

§4. Studies on Transient Heat Transport Characteristics of Fountain Effect for an Improvement in Cooling Performance of Superconducting Magnets

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Transient heat transport characteristics of superfluid helium (HeII) channels have been investigated experimentally. Two parallel HeII channels are separated by a spacer. Four kinds of spacer materials have been tested. One of them is FRP and the others are porous materials which can induce the fountain effect. Unexpected local steep temperature rise in the coil can be suppressed by the fountain effect.

The tested channels having different spacer materials are schematically shown in Fig. 1. The vertical and horizontal directions in this figure are not the same. Two parallel rectangular channels are separated by a spacer. Both channels are 170mm in length, 7mm in width and a gap of 3mm. These channels are made of FRP except for the spacer. A film heater is attached to one side of the walls in the channel. Both ends of the channel are kept open to an atmospherically pressurized HeII bath.

The following spacers are tested as shown in Fig.1. (1) The length and thickness of the FRP spacer, are 170mm and 5mm, respectively. (2) The central portion of the FRP spacer is replaced by an alumina spacer. The length and thickness of the alumina spacer are 150mm and 5mm, respectively. The mean pore size and the porosity of this spacer are $1\mu\text{m}$ and 22%. (3) The FRP spacer is replaced by a high density polyethylene (HDPE) spacer having the length of 170mm and the thickness of 3mm. This material is preferable for practical use compared with alumina because of its elasticity. The mean pore size and the porosity are $4\mu\text{m}$ and 34.5%. (4) A polypropylene micro film is inserted into the channel. The thickness of this film is $40\mu\text{m}$. The mean pore size and the porosity are $0.3\mu\text{m}$ and 35%, respectively.

RuO_2 thermometers are set in the channels. The positions of the thermometers are shown in Fig. 1. The size of the RuO_2 thermometer is 1.6 mm long, 0.8 mm wide and 0.45 mm thick.

Two characteristic times, Take off time and Recovery time, are defined to quantitatively evaluate transient heat transport characteristics of the tested channels. Take off time is defined as the time that the maximum temperature in the channel takes off from T_λ after the heat input is started. Recovery time is the time that the maximum temperature in the channel returns to 2.10K after the heat input is terminated.

Relations between Take off time and applied heat flux for the tested channels are shown in Fig. 2. Take off time becomes longer when porous spacers are installed.

This fact suggests that the porous spacer is effective to delay an initiation of the λ transition when the heat flux larger than q_λ is applied.

Relations between Recovery time and the applied heat flux are shown in Fig. 3. Recovery time for the channel with the porous spacer is shorter than that for the FRP spacer. Especially, the installation of the alumina spacer is effective for quick recovery to the bath temperature after the heat deposition is terminated.

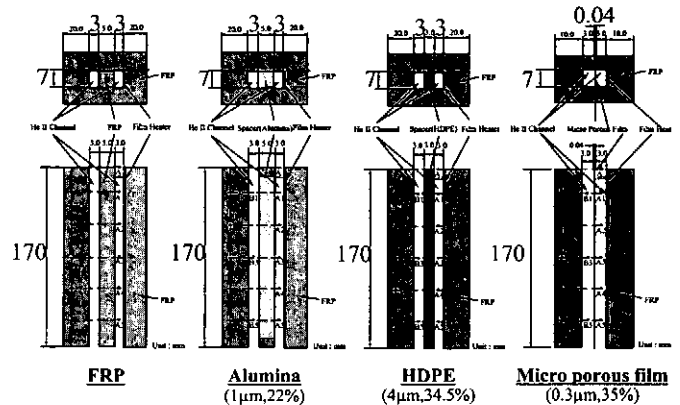


Fig. 1. Schematic cross-sectional views of a spacer equipped HeII channels.

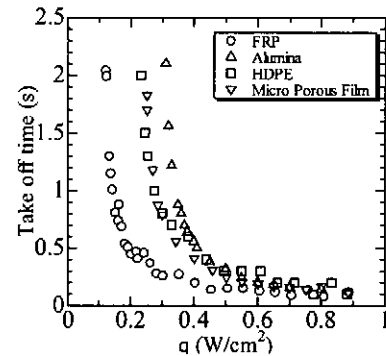


Fig. 2. Relation between Take off time and applied heat flux. The bath temperature is 2.05K.

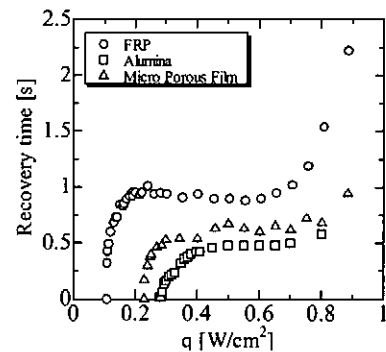


Fig. 3. Relation between Recovery time and applied heat flux. The bath temperature is 2.05K.