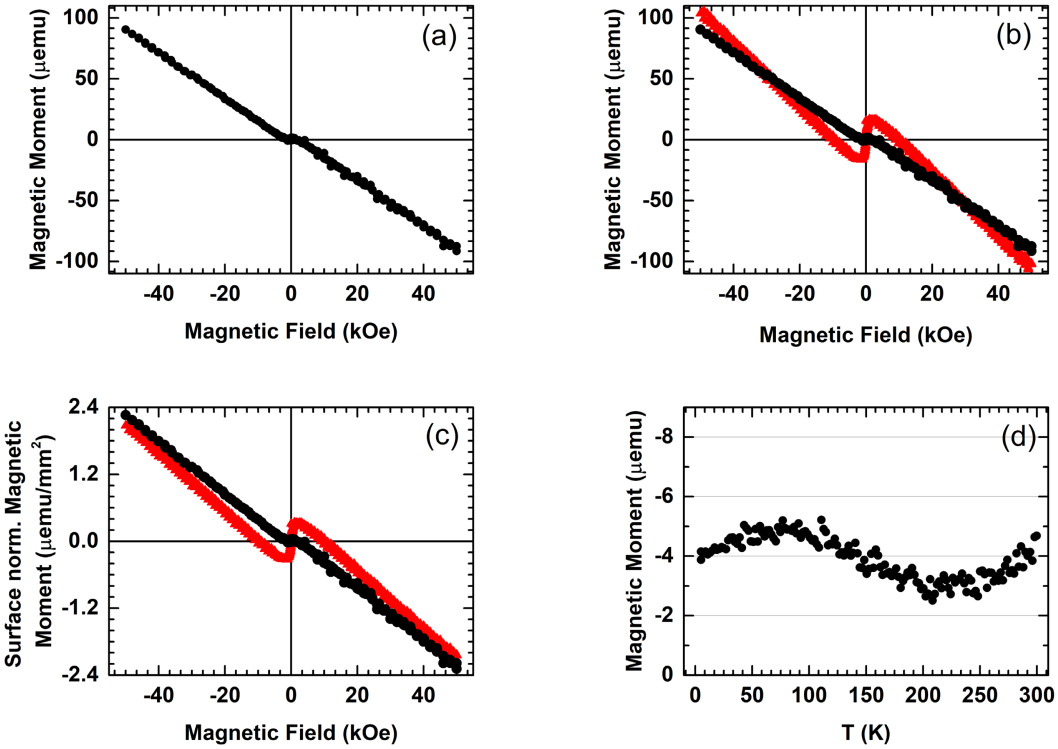

Fig. 4. (Color online) (a) M-H response of K-Tape at room temperature without the usage of any magnetic tools (a piece cut with Cu-Ti alloy Scissor) (b) Comparison of M-H curves of the K-tape of similar dimensions, cut with normal laboratory scissors (solid red triangles) and non-magnetic scissors (solid black circles) at room temperature (c) Surface normalized moment plotted for K-Tape pieces cut with Cu-Ti alloy Scissors (solid black circles) and normal laboratory scissors (solid red triangles) (d) M-T response of K-tape, without the usage of any magnetic tools, with an applied magnetic field of 5 kOe.

different slopes: $(-1.87 \pm 0.01) \times 10^{-9}$ emu/Oe for the sample cut with copper–titanium scissors and $(-2.57 \pm 0.01) \times 10^{-9}$ emu/Oe for that cut with conventional scissors. To take care of different sizes of the tapes, the magnetization data were normalized by the surface area, and the resulting magnetic moment per unit area was plotted against the applied field, as shown in Fig. 4(c). The linear fits to the high-field regions yield slopes of $(-4.67 \pm 0.02) \times 10^{-11}$ emu/mm^2 Oe and $(-5.14 \pm 0.03) \times 10^{-11}$ emu/mm^{2}Oe for samples cut with Cu–Ti and regular scissors, respectively.

Finally, the M(T) measurement under an applied magnetic field of 5 kOe, shown in Fig. 4(d). We clearly observe a negative susceptibility throughout the temperature range. It was expected a constant susceptibility over the given temperature range. Here we see the susceptibility is hovering around - 4 μemu, which is likely influenced by residual environmental factors, given that the measurements were not performed in a completely isolated environment [19, 20].

