2G HTS coil Stability Improvement via V_2O_3 Material and Perforated HTS Wire

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Background

When we look at the results of this research so far, it is clear that the electrical stability of the no-insulation superconducting coils has improved over insulated superconducting coils. However, when being quickly charged or discharged, the no-insulation coils are difficultly controllable than conventional insulated superconducting coils. Because of this, we have developed a smart insulation coil which uses the metal insulator transition (MIT) properties of the V_2O_3 material so that we can put overcome the disadvantages of both conventional insulation coils and no-insulation coils. However, in the case of 2G HTS coils, a problem has been discovered where current bypass does not occur smoothly due to the wire's structural properties.

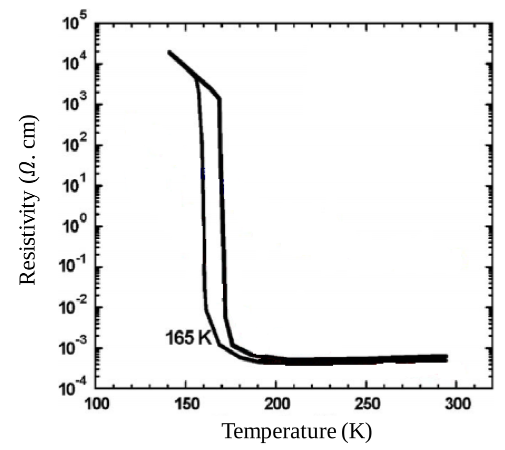
Objectives

We experimentally analyze and verify the current bypass path according to the structural properties of the 2G HTS wire, and we present a method which allows for smooth current bypass.

Conclusion

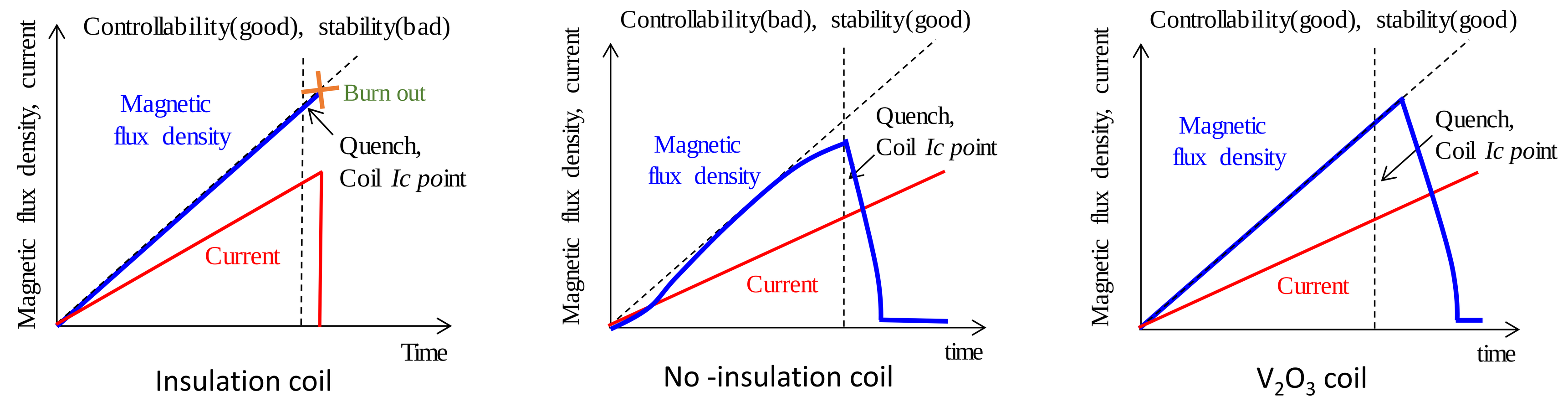
- In this research, we presented a structure which allows the current bypass to occur easily during transient states in order to ensure the stability and reliability of a 2G HTS coil using V_2O_3.
- To verify this, we experimentally analyzed the current's movement path between turns in the 2G HTS wire. Therefore, it was experimentally verified that the current bypass movement path in the 2G HTS coil was structured so that most of it could only flow through the copper layer.
- To supplement this, holes were bored in the wire rod, and we examined whether a single turn state occurred due to the expansion of the current's movement path.
- The experiment results confirmed that even though there was a reduction in the Ic due to the holes, the resistance between turns was reduced by the holes, and a single turn state occurred during transient states, just as in the 1G HTS coil.
- In the experiment, we bored 1 mm holes which were not small, however there is research being performed nm - µm scale holes are created using lasers, etc. so that Ic reduction does not occur. We expect this research will show that it is possible to create an improved structure where a single turn state occurs without a reduction in Ic.

