Dual preamplifier for combined AFM/STM at liquid helium temperature

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The use of piezoelectric cantilevers such as the qPlus sensor in low temperature applications is attractive because of their ease of use and low internal energy dissipation, allowing very low operating temperatures. On the other hand, the preamplifier should be close to the sensor due to detrimental effects of parasitic capacitances of the electrical connections and stray fields. In the past [1], we have used two conventional operational amplifiers (AD744JR by Analog Devices) that were located within approximately 5 cm of the sensor. The amplifiers were nominally specified for operation down temperatures of 270 K, but we found that they still worked at 120 K. We attached a heating resistor to be able to operate the microscope at liquid helium temperature with the amplifiers heated above 120 K. To reach a temperature of 120 K, each amplifier had to be heated with a power of 250 mW. A sample temperature of 4.89 K was reached with the heat load of 500 mW caused by resistive heating of the two pre-amplifiers. Although preamplifiers that work at 4 K without the need for external heating have been introduced [2], we found the simple transimpedance amplifiers comprised of a single operational amplifier and a feedback resistor very attractive due to their great simplicity, high bandwidth and low noise. By changing to a new dual operational amplifier and improved thermal coupling between the heating resistor and the amplifier, the preamplifier heat load could be reduced to 70 mW, a mere 14% of the previous value. The new sample temperature in our microscope is 4.79 K, reducing the temperature difference between the sample and the helium bath by 14% to 0.59 K. Supported by BMBF 13N6918.

[1] S. Hembacher, PhD thesis, Augsburg University, www.dissertation.de (2003)
[2] S. Urazhdin, S. Tessmer, R. Ashoori, Rev. Sci. Instrum. **73**, 310 (2002), and references therein