3.3. Optimised experimental protocol for minimized background signals

We propose the following protocol to minimize magnetic contributions from the sample mounting assembly. Among the materials tested, Kapton tape is found to be the most suitable for mounting samples on the VSM quartz module. The dimensions of the tape should be carefully optimised to ensure secure fixation of the sample on the quartz paddle, as the use of excess tape leads to an increase in background signal. Copper–titanium scissors are recommended for cutting the tape to the required size in order to avoid magnetic contamination from conventional steel tools. Furthermore, any exposed adhesive edges should be trimmed, since these surfaces are prone to accumulating dust and particulates that can introduce unintended magnetic signals. Finally, the auto-centring function of the VSM should be employed to precisely align the sample with the pick-up coils, thereby ensuring reproducible measurements and minimising systematic background effects.

4. Magnetization of $TiSe_2$

Figure 5 shows the magnetization data of a single flake of 1T-$TiSe_2$ weighing 19.4 mg measured by following the above precautions. We choose $TiSe_2$ because it is considered a material with weak diamagnetic susceptibility. Ti in $TiSe_2$ is in a 4+ oxidation state ($3d^0$), meaning there are no localized *d*–electrons. So $TiSe_2$ should exhibit weak, temperature independent diamagnetism across the measured range. However, $TiSe_2$ undergoes a charge density wave (CDW) transition at ~205 K [9, 22]. This makes it an interesting system. Above the CDW transition, impurities or electrons can contribute to Pauli paramagnetism.

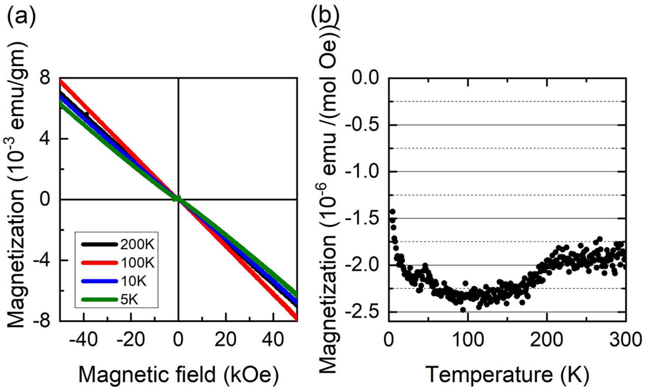

Fig. 5. (Color online) (a) Comparison of M(H) data of 1T-$TiSe_2$ at 200 (Black), 100 (Red), 10 (Blue), 5 K (Green) (b) M(T) graph of 1T-$TiSe_2$ with an applied field of 5 kOe.

In Fig. 5(a), the data from M(H) measurements are presented which were collected at 200 K, 100 K, 10 K, and 5 K. All curves exhibit linear behaviour with no hysteresis, all showing a negative slope, indicating diamagnetic behaviour at the measured temperatures. Fig. 5(b) shows the M(T) response of $TiSe_2$ measured in a fixed field of 5 kOe. Here, we have subtracted the constant magnetic contributions from the K-tape, which was 4×10^{-6} emu for a 5 kOe magnetic field in the measured temperature range. The magnetic moment remains negative over the entire temperature range, consistent with the intrinsic diamagnetic behavior. A broad minimum is observed around 90-100 K, followed by a gradual increase in moment (less negative) above 150 K. This change in curvature and slope near 200 K is suggestive of the CDW transition known to occur in 1T-$TiSe_2$ at around 200 K [23, 24]. It is also interesting to note that in some studies, small positive susceptibilities are reported at higher temperatures [25, 26]. These are interpreted as contributions from the impurities and conduction electrons. In our case, we did not observe such contributions; our sample showed negative susceptibility throughout the measured temperature range.

5. Conclusions

In this experimental study, we studied the background contributions from Teflon and Ktape. K-tape has lower background signals, which remain relatively constant in the 5-300 K temperature range. It is important to note that for cutting the tape, etc., copper-titanium scissors must be used. It is also very important to remove the edges of the tape before using it for mounting in the magnetometer. We followed the above measurement procedures and studied the temperature and magnetic field-dependent magnetization of 1T-TiSe$_2$, which is diamagnetic in the measured temperature range of 5-300 K.

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References

[1] S. Foner, Rev. Sci. Instrum. **27**, 548 (1956).

[2] S. Foner, IEEE Trans. Magn. **17**, 3358 (1981).

