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Effect of γ−Irradiation on the Critical Current Density of Tl/F Superconductors

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The effect of low dose γ-irradiation on the hysteresis width and critical current density of thallium fluorine superconductors is reported. We found that addition of fluorine in a controlled manner to the Tl-1223 may enhance the critical current density and make this matterial very sensitive to γ- irradiation.

1. INTRODUCTION

We found that addition of Fluorine (F) to Tl-1223 high T_c superconductors (HTSC) with the composition $(Tl_{0.5}Pb_{0.5})Sr_{1.6}Ba_{0.4}Ca_2Cu_3O_9$ affects its superconducting properties. We found that addition of fluorine increases the critical current density of Tl-1223 by 300% of its value for the fluorine-free samples. Also observed an increase of T_c of about 15 K with F addition[1].

Pinning centers can be increased through controlled γ-irradiation[3,4]. The knowledge about the behavior of superconductors under various types of irradiation is important for practical applications. In particular, the effect of γ- irradiation has special importance because γ-rays can penetrate through the protecting tubes and shielding and easily penetrate into the superconducting devices whenever these HTSC are used in environment exposed to γ-rays.

Low dose γ- irradiation dose not affect the properties of most of HTSC. Only high doses of γ-irradiation affect the critical current density and other superconducting properties of these materials[6,7].We do not know of any published work about the effect of γ- irradiation on Tl-based materials. We believe that F addition affects the pinning mechanisms in Tl-based oxides and partially replaces the light oxygen atoms in the structure. Therefore these materials become more sensitive to introducing further defects through γ-irradiation than any other HTSC. In this paper, we report the effect of γ-irradiation on the critical current density of two Tl/F superconducting samples.

2. EXPERIMENTAL

$(Tl_{0.5}Pb_{0.5})Sr_{1.6}Ba_{0.4}Ca_2Cu_3O_yF_x$ samples were prepared using solid state reaction method with different F content x. The details of the preparation and characterization will be published elsewhere[1,2]. γ-irradiation for two samples with different F contents was done using a Co^{60} source at room temperature with a dose of 6.82 MRad h^{-1}.The DC magnetic hysteresis loops in cycling field ± 9 T before and after γ-irradiation were performed using a Lake Shore VSM 4500 model magnetometer at 4.2 K.

3. RESULTS AND DISCUSSIONS

The onset transition temperature of sample 1 (x=1) is 128 K which is the highest among a series of samples with different values of x. Meanwhile sample 2 (x=2.2) has the highest width of the hysteresis loops which - according to Bean's critical state model- is proportional to the critical current density[1,2]. The onset of the superconducting transition of this sample is 124 K.

Figure 1 shows that the width of the hysteresis loops of sample 1. Unlike other HTSC this sample is very sensitive to γ-irradiation in the low dose region. It decreases first for very low γ-dose, and then it starts increasing with increasing the dose until it reaches the width of the unirradiated sample. The initial rapid decrease in the width of the loops, may be due to changes in the

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weak links at the grain boundaries, while the increase at higher doses can be attributed to introducing more structural defects and affecting the pinning mechanism within the grains. Figure 2 shows hysteresis loops of sample 2 for different γ-dose. It is clear that this sample is less sensitive to γ-irradiation than sample 1which has the highest T_c. This result is in agreement of our earlier finding that sample 2 has the optimum critical current density before γ-irradiation. This can be explained in terms of the oxygen deficiency of Tl-based superconductors. This sample has more F partially substituting oxygen, and introducing further defects through γ-irradiation may not improve on the hole doping, unlike sample 1, where the hole doping can be further improved through introducing further defects in the oxygen sites. We have also investigated the effect of the same γ-doses on the hysteresis loops of a Bi-2223 sample. We found that the width of the hysteresis loops was not affected up to 60 MRad, in agreement with published date for this material[6,7].

4. CONCLUSIONS

In conclusion, we noticed that γ-irradiation affects the critical current density of Tl-1223/F_x with fluorine content x=1. This indicates that the superconducting properties of this material can still be improved through optimizing the synthesis conditions. It shows that the position of the irreversibility line of these technologically important material can be improved through γ-irradiation. We are investigating in more details the effect of γ-irradiation on the superconducting properties of this material with different γ-doses up to very high dose.

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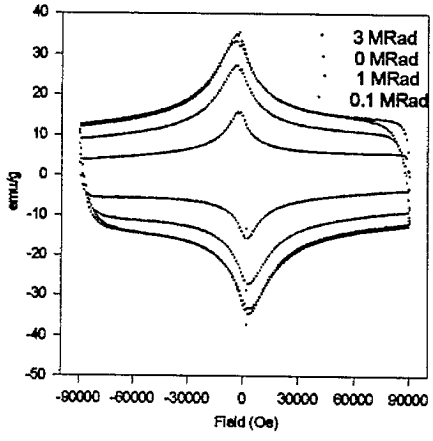

Figure 1 Hysteresis loops of sample 1 with different γ doses

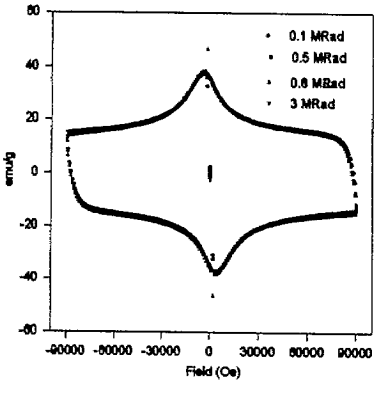

Figure 2 Hysteresis Loops of sample 2 with different γ–doses