MIT Characteristics and Output Characteristics According to Electric Insulation Method



MIT characteristic refers to an instant change in material property from metal to insulator or from insulator to metal due to the change in the resistance under certain conditions.

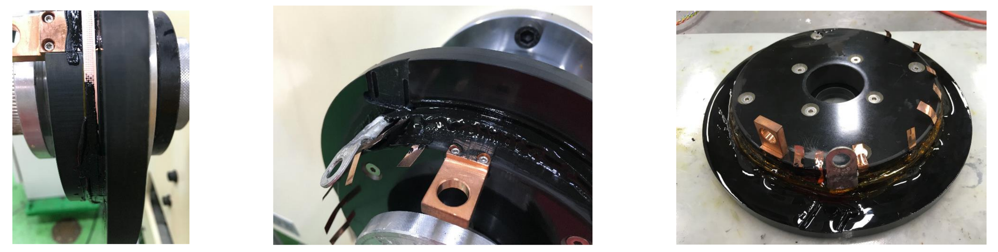
Among the many materials with an MIT characteristic, vanadium (III) oxide (V_2O_3) was used in this study because its temperature transition range was considered appropriate for the required conditions in this study. V2O3 is a material whose resistivity in a pure singlecrystal state sharply changes by 1/600,000 times at approximately 150–170 K.



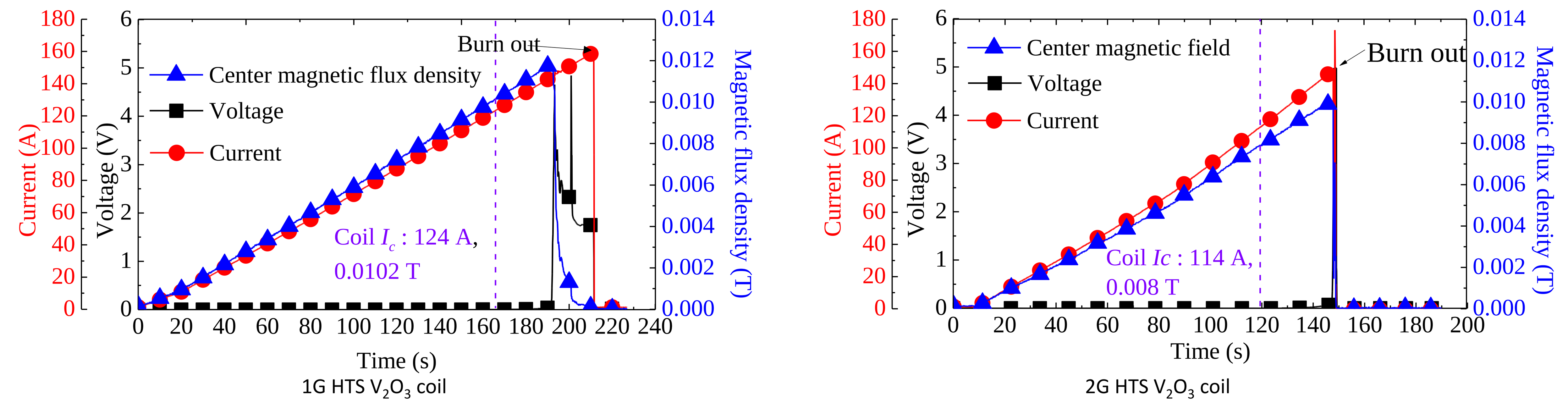
Relationship between current and magnetic flux density according to electric insulation method

