FLEXIBLE TEMPERATURE SENSORS FOR USE IN HIGH MAGNETIC FIELDS

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Introduction

Our previous work has produced miniature, rotatable calorimeters for use in top-loading dilution refrigerators at high magnetic field [1]. That project also lead to the development of dramatically improved algorithms for control of temperature as the magnetic field is continuously swept [1, 2]. Our current work seeks to extend these capabilities by developing miniature sensors with smaller total heat capacities and smoother field response than commonly used ruthenium oxide resistors. These new sensors will be generally applicable to high field, low temperature research by users and NHMFL staff.

Experimental

This work seeks to (1) produce low mass, low heat capacity, rapid thermal response, miniature silicon strips (3 mm x 0.3 mm x 0.005 mm) carrying gold-germanium thermometers [3] and nichrome heaters and (2) to calibrate these sensors in field. Thin film deposition of Au/Ge multilayers was done at Rowan University with assistance from Boston College; post-deposition processing was done at Smith College and NHMFL. Photolithography was done by third party vendors.

Results and Discussion

Our deposition process produces a controlled Au concentration gradient across the length of the wafer. This leads to differences in overall resistivity ρ and sensitivity η between sensors: The characteristic quasi-power-law temperature dependence of the resistivity[3] is shown in Fig. 1 for three representative sensors following a 1 hour anneal at 265°C.

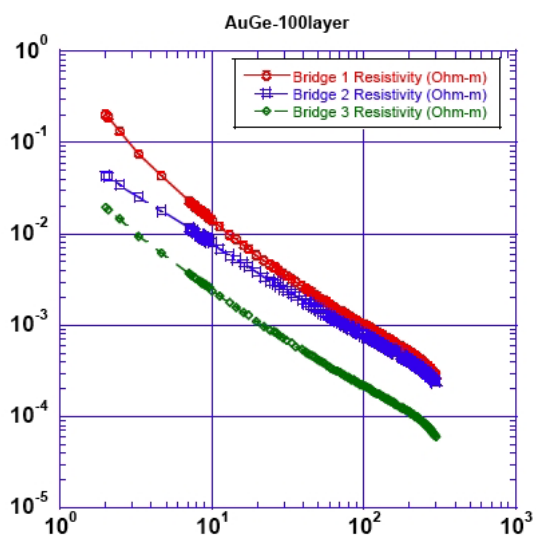

Figure 1: typical temperature dependence of the resistivity of post-annealed Au_xGe_{1-x} thin films between 2 K and 300 K in zero field.

These particular sensors have a dimensionless sensitivity η = dlnR/dlnT ≈ -1 below 100 K. The sensitivity depends on annealing temperature; the minimum necessary annealing temperature for extended quasi-power-law behavior varies with Au concentration [3].

Preliminary measurements up to 18 tesla at ^{3}He temperatures on these and other sensors annealed at higher temperatures confirm a smoothly varying field dependence suitable for field-dependent low temperature calorimetry. Temperature calibration in field includes cross-calibration against field-independent Coulomb blockade thermometers.

Additional measurements on sensors with different Au concentrations and annealing temperatures are currently underway.

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References

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[3] Fortune, N.A., *et al.*, Review of Scientific Instruments, **69**, 133-138 (1998).