§20. Measurement of Properties of High Purity Metals

Tomaru, T. (Cryogenic Science Center, High Energy Accelerator Research Organization),
Takada, S.

It is well known that purity is significant factor for electric resistance and thermal conductivity at low temperature. Thermal conductivity of high purity copper can be about 100 times higher than commercially available copper due to less scattering of electron [1), 2), 3)]. And of course annealing of high purity metals is also significant factor. For fusion science, high purity metals can be useful to the design of new superconductor for high field superconducting magnet. Thus, the measurements of properties of high purity metals at cryogenic temperature are important to make databases.

The Joule heating vacuum furnace was assembled for annealing in this study shown in Fig. 1. The temperatures of annealing wires were measured by the radiation thermometer from outside of the vacuum vessel.

In this year, we have tried to investigate 5N (99.999%) class high purity Tungsten which is commercially produced recently. The electric resistance and thermal conductivity of the pure tungsten wires were measured on several annealing conditions.

In Fig. 2, the comparison of measurement results of thermal conductivity between un-annealed sample and annealed sample by 900 ℃. The thermal conductivity of annealed sample is about twice higher than that of un-annealed one. The shift of thermal conductivity peak was observed. In Fig. 2, the sample made by the Institute in Nederland, Nationaal instituut voor subatomaire fysica (NIKEF), were also measured and compared with our sample. The validity of measurements was confirmed from each other.

Furthermore, effect of the annealing condition of 1800 ℃ which is above re-crystallization temperature was also measured. In the case of the annealing of 1800 ℃, the Residual Resistance Ratio (RRR) became much larger than the value shown in Table 1. RRR is the ratio of electric resistance between room temperature and 4.2 K. It is well known that electric resistance and thermal resistance have positive correlation which is formulized as Wiedemann-Frantz law. On Table 1, the values of the calculated thermal conductivity by the Wiedemann-Frantz law were estimated. It is found that this annealing temperature is good for thermal conductivity. However, these samples became fragile after annealing. The fragile samples are not available. We need more studies and he precise control of temperature is needed.to seek optimal condition Thus more sophisticated furnace are planned to install.

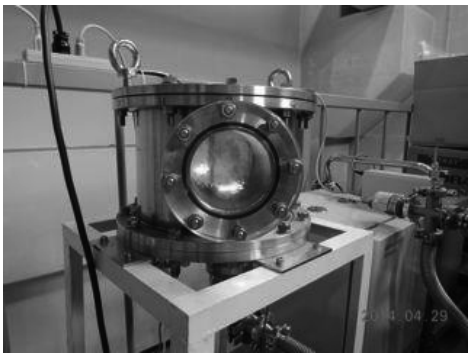

Fig.1 Joule heating furnace with vacuum vessel

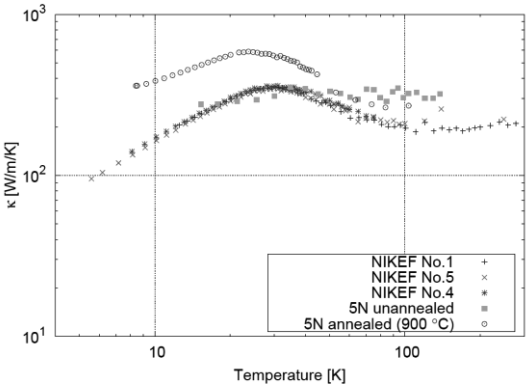

Fig.2 Thermal conductivity of 5N-class high purity Tungsten on several annealing condition

Table 1 Improving residual resistance ratio in the case of the annealing condition of 1800℃ joule heating

	RRR	Calculated thermal conductivity W/(m K)
Before	**37**	**200**
After	**1800**	**10,000**

1) T. Tomaru, et al. TEION KOGAKU **46** (2011) 415-420 [in Japanese]

2) K. Kasahara et al. TEION KOGAKU **39** (2004) 25-32 [in Japanese]

3) T. Shintomi et a. TEION KOGAKU **46** (2011) 421-425 [in Japanese]