TABLE I
SPECIFICATIONS OF HTS COIL

Item	Parameters	
	1G HTS coil	2G HTS coil
Wire model	Sumitomo type-H BSSCO 2223	SuperPower SCS-4050
Width of wire (mm)	4.3	4
Thickness of wire (mm)	0.23	0.094
Short sample I_c, self-field, at 77 K (A)	184	135
n-value	21.3	22.5
Winding tension (N)	19.6	21.56
Stabilizer thickness (µm)		20 ~ 25
Inner diameter of coil (mm)	140	
Number of turns	8	
Insert material in turn to turn	V_2O_3	
Charge ramp (A/s)	1	



HTS coil using V_2O_3

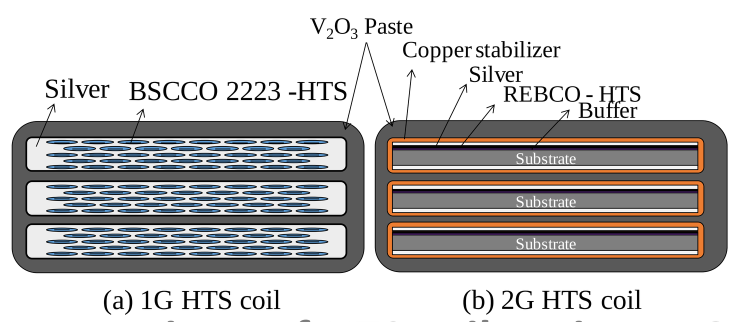


Output characteristics of 1G and 2G HTS coils using V_2O_3

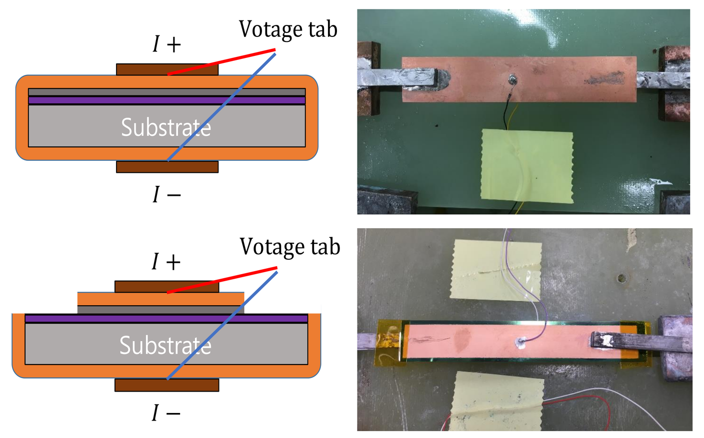
Analysis of Output Characteristics According to The Turn-to-turn Electrical Resistance of The 1G And 2G HTS Coils Using V_2O_3

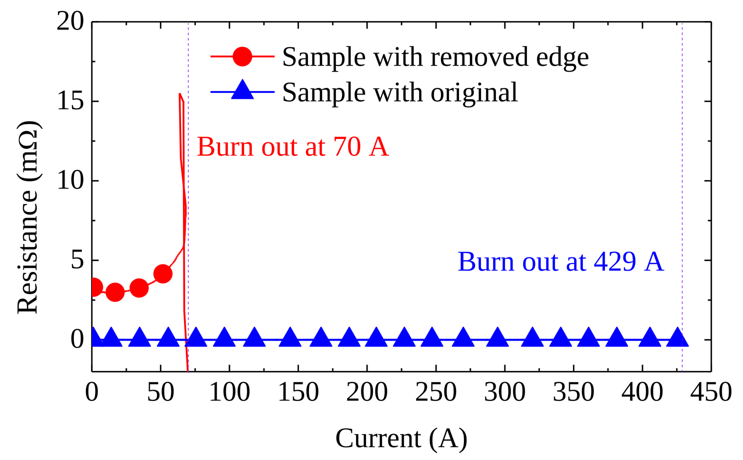
In the case of the 2G HTS wire, its structure is layers of complex material, so the resistance of each material and the resistance of the V2O3 become the total turn-to-turn resistance.

