Electronic Transport in Al-Pd-Re Quasicrystalline Multigrain Samples

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Introduction

Quasicrystalline (QC) samples display unusual electronic transport properties, including very high room temperature resistivities and in certain cases even metal-insulator transitions (MIT). Most of these materials are ternary alloys, annealed at high temperatures in order to form the icosahedral (I) QC structure and then quenched very rapidly to room temperature. Measurements have been made previously on the (I) Al-Pd-Re system. For a *single grain* sample, Tsai's group observed *metallic* conductivity behavior [1]. In contrast, the Swedish group observed in *multigrain* samples *insulating* behavior with *saturation* of the conductivity [2]. This report illustrates insulating behavior in multigrain samples without saturation.

Experimental

QC samples of Al-Pd-Re were prepared using the rf induction method [3]. Zero field resistivity measurements and magnetoresistivity (MR) data were taken using the dilution refrigerator and 20 T superconducting magnet at the NHMFL.

Results and Discussion

We summarize the results on a "weakly insulating" sample having a resistance ratio $r_T = R(4\text{ K})/R(300\text{ K}) = 7.76$. Between 300 K to 0.5 K, the zero field resistivity data can be described nicely using the "phenomenological expression" given by $\sigma(T) = 1/\rho(T) = 9.80\ T^{0.225} \exp(T/279)$ in $(\Omega\text{cm})^{-1}$; note that the conductivity vanishes at $T = 0$ K. The high temperature data and fit are shown in Fig. 1. Surprisingly, there is a crossover to activated variable-range hopping below 0.5 K as shown in Fig. 2; the hopping expression, $\rho(T) = 0.067\exp(0.085/T)^{0.35}$ in Ωcm, fits the data well below 0.5 K. The "wave function shrinkage" expressions give fair fits to the magnetoresistance data [3]. Note that there is no saturation of $\rho(T)$ even down to 20 mK. The insulating behavior is attributed to the "needle-type" morphology and the small presence of a second phase, maybe insulating. Surprisingly, a second sample having $r_T = 2.1$ exhibited a very weakly insulating power law with $\sigma(T) \approx 11.4T^{0.03}$ in $(\Omega\text{cm})^{-1}$.

References

[1] Guo J.Q., *et al.*, Philos. Mag. Lett. **80** 495 (2000).
[2] Rodmar M., *et al.*, Phys. Rev. B. **60** 10807 (1991).
[3] Rosenbaum R, *et al.*, Journal of. Low Temp. Phys. (manuscript entitled "Very Low Temperature Electronic Transport in Al-Pd-Re Quasicrystalline Alloys" in press- December, 2007/January 2008; preprint request via: rachel-r@zahav.net.il).

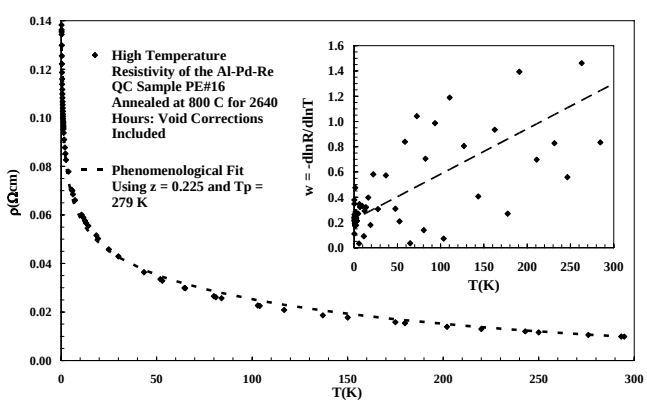

Fig.1. Zero field resistivity data with the "phenomenological fit".

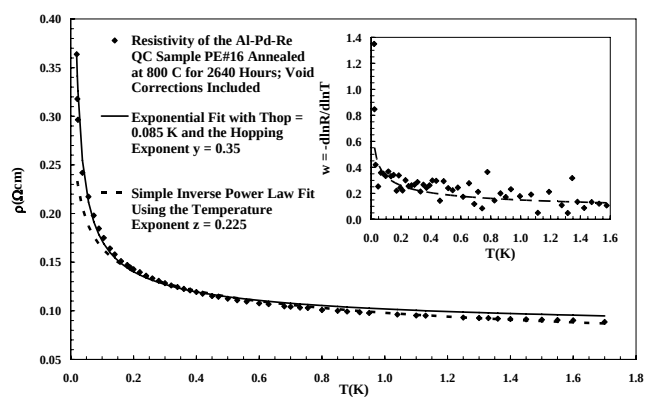

Fig. 2. Very low temperature activated resistivity data.