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Estimation of Electricity Storage Density of Compact SMESs Composed of Si-wafer Stacks Loaded with Superconducting Thin Film Coils in Spiral Trenches under the Constraint of Critical Magnetic Flux Density

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We have been developing a superconducting thin film coil in a spiral trench on a Si wafer [1]. Having completed in fabrication of a NbN superconducting thin film coil on 76.2 mm-diameter Si wafer [2], we have replaced NbN with $YBa_2Cu_3O_{7-\delta}$[3]. The high critical current density of $YBa_2Cu_3O_{7-\delta}$ is possible to impose high magnetic flux density as well as electromagnetic hoop stress on the coil. In the constraint of the upper limit of critical magnetic flux density of 20 T for $YBa_2Cu_3O_{7-\delta}$ and hoop stress of one third of 4 GPa for Si wafer, the design of the spiral coil must be optimized. For this purpose, estimation of magnetic field generated by the superconducting current in the spiral coil was performed based on Biot-Savart low [4]. The spiral coil was approximated to be multiple loops with the same current in a 101.6 mm Si wafer and 600 wafers were supposed to be stacked. The sum of the generated magnetic fields was obtained at the innermost loop in the trench to obtain the maximum magnetic flux density and hoop stress in the 600 wafers. A typical result in Figure 1 shows the maximum electricity storage density of 13.8 Wh/*l* appeared at the innermost coil radius about 45.4 mm. The hoop stresses were well below the one third of 4 GPa.

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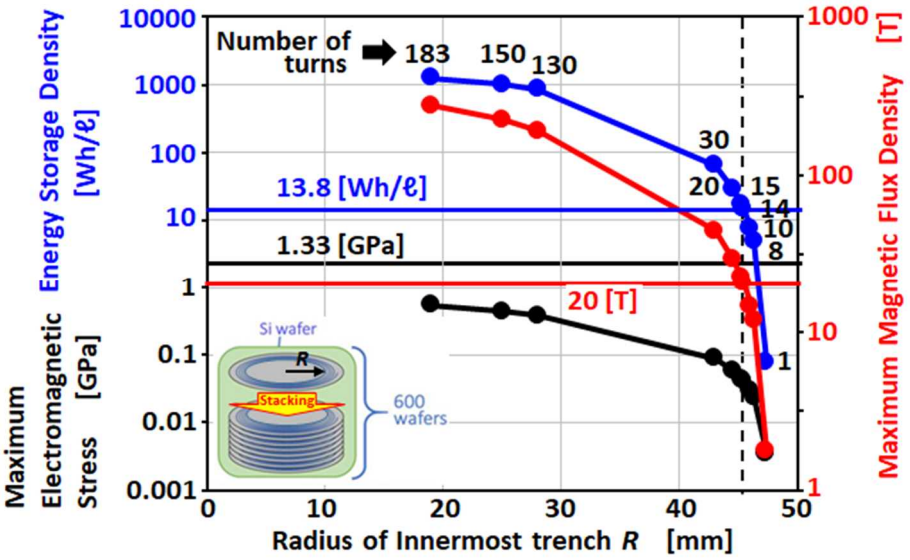

Fig. **1** A typical result of estimations of energy storage, maximum magnetic flux density and maximum electromagnetic stress as a function of the radius of the innermost trench radius.

Keywords: Electricity storage density, SMES, Si wafer, Critical magnetic field