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Aging effect in Magnetotransport Property of Oxygen adsorbed $BaFe_2As_2$

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Abstract. Presence of oxygen (O_2) has been found by Energy Dispersive X-ray Analysis (*EDAX*) on the surfaces of flux grown $BaFe_2As_2$ single crystals which were kept in air ambience for several months. Transport studies show that the O_2 adsorbed crystals are more resistive and do not display any sharp slope change near 140 K which is the well known Spin Density Wave (*SDW*) transition temperature (T_{SDW}) accompanying structural transition for as grown $BaFe_2As_2$. An anomalous slope change in resistivity is observed around 18 K at 0 and 5T. Magnetoresistance (*MR*) is noticed to increase as a function of applied field (H) quite differently than that for as grown crystals below T_{SDW} which may be attributed to aging effect.

Keywords: Spin Density Wave, Magnetoresistance
PACS: 74.70.Xa, 73.43.Qt,

INTRODUCTION

$BaFe_2As_2$ is the well studied parent compound in the 122 family of unconventional FeAs based superconductors which undergoes Spin Density Wave (*SDW*) transition around 140 K (T_{SDW}) accompanied by tetragonal (paramagnetic) to orthorohmbic (antiferromagnetic) structural transition [1]. Strong influence of adsorbed oxygen (air) in polycrystalline $BaFe_2As_2$ to mask the spin state of Fe is reported [2]. Linear magnetoresistance (*MR*) is observed in $BaFe_2As_2$ and attributed to Dirac fermions [3]. However, it is reported that non linear *MR* is also observed for $BaFe_2As_2$ single crystals which are annealed with BaAs powder [4]. Recently large low temperature *MR* is noticed for $SrFe_2As_2$ single crystals which is attributed to sample aging effect [5]. So far, not much work has been done in this area. Here, we report the results of our magnetotransport measurements on oxygen (O_2) adsorbed and aged $BaFe_2As_2$ single crystals i.e $BaFe_2As_2$:O_2 with as grown $BaFe_2As_2$.

EXPERIMENTS

Single crystals of $BaFe_2As_2$ are grown by the self flux, where excess FeAs is used as a flux [6]. The crystals were kept in air ambience for several months to study the effect of oxygen adsorption and aging. Composition of the crystals has been determined by Energy Dispersive X-ray Analysis (EDAX). Temperature dependent *MR* has been measured in the 4-probe geometry in commercial PPMS system by Cryogenic Limited at 0 and 5T magnetic fields. In order to investigate the field dependence of *MR*, measurements have been carried out at various constant temperatures below T_{SDW} by ramping the magnetic field up to 10T.

RESULTS AND DISCUSSIONS

Figure 1 describes the results of EDAX on $BaFe_2As_2$:O_2. The intensity peak for oxygen is clearly observed. The oxygen is adsorbed on the surface of as grown $BaFe_2As_2$ crystals due to exposure in air for several months. Adsorbed O_2 is known to be an effective electron acceptor forming O_{2^-} which can permeate the crystal and form spin clusters around Fe. As a result, Fe spin state gets effected [2]. Resistivity as a function of temperature is measured for as grown $BaFe_2As_2$ in 4 probe geometry which shows clear magnetostructural transition at 140K (T_{sdw}) as reproduced in Figure 2. After the sample was left in air ambience for several months the resistivity is increased and there is no sharp slope

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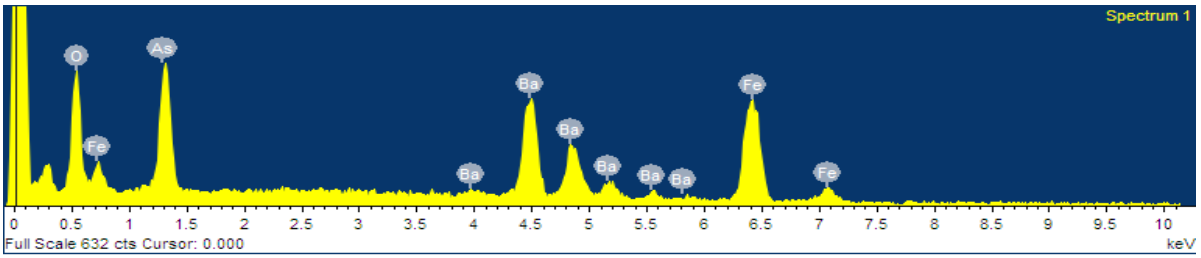

FIGURE 1. The results of E DAX measurements of $BaFe_2As_2$ single crystals which were kept in air ambience for several months.

change around T_{sdw}. However, an anomalous slope change occurs at 18 K in resistivity following a down turn.

