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Chemical State Analysis of Superconducting Whiskers for Nano-Devices

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$Bi_2Sr_2Ca_{n-1}Cu_nO_y$ (Bi-based) superconducting whisker is one of the most promising materials for nano-devices. However, in order to attain the application of Bi-based superconducting whisker, its fundamental physical and chemical properties, e.g. exact crystal structure, chemical bond nature of constituent elements and so on, should be urgently clarified.

We have already succeeded to clarify the exact chemical bond nature of Bi-based superconducting whisker by X-ray photoelectron spectroscopy using synchrotron radiation with high excitation energy(XPS). From the results, we have found that there is a reduction layer in the range of 100-200 Å from the surface which corresponds to the measurement depth in using the excitation energy with $h\nu = 4750$eV. Recently, a cross-whiskers junction method which two whiskers are crossed and annealed to fabricate a junction was developed[1]. The method to fabricate a junction is very important because we can easily obtain the intrinsic Josephson junction characteristics without any special process technique. However, the current-voltage(I-V) characteristics of the cross-whiskers junction has a slope at Josephson current flowing. It indicates that the property of the junction is not ideal. Considering the results mentioned above, the origin of the slope seems to be the existence of the reduction layer in the surface of whisker.

In this experiment, we investigated the chemical state of the surface in Bi-based superconducting whisker which is annealed in flowing oxygen at 500℃ for 5min or 22h to clarify whether the reduction layer of the surface will be made back in superconductor by supplying oxygen or not. For the excitation source, we used synchrotron radiation with the energy of $h\nu$ =3086 and 4750eV, which is also used for the measurement of as-grown whisker.

As shown in Fig.1, we found that the intensity of Cu-2p satellite peak increased in the sample annealed in oxygen, which indicates that the enough oxygen was supplied to the reduction layer in the surface of whisker and the reduction layer should be made back in superconductor.

Considering the results of XPS measurement with synchrotron radiation, we can suggest that we should pay attention to the surface treatment in fabricating a junction of which the interface consists of the surfaces of the whiskers. As the Bi-based superconducting whisker is very tiny and oxide, we can not adopt the cleavage and annealing in vacuum to clean its surface. Therefore, annealing in oxygen seems to be proper for Bi-based superconducting whisker to obtain the clean surface. We expect to be able to obtain the better property in I-V characteristics by preliminarily annealing of the whisker's surface in oxygen in fabricating the junction.

[1]Y.Takano, T.Hatano, A.Ishii, A.Fukuyo, Y.Sato, S.Arisawa, K.Togano: Physica C, 362(2001)261.

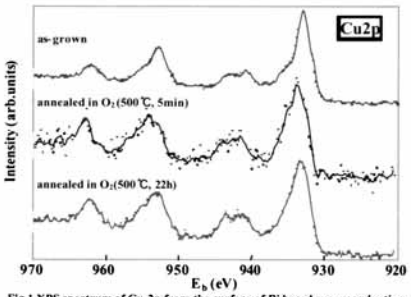

Fig.1 XPS spectrum of Cu-2p from the surface of Bi-based superconducting whisker annealed in oxygen (excitation energy: $h\nu$ =4750eV).

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Stress and strain analysis of Pd/V/Pd films under hydrogen atmosphere

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V can absorb and desorb hydrogen reversibly around room temperature. However, the effective usable hydrogen absorption-desorption content is only about 50 % of the absorption capacity because the equilibrium dissociation pressure of the first plateau of two plateau regions is very low in the pressure-composition isotherms[1]. Recently, it has been reported that the hydrogen desorption temperature of the metal hydride in multi-layered films decreases due to elastic interactions between the layers[2]. In this work, we tried to estimate the stress and strain on V and Pd layers in Pd/V/Pd/Cr films under helium and hydrogen pressure.

The films were prepared on a Si (100) substrate by a RF-associated magnetron sputtering method without additional heating at Ar pressure of 0.4Pa. Pd, V and Cr layers were 20, X (= 50, 100) and 30 nm thick, respectively. The diffraction measurements were carried out by side-inclination method at room temperature under 0.5 MPa of helium and hydrogen, respectively. The wavelength of incident X-ray was 0.124 nm.

The stresses on Pd and V layers were estimated with the slopes of the fitting straight lines by the method of least squares in the diffraction angle 2θ versus $\sin^2\psi$ plots. The stress σ versus the thickness of V layer X plots under helium and hydrogen pressure are shown in Fig.1 and Fig.2, respectively. As the thickness of V layer increases, the stress on V layer decreases while that on Pd layer increases under helium pressure. Under hydrogen pressure, the compressive stresses are induced on V and Pd layers, respectively.

1) E. Fromm, E. Gebhardt (eds.), Gase and Kohlenstoff in Metallen (1976) 26.

2) K.Higuchi et al., J. Alloys Comp. 330 - 332 (2002) 526.

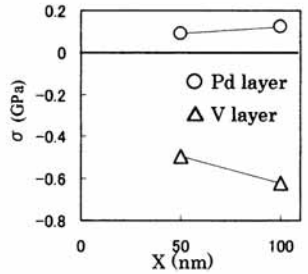

Fig.1. The stress σ versus X plots of Pd/V/Pd/Cr films under helium pressure.

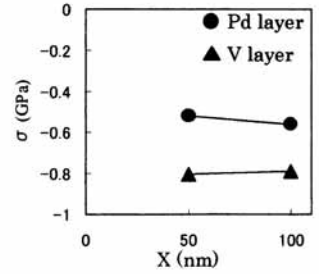

Fig.2. The stress σ versus X plots of Pd/V/Pd/Cr films under hydrogen pressure.