

Recent Progress in Development of SFQ Arithmetic Logic Unit in Korea

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We report recent progress in the development of an arithmetic logic unit (ALU) based on the single-flux-quantum (SFQ) logic circuits, propelled by 21C Frontier R & D program in Korea. Our program, developing an ultra-fast RSFQ ALU, started on Sep. 25th of 2001. During the two years of the program that lasted from Sep. 2001 to July 2003, we have constructed Nb superconducting circuit fabrication facilities by purchasing all the necessary equipments and installing them in Korea Photonics Technology Institute (KOPTI), the leading organization of the program. These equipments include two dual chamber sputtering systems for the deposition of Nb, Al, Mo, and SiO₂ films, one e-beam evaporator for the deposition of Ti/Pd/Au films, one dual chamber RIE system and two ICP etching systems to etch various films, and various equipments for the tests and analyses. After finishing the equipments installation, we are currently investigating the optimum fabrication conditions for Nb superconducting SFQ circuits. Our works include establishing a robust Nb/Al₂O_x/Nb junction fabrication process, the deposition conditions of Mo and SiO₂ films and their etching conditions, and the deposition conditions of the Ti/Pd/Au electrodes. Our progress to date in optimizing the fabrication processes contain 1) optimizing the etching processes of all the thin films (uniformity < 5%), 2) obtaining a good Nb film fabrication process with T_c of 9.2 K, and 3) optimizing the fabrication process of Mo resistor films that have the sheet resistances of 1 /sq. at 4.2 K. Our ongoing efforts are in improving the optimum deposition conditions of the various films by varying the distances between the targets and the substrates, the RF and DC sputtering powers, and the sputtering gas pressures. These optimum conditions will be used to obtain the uniform Josephson junctions and the good circuit parameters. Besides the works for the circuit fabrication, we have also installed and utilized the circuit design programs to design the basic SFQ circuits that include DC/SFQ, JTL, Confluence Buffer, SFQ/DC, and D-FF. Those circuits were fabricated by using HYPRES foundry service and a DC/SFQ-JTL-SFQ/DC circuit combined with a counter was tested at 20 GHz. We also designed and fabricated some logic circuits that include an AND gate, an OR gate, a XOR gate, and a half adder. The correct operations of these circuits were tested at the various speeds of up to 5 GHz. As a preliminary design of a 1-bit ALU, we designed an RSFQ ALU similar to the current semiconductor ALU in the architecture. However, due to the difficulties in the timing, we are now developing an ALU in the pipeline architecture. In the third year of the program that may start on July 25th of 2003, we are planning to develop an RSFQ 4-bit, 5 GHz ALU, based on our progresses established in the first year and the second year of the program.

keywords : arithmetic logic unit, single-flux-quantum, Nb/Al₂O_x/Nb junction, 4-bit, 5 GHz ALU