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Lithium Ion Emitter for Low Energy Beam Experiments

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The fact that the crystalline compounds Li_2O-Al_2O_3-$2SiO_2$ (ß-eucryptite) and Li_2O-Al_2O_3-$4SiO_2$ (spodumene) will emit Li^+ ions when heated above 1000°C has been known for many years, and a number of papers dealing with the preparation of the compounds and their use for the production of ion beams have appeared in the literature.[1] We wish to report a compact Li^+ emitter particularly suited for low energy experiments (E<100 eV) where beams with small energy spreads are essential. Since energy spreads of less than 0.5 eV are usually desired it is important that all points of the emitter surface be at the same potential. To obtain optimum beam focusing it is also desirable to have a geometrically well-defined emitter surface.

Figure 1 shows the emitter consisting of an indirectly heated, highly porous, tungsten plug into which the emitter material has been fused. The molybdenum body holding the plug is machined with a solid partition for complete isolation between the emitter and the heater cavity. The three rhenium support struts are brazed at a 120° spacing with a moly/ruthenium eutectic at 2100°C in hydrogen, yielding a ductile and versatile mounting tripod. The heater is a noninductively wound bifilar coil with heliarc welded rhenium legs solidly potted into the body cavity. The high purity Al_2O_3 potting mix is H_2 fired at 1900°C which completely immobilizes the heater. The emitter matrix, a specially prepared, extremely porous, tungsten disc with a density of 30% (70% porosity) is heliarc welded to the moly body. The ß-eucryptite or spodumene powder is placed on the face in controlled amounts and melted into the porous disc at approximately 1650°C in a hydrogen atmosphere. Beams of either $^6Li^+$ or $^7Li^+$ can be produced by using isotopically purified Li_2CO_3 in the preparation of the powder. A simple heat shield consisting of three dimpled layers of 0.005 cm moly sheet (not shown in figure 1) is attached around the assembly.

The observed total emission current as a function of

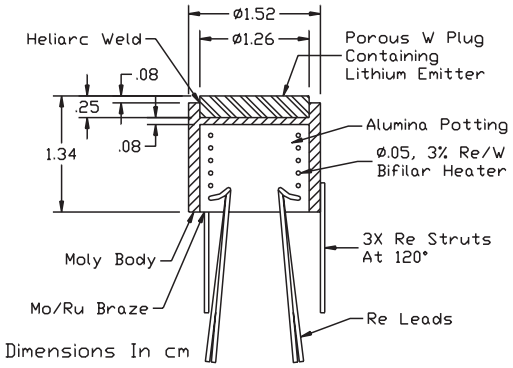

Figure 1. Construction of Li^+ Emitter

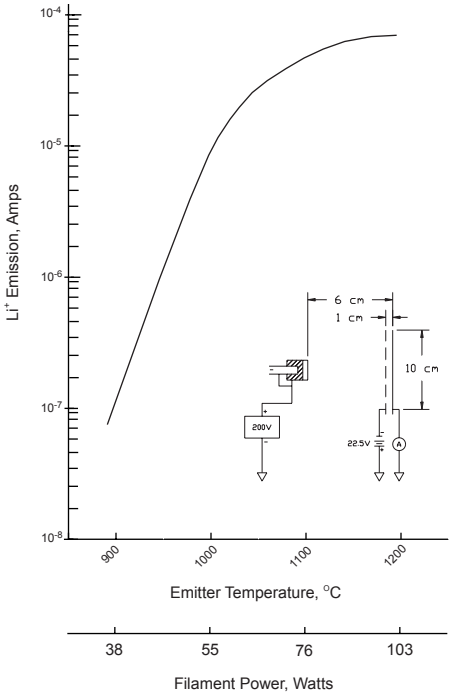

Figure 2, Total emission current as a function of input power and emitter surface temperature. Insert shows experimental arrangement.

emitter powder and emitter surface temperature (as measured with an optical pyrometer) is shown in Figure 2. Although the currents are small they are more than adequate for most low energy beam experiments where space charge limitations usually restrict the beam to lower values than those shown in figure 2 (see Haskell *et al.*[2] for numerical values). A mass analysis of the beam indicates that there are small amounts of other alkali ions present (~1%) when the emitter is first fired up, but that after a few hours of running the impurities decrease to about 0.01% resulting in a lithium ion beam of very high purity.

Measurements of the energy spread, some of which were reported by Haskell *et al.*,[2] were carried out using a 127° cylindrical electrostatic energy analyzer with a resolution $\Delta E/E$=0.014. The beam was decelerated to energies below 20 eV to assure a sufficiently small ΔE for the analyzer. The measured energy spread of the beam (full width at half maximum) was 0.24 eV, which agrees with the width at half maximum of a Maxwellian energy distribution at 1440 K of 0.22 eV.

While our experience with sources of the construction reported her is still rather limited we have operated one emitter ($^6Li^+$) about 200 h and another one ($^7Li^+$) in excess of 100 h without observable deteriation.

[1]J.P.Blewett and E.J.Jones, Phys. Rev. 50, 464 (1936); R.A.Hatch, Am. Mineralogist 28, 471 (1943); S.K.Allison and M.Kamegai, Rev. Sci. Instr. 32, 1090 (1961); F.M.Johnson, RCA Rev. 22, 427 (1962); A.Spetier and H. Leal, Nucl. Instr. Methods 29, 527 (1964)
[2]H.B.Haskell, O.Heinz, and D.C.Lorents, Rev. Sci. Instr. 37, 607 (1966)

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