

THIN RECHARGEABLE BATTERIES FOR CMOS SRAM MEMORY PROTECTION

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ABSTRACT

New rechargeable battery technology is described and compared with classical primary battery back-up of SRAM PC cards. Thin solid polymer electrolyte cells with the thickness of TSOP memory components (1 mm nominal, 1.1 mm max.) and capacities of 14 mAh/cm² can replace coin cells. SRAM PC cards with permanently installed rechargeable cells and optional electrochromic low battery voltage indicators will free the periodic PC card user from having to "feed" their PC cards with coin cells and will allow a quick visual check of stored cards for their battery voltage status.

INTRODUCTION

The advantages of CMOS SRAM's fast access time, access time equal to cycle time, equal duration read/write cycles and low voltage write capability are tempered by SRAM's requirement of a small data retention current when disconnected from the host computer's power. For this reason PC cards with SRAM require a battery back-up in order to retain their memory when disconnected from system power. The PCMCIA standard specifies a battery location at the end of the PC card opposite the connector (Figure 1) and PC card manufacturers use a coin type battery in a removable battery holder (Figure 2) in this location. The PCMCIA standard section 4.12 also makes provision for the PC card to compare the battery voltage with two reference voltages and provide status signals (BVD1 · BVD2 = 0) when the battery needs to be replaced.

PRIMARY COIN CELLS

The low profile of the 2025 coin cell makes it the cell of choice for memory cards. The 20 represents its diameter in millimeters and the 25 represents its thickness in tenths of a millimeter. The voltage and capacity of this cell varies depending upon the chemistry used in the cell. Two types of three volt coin cells are commercially available: the CR2025 uses lithium - manganese dioxide chemistry and has a capacity of 140 mAh, while the BR2025 uses lithium - polycarbon monofluoride chemistry and has 120 mAh of capacity.

Battery capacity can be translated into PC card memory life if both the SRAM's data retention supply current (ICCDR) and average storage temperature are specified. Figure 3 is a plot of the battery capacity as a function of average storage temperature for 1 Mbyte of SRAM (eight NEC uPD431000A). The two sloping lines indicate the capacity for one month and two years of data retention. As indicated on this plot a CR2025 battery will provide 2 years/MByte of data retention at 25°C and only 1 month/MByte at 80°C. This steep temperature dependence puts the responsibility for memory retention upon the user, as they must keep their cards cool and periodically insert them in a computer to check on battery status.

RECHARGEABLE TLOP CELLS

Recent advances in thin solid polymer electrolytes have made it possible to provide rechargeable cells in the same thickness as SRAM in thin small-outline packages (TSOP). The TSOP SRAM have a height above the circuit board of only 1.0 mm nominal and 1.1 mm maximum. Since the rechargeable cells are in thin large-outline packages (2 to 30 cm²), we call them TLOP cells, an example of which is shown in Figure 4. The capacity of these TLOP rechargeables depends upon both their surface area and chemistry. Figure 5 is a plot of battery capacity per square centimeter versus cell thickness for several commercially available coin and rectangular primary cells as compared with a solid polymer electrolyte rechargeable TLOP cell.

Comparing the two 1 mm thick cells in Figure 5 shows that the rechargeable LIMO TLOP cell has capacity per square centimeter equal to commercially available primary coin and rectangular cells of comparable thickness.

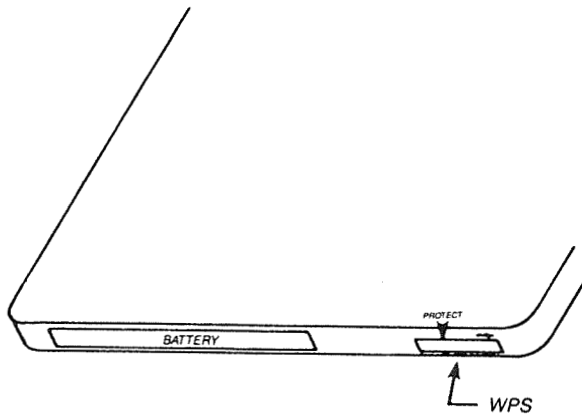


Figure 1. Battery and Write Protect Switch (WPS) Location on PC Card.

