ATOMIC HYDROGEN EFFECTS ON HIGH-T_c SUPERCONDUCTERS

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The atomic hydrogen effects on the properties of bulk high-temperature superconductors were investigated. It is shown that the insertion of the atomic hydrogen into the bulk of these materials from a DC plasma leads to the increase of the critical current density J_c for YBaCuO(123) as well as for BiSrCaCuO(2223) high-temperature supercondu-ctors. It is found that the hydrogenation of the He implanted samples with following annealing leads to the optically detected blistering on the surface. It means that the textured thin subsuface layers of high-temperature superconductors can be formed by this method. The improvement of superconductivity by atomic hydrogen can be explained by the passi-vation of dangling bonds and defects on grain boundaries of these materials.

1. Introduction

Superconductivity of the bulk high-T_c materials is highly sensitive to the amount of oxygen vacancies and properties of grain boundaries. The vacancy concentration as well as properties of grain boundaries is thought to be influenced considerably by low power density oxygen or hydrogen plasma treatment. It is necessary to note that recently there have been a lot of studies on the hydrogen effects in semiconductors [1-3]. The improvement of electrical properties of these materials due to passivation processes of defects and dangling bonds is well established. Therefore it is important to use this phenomenon for the improvement of the properties of high-T_c materials. An increase of critical temperature T_c and J_c by oxygen or hydrogen plasma treatment at 80 and 300 K of YBaCuO(123) and BiSrCaCuO(2223) has been observed earlier [4-8]. It is necessary to note also that the buried defect layers in silicon created both by hydrogen or helium implantation act as good getter centers for hydrogen at appropriate heat treatment [9-11]. The hydrogen accumulation in an buried layer leads to the formation of blisters, bubbles and platelet defects in different materials [12]. Therefore it is important to investigate the possibility to form such defects in high-T_c materials just to verify the possibility to realize the texture structure, the pinning centers formation or SMART-CUT processing [12-14]. The aim of this work is the analysis of the possible application of hydrogen effects for the improvemet of the critical parameters of high-T_c materials by hydrogenation from a plasma at higher temperatures as compare to earlier investigations [4-8] as well as the investigation of the surface texture formation in He implanted samples with following hydrogenation.

2. Experimental

The used YBaCuO(123) and BiSrCaCuO(2223) samples were prepared from mixed powders by standart solid-phase method as was described in [4-8]. The critical current of the ceramic superconductors has been measured by a contactless technique [15]. The BiSrCaCuO(2223) samples were implanted by 1 MeV He ions at room temperature with dose of $1\times\cdot10^{16}$ cm^{-2}. DC hydrogen plasma treatments were carried out in a reactor normally used for reactive ion etching. All DC plasma treatments were done at 180°C. A plate voltage of 500 V and a current density of 300 μA/cm^2 were used.

3. Results and discussion

Fig.1 shows the average changes in J_c difference (ΔJ_c) versus hydrogen plasma treatment time for YBaCuO(123) ceramic material and fig.2 for BiSrCaCuO(2223) one. It can be seen that the critical current density can be improved by the hydrogen insertion into the bulk of high-T_c superconductors from hydrogen plasma. To investigate the nature of such enhancement the oxygen plasma treatments with the same parameters were performed. The increase of the critical current density was not observed in later case. This means that the observed increase of J_c is caused by the hydrogen passivation effects at grain boundaries and possibly at dangling bonds in the bulk of grains. It also can be concluded that due to the high diffusivity of hydrogen the properties of the full volume of the bulk material can be improved. The hydrogenation of He implanted samples with following annealing leads to the optically detected blistering on the surface after treatments at 450 °C for 60 min. It means that textured thin subsuface layers of high-T_c super-conductors can be performed by this method

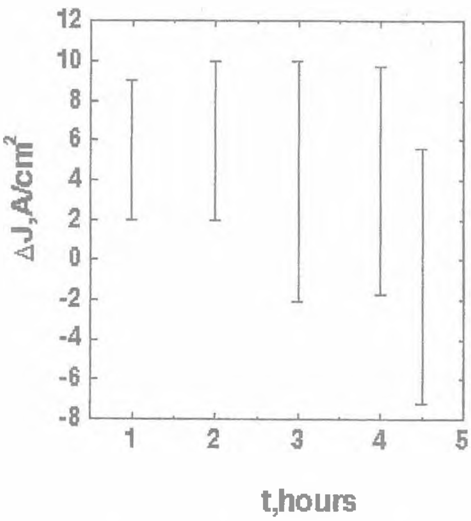

Fig.1. The average changes in J_c difference (ΔJ_c) versus hydrogen plasma treatment time for YBaCuO(123) ceramic material.

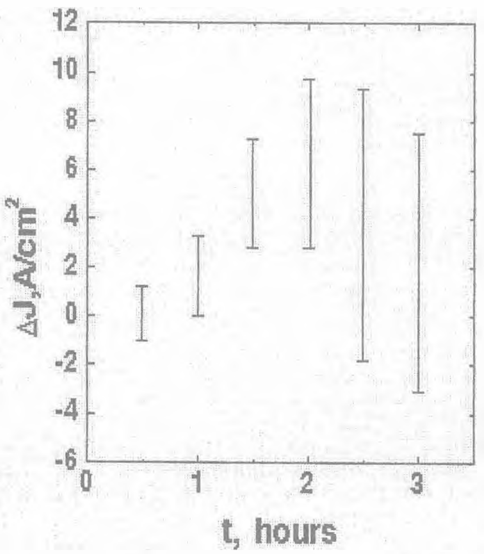

Fig.2. The average changes in J_c difference (ΔJ_c) versus hydrogen plasma treatment time for BiSrCaCuO(2223) ceramic material.

Summary

Our experimental results show that the atomic hydrogen saturation of the bulk of high-T_c materials leads to the increase of the critical current density due to passivation of dangling bonds and grain boundaries. It means that methods normally used in semiconductors technology for the improvement of the quality of semiconductors [1-3] can be used also for the improvement of the critical parameters of high--T_c materials. Further investigations for the optimization of this processing based on atomic hydrogen insertion are necessary. It is also necessary to underline that the semiconductor technology based on ion implantation in combination with the hydrogen plasma treatment can be used for the modification of the structure of subsurface layers of high--T_c materials. For the possible realization of the benefits offered by the technology of H-insertion-induced layer splitting, several issues also need to be further investigated.

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