[3] S. Foner, J. Appl. Phys. **79**, 4740 (1996).

[4] A. Niazi, P. Poddar, and A. K. Rastogi, Curr. Sci. **79**, 99 (2000).

[5] D. J. Griffiths, Introduction to Electrodynamics, 4th Edition, Cambridge University Press, Cambridge (2017) pp. 309-313.

[6] M. A. Garcia, E. F. Pinel, J. de la Venta, A. Quesada, V. Bouzas, J. F. Fernández, J. J. Romero, M. S. M. González, and J. L. Costa-Krämer, J. Appl. Phys. **105**, 013925 (2009).

[7] I. K. Schuller and Y. Bruynseraede, MRS Bulletin **30**, 75 (2005).

[8] VSM Sample Mounting Techniques, Tech. Rep. USA (2016).

[9] D. R. P. Guy, R. H. Friend, D. C. Johnson, and M. J. Sienko, J. Phys. C: Solid State Phys. **15**, L1251 (1982).

[10] A. Nomura, S. Demura, S. Ohta, S. Kobayashi, and H. Sakata, J. Low Temp. Phys. **213**, 215 (2023).

[11] K. Kaneko, J. Suzuki, and C. Ishii, Chem. Phys. Lett. **282**, 176 (1998).

[12] T. C. Kobayashi, A. Matsuo, M. Suzuki, K. Kindo, R. Kitaura, R. Matsuda, and S. Kitagawa, Prog. Theor. Phys. Suppl. **159**, 271 (2005).

[13] A. Mari and L. Brossard, Rev. Sci. Instrum. **64**, 1364 (1993).

[14] Y. W. Ma, Y. H. Lu, J. B. Yi, Y. P. Feng, T. S. Herng, X. Liu, D. Q. Gao, D. S. Xue, J. M. Xue, J. Y. Ouyang, and J. Ding, Nat. Commun. **3**, 727 (2012).

[15] Y. Kaburagi and Y. Hishiyama, J. Mater. Res. **17**, 2000 (2002).

[16] A. Rahnamoun, D. P. Engelhart, S. Humagain, H. Koerner, E. Plis, W. J. Kennedy, R. Cooper, S. G. Greenbaum, R. Hoffmann, and A. C. T. van Duin, Polymer **176**, 135 (2019).

[17] Y. Kaburagi, Y. Hishiyama, H. Oka, and M. Inagaki, Carbon **39**, 593 (2001).

[18] S. S. M. Tavares, P. R. Mei, A. S. Lozano, and F. J. G. Landgraf, J. Alloys Compd. **320**, 241 (2000).

[19] L. M. C. Pereira, J. P. Araújo, M. J. V. Bael, K. Temst, and A. Vantomme, J. Phys. D: Appl. Phys. **44**, 215001 (2011).

[20] T. D. Jickells, Z. S. An, K. K. Andersen, A. R. Baker, G. Bergametti, N. Brooks, J. J. Cao, P. W. Boyd, R. A. Duce, K. A. Hunter, H. Kawahata, N. Kubilay, J. laRoche, P. S. Liss, N. Mahowald, J. M. Prospero, A. J. Ridgwell, I. Tegen, and R. Torres, Science **308**, 67 (2005).

[21] A. Sundaresan, R. Bhargavi, N. Rangarajan, U. Siddesh, and C. N. R. Rao, Phys. Rev. B **74**, 161306 (2006).

[22] F. Di Salvo, D. Moncton, and J. Waszczak, Phys. Rev. B **14**, 4321 (1976).

[23] G. Li, W. Z. Hu, D. Qian, D. Hsieh, M. Z. Hasan, A. Fang, W. A. Goddard, R. J. Cava, N. P. Ong, and N. L. Wang, Phys. Rev. Lett. **99**, 027404 (2007).

[24] T. E. Kidd, T. Miller, M. Y. Chou, and T. C. Chiang, Phys. Rev. Lett. **88**, 226402 (2002).

[25] S. Kitou, S. Kobayashi, T. Kaneko, N. Katayama, S. Yunoki, T. Nakamura, and H. Sawa, Phys. Rev. B **99**, 081111 (2019).

[26] E. Morosan, H. W. Zandbergen, B. S. Dennis, J. W. G. Bos, Y. Onose, T. Klimczuk, A. P. Ramirez, N. P. Ong, and R. J. Cava, Nature Phys. **2**, 544 (2006).