New Technology of Lead-Tin Plating of Superconducting RF Resonators for the ANU LINAC

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The RF accelerating resonators for the ANU superconducting LINAC have been re-plated with lead-tin and their performance substantially improved. The re-plating was at first derailed by the appearance of dendrites on the surface. This problem was overcome by a new combination of two techniques. Rather than the standard process of chemically stripping the old Pb and hand polishing the Cu substrate the unsatisfactory Pb surface was mechanically polished and then re-plated. This is enormously easier, faster and doesn’t put at risk the thin cosmetic electron beam welds or the repaired ones. Reverse pulse plating was then used to re-establish an excellent superconducting surface. Average acceleration fields of 3.5 to 3.9 MV/m have been achieved. The replated resonators will double the energy gain of the accelerator significantly extending capability of the facility research.

Lead-tin plating provides fast adequate results with modest equipment and at relatively low cost. SUNY replated six high-beta SLRs with 2 microns of Pb-Sn using a modern, commercial, methane-sulfonate process (Lea Ronal Solderon MHS-L) and a simple open-air procedure [2]. This proven success motivated ANU to adopt MSA chemistry and to re-plate the first SLR in November 1998 followed by re-plating all twelve SLRs by November 2002. This increased the booster energy gain by almost 100%. A view of ANU LINAC comprising four module cryostats is shown in figure 1.

The Pb/Sn plating process at ANL initially employed Solderon MSA plating solution. A detailed account of this plating technology is given in [3]. The smoothest result was produced with a current density of about 5 mA/cm². However, the deposit contained crystallites with sharp edges, which probably compromises performance due to enhancement of magnetic and electric fields.

One strategy to reduce the sharp edges, pioneered at Caltech [4], was post-plating chemical polishing. This leaves a smooth mirror-like surface. Unpolished Solderon-plated SLRs have achieved remarkably the high average accelerating fields of 3.5 MV/m in spite of the high roughness [5]. Although the Solderon plating solution has a nominal shelf life of one year, it was employed at ANU for three and half years without noticeable degradation of its plating capability. After that, rapid aging turned the
solution yellow, tin oxide precipitated and the throwing power decreased. In July 2002, the old Solderon solution was replaced with a similar MSA based solution from Schlotter, Germany [1]. Schlotter MSA solutions are readily available in Australia through the local electronics industry. In addition, the Munich cyclotron [6] and Mumbai heavy ion booster [7] successfully used Schlotter MSA chemistry in RF superconductivity applications.

These investigations improved the understanding of Pb/Sn plated superconducting films resulting in the substantial improvement in the performance of the SLRs. This technology can lead to successful fabrication of LINAC resonators at low cost - crucial for university-based laboratories. At present, the ANU LINAC is able to provide an energy gain of ~ 7.1 MeV/q for beta 0.1 beams. The main advantages of the new Pb/Sn plating procedure are reliability, simple surface preparation, the possibility of solder repair of the substrate and it is inexpensive.

References