Rf Superconductivity Research and Development at Stony Brook*

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SRF activity in the last two years has been concentrated on improving the performance of the heavy-ion linac by upgrading and refurbishing its twelve modules. Recently as part of this general program a new generic lead-tin plating chemistry was developed and a procedure was devised to calculate the optimum linac cooling power distribution.

Introduction

Rf superconductivity research and development at Stony Brook is based on a lead-copper technology applied to various low-beta structures [1]. The high points of this twenty-year effort are the construction of the first university-based superconducting heavy-ion linac and the development of two key prototypes: the first superconducting quarter-wave resonator (QWR) and the first true superconducting rf quadrupole (SRFQ). The QWR has become the structure of choice for small heavy-ion linacs around the world, with several interesting variations. The newer SRFQ is still in the prototype stage, with a second-generation device currently under development at INFN-Legnaro by the same group that collaborated in the original effort [1]. Meanwhile the heavy-ion linac has been in continuous operation since 1983, providing beams for a variety of nuclear physics programs.

Srf activities since the last workshop have all been somehow related to improving the performance of the existing linac rather than to any major new project. An upgrade of the low-beta section to QWR's was completed at the end of 1994, and a program to systematically refurbish (replate) the high-beta SLR modules is underway. Much of the effort in recent months has been devoted to finding a acceptable electroplating chemistry and to optimizing the linac field setting procedure.

Quarter-wave upgrade

The QWR upgrade project [1] was concluded at the end of 1994 with the installation of the fourth and final module. The sixteen installed resonators operate reliably and very stably at field levels up to 3.5 MV/m. Multipactoring triggered by the beam or operation of adjacent resonators still occasionally makes resonators difficult to start, but it does not prevent operation and can in any event be eliminated by Freon processing [2] during a warmup period.

The new modules provide a total of ~ 7 MeV of acceleration per charge. The improvement over the original small split-loop resonators is especially dramatic for relatively light ions such as carbon or oxygen, due to the much broader velocity acceptance of the two gap QWR.

Split-loop refurbishing

The SLR refurbishing program was described in some detail at the last workshop [1,3]. The thermometry study [3] proved that losses on the outer housing from the coupler port and end plate joints are actually quite insignificant. Not surprisingly, chemically polished resonators were also found to have much less field emission than mechanically polished ones. This leaves field-dependent magnetic losses on the loading arms as the main determinant of the practical operating field. The absolute limit of the structure with the current one micron PbSn technology seems to be about $\mathcal{E}_a = 4.5$ MV/m. Thermal breakdown within a few milliseconds is consistently observed at this field, which corresponds to $H_p \simeq 450$ G.

The refurbishing of module 6 began early this year. For the copper preparation we abandoned Shipley Chempolish [3] in favor of the well known sulfamic-acid based polish developed at CERN, with greatly improved results. Resonators were polished immediately after stripping, with no intervening hand work. After polishing a 5-minute dip in 20 g/l sulfamic acid solution served as a remarkably effective passivating method. Final rinsing after polishing, passivating and later plating was with 18 MΩ DI water supplied through a standard household pressure washing machine (Kärcher 401).

Lead-tin electroplating

Some small-sample plating tests were tried before risking the beautiful copper surfaces that had been obtained by the methods mentioned above. These tests revealed serious problems with the plating bath chemistry that could only be fully understood and remedied after the separate R&D effort discussed elsewhere [4] had been completed. This took several months.

Once an acceptable bath (gelatin+resorcinol) was available the plating of the three M6 resonators and their six tuning plates could be accomplished in less than a week. The plating anode was a simple oval shaped bagged lead sheet at the center of the resonator. For expediency the plating and rinsing operations were done in open tanks rather than by enclosing the resonator [1]. The parts were dried in open air with a stream of warm nitrogen gas. The one micron thick platings were highly reflective throughout, except for a few slight drying stains. The module was re-assembled in November and at the time of this report had been re-installed in the linac but not yet cooled down.

Linac Optimization

The traditional procedure for setting up a lead-copper heavy-ion linac is simply to set each resonator's field for an equal dissipation. A recent short study with a summer student [4] has provided some information on the effectiveness of this procedure compared to an optimized distribution of cooling power. Results so far with preliminary $Q(\mathcal{E}_a)$ data suggest that the traditional set-up strategy is remarkably efficient, at least for our linac, in that it achieves all but 2–3% of the maximum possible acceleration. That the equal-power method works so well could be due in part to cancellation effects [4] and in part to the large $\frac{dQ}{d\mathcal{E}}$ term [4] at the usual 6–8 watt operating point.

Other linac-related activites

Several other areas of linac infrastructure are being steadily improved. As one example, a concerted effort to eliminate leaks as modules are upgraded or reworked has dramatically improved vacuum levels and made it possible for the first time to operate routinely at 4K with only the inherent cryopumping of the modules.

References

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