The 2G HTS wire's buffer layer is made of oxides and has the specific resistance close to an insulator, so we have deter-mined that when current bypass occurs, most of the current flows to the copper layer which is a stabilizer.



Cross sections of HTS coils using V_2O_3





Comparison of resistance in sample with copper, silver and superconductor layers removed and sample without layers removed

Perforated 2G HTS Wire Test to Reduce Turn-to-turn Resistance

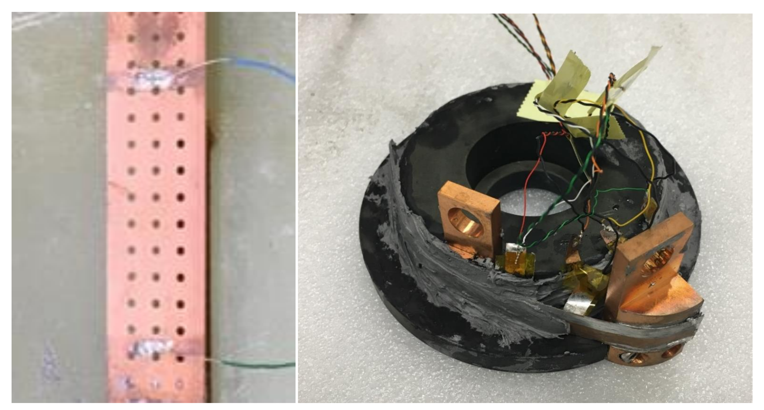
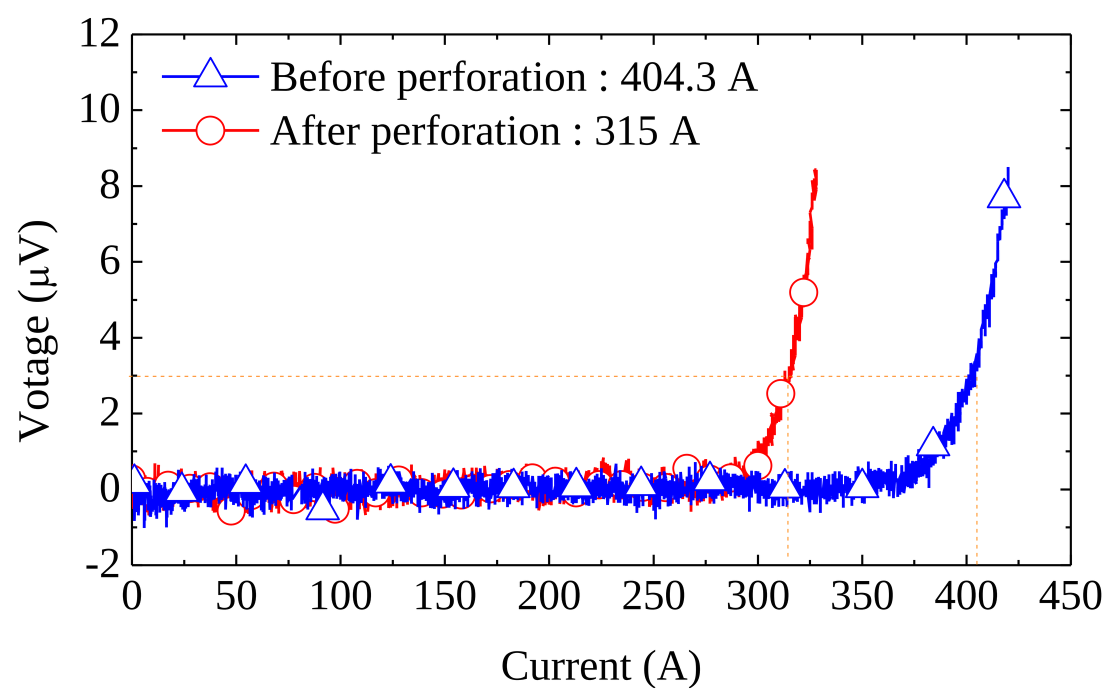
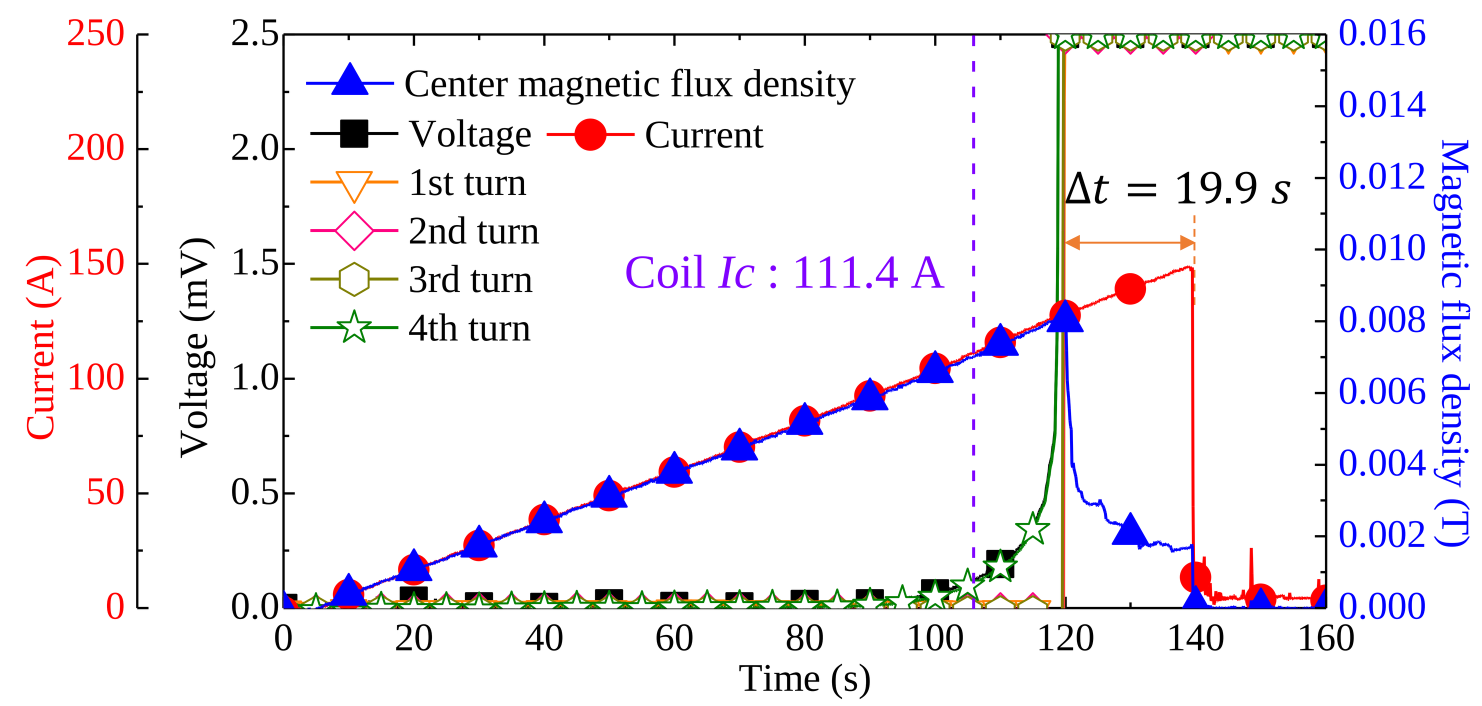


TABLE II
SPECIFICATIONS OF PERFORATED 2G HTS COIL

Item	Parameters
Wire model	SuperPower SCS-12050
Width of wire (mm)	12
Thickness of wire (mm)	0.065
Short sample I_c, self-field, at 77 K (A)	411.3
Short sample I_c, after perforate (A)	315
n-value	31.1
Inner diameter of coil (mm)	80
Number of turns	4
Winding tension (N)	21.56
Insert material in turn to turn	V_2O_3
Charge ramp (A/s)	1



Short sample Ic measurement of 2G HTS wire



Over current test for perforated 2G HTS coil

The results of measuring the short sample Ic of the perforated 2G HTS wire and the results of the over current test.