D. Performance

When the SQUID microscope was cooled with liquid helium, the temperature of the sapphire rod reached 4.8 K. The maximum output voltage of the SQUID was 67 μV, which was 15 % smaller than that observed in liquid helium. When the SQUID was operated with the low-drift FLL, we obtained the field noise of 1.1 pT/$\sqrt{\ }$Hz at 1 Hz in a superconductive shielding. We also confirmed that the low frequency drift due to temperature change was ~ 10 pT/ºC.

The separation between the SQUID and the sapphire window was estimated by scanning the magnetic field generated with a 1-mA DC line current, which was applied to a 25-μm-thick and 100-mm-long aluminum wire. We have achieved the separation between the SQUID and the wire of 230 μm. We evaluated the precision of the adjustment of the separation between the SQUID and the sapphire window, repeating up-and-down movements of the sapphire rod by rotating the micrometer spindle. The difference in the separation among five runs was within ±5 μm for a movement of 200 μm.

The boil-off rate of the liquid helium was 3.3 L/day, and stable performance of the SQUID was maintained for almost 3.5 days until the liquid helium reservoir was empty.

III. Demonstration of Imaging

We demonstrated magnetic imaging of a natural zircon crystal using the SQUID microscope. The zircon crystal was about 0.5 mm in size and contained magnetite grains. Isothermal remanent magnetization with a field of 140 mT was artificially imparted to the zircon crystal, resulting in the magnetic moment of 1.9×10^{-10} Am^2. Then, the zircon crystal was buried in the surface of a resin cylinder with 25 mm in diameter and 5 mm in thickness so that the magnetic moment was perpendicular to the surface of the cylinder. The distance between the surface of the resin and the SQUID was set to be about 500 μm. Fig. 4a shows a microscopic picture of the surface of the resin, where the zircon crystal is inside the white dotted circle. By scanning this zircon sample with the SQUID microscope, we obtained an image of a magnetic dipole-like field of ~180 nT (Fig. 4b), which is consistent with the calculated magnetic field using the magnetic moment of 1.9×10^{-10} Am^2 and the distance of 500 μm. According to this result, we consider that this SQUID microscope has the sensitivity to image magnetic moments in the order of 10^{-14} Am^2 or smaller.

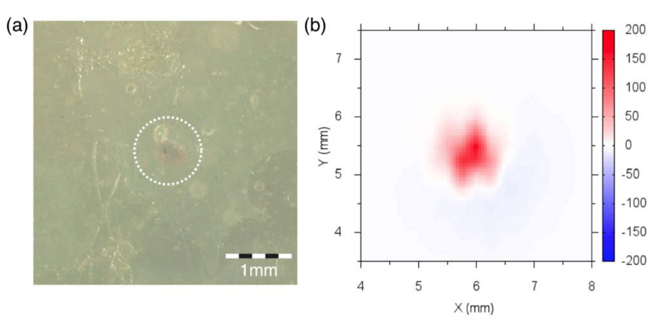

Fig. 4 Microscopic picture of a zircon crystal buried in the surface of a resin (a), and the scanned results (b).

IV. Conclusion

We developed a SQUID microscope employing a hollow-structured cryostat and a low-drift FLL. We confirmed that the SQUID microscope could be applied for the fine magnetic imaging of geological samples.

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