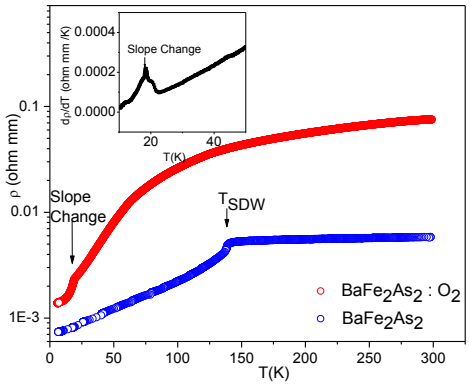

FIGURE 2. The results of resistivity vs temperature measurement for $BaFe_2As_2$:O_2 and $BaFe_2As_2$.Inset shows $d\rho/dT$ *vs* T for $BaFe_2As_2$:O_2.

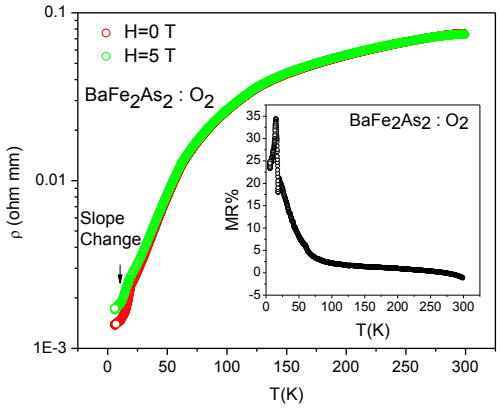

FIGURE 3. The results of resistivity vs temperature measurement for $BaFe_2As_2$:O_2 at H = 0 and 5 T. The inset shows MR as a function of temperature.

The resistivity when measured under magnetic field H = 5T, the anomalous slope change still remains (see Figure 3). The down turn in resistivity indicates the possible presence of an inhomogeneous electronic state where superconducting and non -superconducting regions do exist simultaneously but superconducting fraction may be below percolation threshold [5]. *MR* [=ρ(*H*)-ρ(0)/ρ(0)] is found to be maximum as 35% around 15 K and negligible above T_{sdw} (inset of Figure 3). *MR* measured as a function of H up to H = 10T for $BaFe_2As_2$:O_2 at various constant temperatures below T_{SDW} and results are reproduced for a representative temperature 60 K in Figure 4. The *MR* appears to be linear above H = 6T, but below it has a nonlinear H dependence. In contrast, *MR* for as grown $BaFe_2As_2$ has linear and parabolic field dependence at high and low H at 60 K due to quantum and classical transport respectively [3]. Inset of Figure 4 shows *dMR/dH* vs H for $BaFe_2As_2$:O_2 and. $BaFe_2As_2$ single crystals where the difference is clearly realized. It is to be considered that $BaFe_2As_2$:O_2 crystals have strains and defects induced by aging effect. In addition, there may be spin

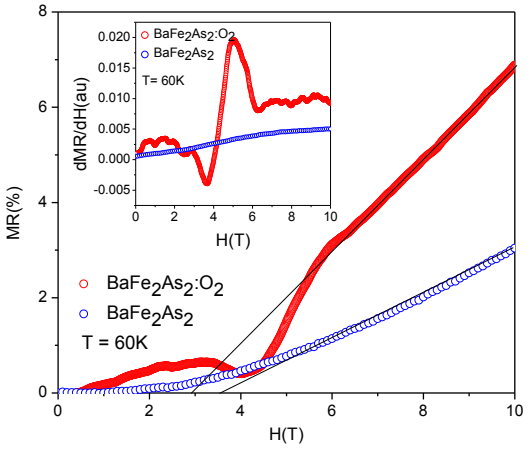

FIGURE 4. *MR* vs H for $BaFe_2As_2$:O_2 and $BaFe_2As_2$, shown in positive direction, displayed at a representative temperature 60K. The straight line guides the eye for the linear region. The inset shows *dMR/dH* vs H for both.

clusters present due to O_2 adsorption. Hence, the situation is more complicated in case of $BaFe_2As_2$:O_2 crystals which can be attributed to its nonlinear and peculiar *MR* response.

In conclusion, we have demonstrated the effect of aging and O_2 adsorption on the magnetotransport property of $BaFe_2As_2$ single crystals which is quite interesting and worth exploring further.

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