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Electrophoretic Superconducting Film Applications

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ABSTRACT : $YBa_2Cu_3O_{7-\delta}$ superconductor films have been prepared on silver substrates by electrophoretic deposition. As silver does not react with $YBa_2Cu_3O_{7-\delta}$ compound and has little influence on its superconductivity, it is usually doped in $YBa_2Cu_3O_7$ to improve the strength of the material and eliminate micro cracks. It has been proved that Ag additive can lower the melting temperature of $YBa_2Cu_3O_{7-\delta}$ and act as linking bridge among $YBa_2Cu_3O_{7-\delta}$ particles, thus in this paper Ag doped $YBa_2Cu_3O_{7-\delta}$ thick films are prepared by electrophoretic co deposition. As there are only some referenced experience formula and models for co electrophoretic deposition and does not exist unified explanation, the behavior of Ag particles during co electrophoretic deposition is also studied.

1. Experiment

$YBa_2Cu_3O_{7-\delta}$ powder was prepared by solid phase reaction, then mixed with Ag powder with the mass content of 5%, 10%, 15% and 20%. After ground and weight, 0.3g mixture and a little iodine was added into 100ml acetone in the electrophoresis container, then, stirred to disperse enough. The anode was made of pure nickel around the container wall and the cathode was silver substrate with the size of 0.24mm×15.7mm×4.00mm in the middle of container. The space between the two electrodes was 2.5cm. The deposition completed within 10 minutes. The films were sintered at 850℃ for 3 hours. After oxygenation for 12 hours at 400℃ the superconductivity of films was measured by four probe method.

2. Results and discussion

The contents of Ag in films were analyzed by atom absorb spectrophotometer. The results showed in table 1. There still existed relatively much Ag in the films and the contents of Ag tended to increase with those in original mixtures. It indicated that Ag could also deposit on cathode in acetone dispersoid.

When Ag and $YBa_2Cu_3O_{7-\delta}$ mixtures sintered at 900℃ were ground, the particles

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obtained might be grains containing both Ag and $YBa_2Cu_3O_{7-\delta}$ which meant during their electrophoretic deposition Ag might have more opportunities to deposit on cathode than the particles directly mixed and not sintered. However the results proved that sintered particles had not carried more Ag to deposit. Hence it was considered that Ag particles could also adsorb electric charge and move to cathode by static force. It had been proved by the single phase Ag particle electrophoresis experiment.

The relation between electric quality Q adsorbed by $YBa_2Cu_3O_{7-\delta}$ and that adsorbed by Ag was deduced according to the mol content of $YBa_2Cu_3O_{7-\delta}$ and Ag in the films as following:

The mol contents of particles deposited on electrode were y=QYBCO/F, x=QAg/F. Thus the relation between electric quality Q adsorbed by $YBa_2Cu_3O_{7-\delta}$ and that adsorbed by Ag was QYBCO=-0.1638QAg+0.1519F.

The X-ray diffraction of sintered film surface showed that the main phase was Y123 and there also existed small content of Ag. The SEM graphs of surface and transect of co-electro deposited $YBa_2Cu_3O_{7-\delta}$ films were show as figure 3. It could be observed that particles tiled on the substrate evenly. There existed texture in the film close to substrate surface which might be caused by rolling (figure 3-b).

3. Conclusions

In acetone dispersoid Ag particles can also adsorb protons and deposit along with $YBa_2Cu_3O_{7-\delta}$ on the substrates. Thus the electric field between electrodes and the charges on particles are the key factors of co-electrophoretic deposition of Ag and $YBa_2Cu_3O_{7-\delta}$ but not the dynamic stirring. The relation between electric quality Q adsorbed by $YBa_2Cu_3O_{7-\delta}$ and that adsorbed by Ag was QYBCO=-0.1638QAg+0.1519F. Glycol can improve the adhesion affinity between substrates and films.

Table 1. Contents of Ag in co EPD films

Content of Ag in original mixture powder (mass%)	5	10	15	20
Content of Ag in films from directly mixed powder (mass%)	2.55	4.31	4.82	9.30

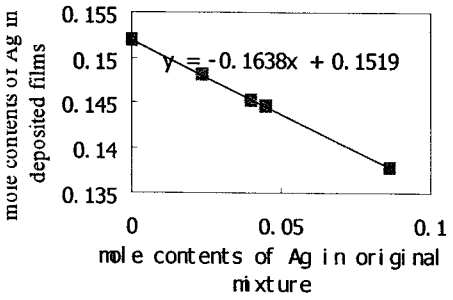

Fig 1. Relation between mol content of $YBa_2Cu_3O_{7-\delta}$ and Ag

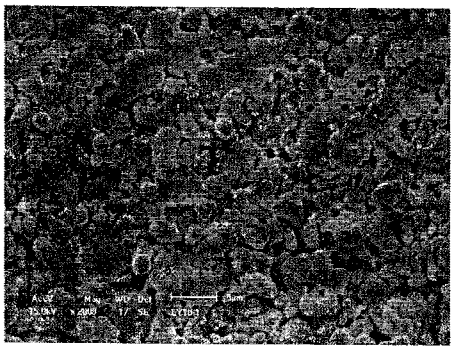

Fig 2. SEM graphs of co-electrophoretic deposited surface of $YBa_2Cu_3O_{7-\delta}$ film (×2000)

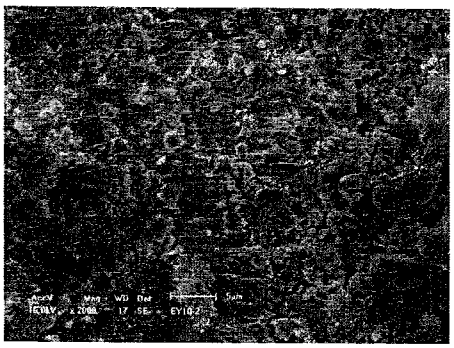

Fig 3. SEM graphs of co electrophoretic deposited transect close to Ag substrate of $YBa_2Cu_3O_{7-\delta}$ film (×2000) (on the left is substrate)