P19

The initiation of N zone propagation with combustion wave qualities by micro-sized magnetic cumulation

Oleg Kiprijanovič and Linas Ardaravičius

Center for Physical Sciences and Technology, Saulėtekio al.3, LT-10257, Vilnius, Lithuania.
Email: oleg.kiprijanovic@ftmc.lt

Overcritical current induces a transition from a superconducting (S) state to a normal (N) state – S-N switching. Paper [1] reports that at high current densities, N zone propagation velocity during the S-N switching reaches values corresponding to detonation mode. However, the paper does not explain the reasons for initiating such a mode. Paper [2] reports that the unstable S-N border on the thin YBaCuO film edges disrupts via current reconnection encircling N areas with a diameter of about ten μm with trapped magnetic flux. S state squeezes these areas, and magnetic cumulation occurs due to the conservation of magnetic flux. Here, estimations were made, showing that the temperature increase due to the magnetic cumulation and properties of a type-II superconductor is sufficient to form N zone propagation with combustion wave qualities.

The quality of the film and its S-N border is characterized by the effective penetration length λ_{eff} at the film edges. The thinner the λ_{eff}, the higher the tensile strength of the S-N border and its ability to withstand Lorentz force. Three cases with λ_{eff} equaling 2.64, 1.64, and 1.155 μm are considered as they were in [2] for N zone propagation analysis. The areas with trapped magnetic flux are squeezed by a S current ring of λ_{eff} width. For the first and second cases, the final condition for cumulative S-N switching is the achievement of the de-pairing current. For the third one, the final condition is the achievement of the pulsed critical field H_{c2} that is 2.4 T.

As a result of the cumulation, intense energy release occurs after S-N switching in the ring of λ_{eff} width when both the high temperature and its gradient form a front of N zone. The rings' temperature increases in these cases from 78 K by 478, 680, and 960 K, correspondingly. Counteraction to the Lorenz force does not allow S state to retreat with Fermi velocity. The analysis shows that in the first and the second cases, diffusing hot electrons after thermalization induces S-N switching with heat release ahead of the front at about 0.03 λ_{eff} width. The release initiates and continues to sustain high-velocity N zone propagation. In the third one, cracks open in the film due to a large temperature increase. They penetrate inside the S-N border at 0.03 λ_{eff} where high-density S currents are. Intense energy release begins at the crack tips, which induces film melting, thus causing further high-velocity propagation [3].

However, these high-velocity propagation processes quickly decay as they spread because S current in the rings of λ_{eff} width and corresponding magnetic fields decrease. As follows from the above, in contrast to the detonation in explosives, in thin high-quality YBaCuO films the front of the N zone constantly replenishes energy ahead of itself while propagating, which corresponds to the qualities of the combustion wave.

REFERENCES

[1] V. Fortov et al., *Physica C Superconductivity* **310** (1998) pp. 400-402. doi.org/10.1016/S0921-4534(98)00499-7
[2] O. Kiprijanovič, L. Ardaravičius; *Thin Solid Films* **748** (2022) 139159. doi.org/10.1016/j.tsf.2022.139159
[3] L. Ardaravičius, et al., *Intern. J. Struct. Integrity* **7** (2016) pp. 607-416. doi.org/10.1108/IJSI-09-2015-003