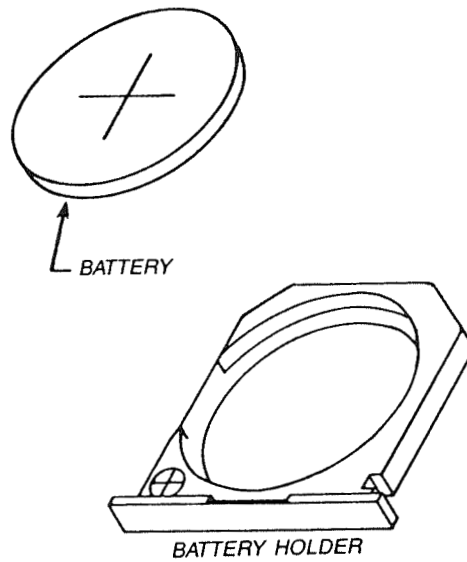


Figure 2. Coin Cell and Battery Holder.

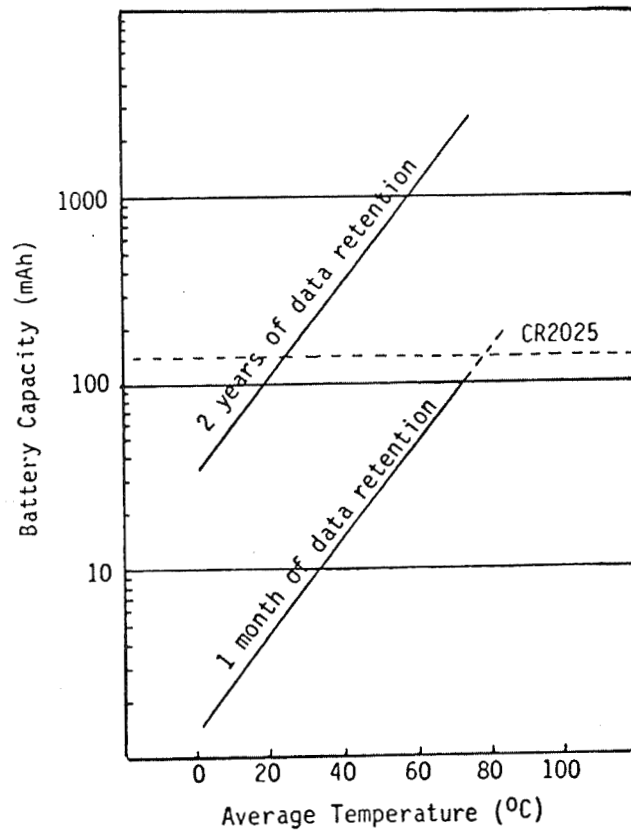


Figure 3. Battery Capacity Required for Data Retention in Eight 1 MBit SRAMs (based upon NEC uPD 431000A).

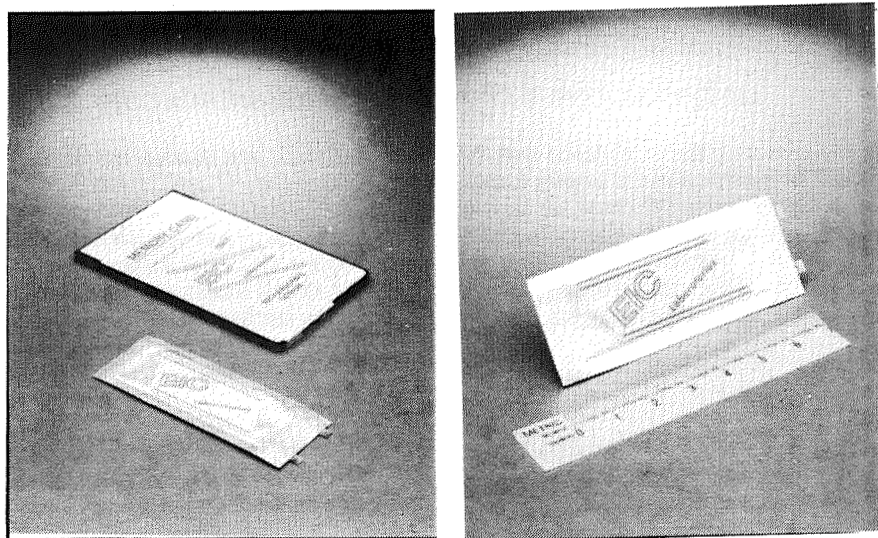


Figure 4. Rechargeable TLOP Cells for PC cards.

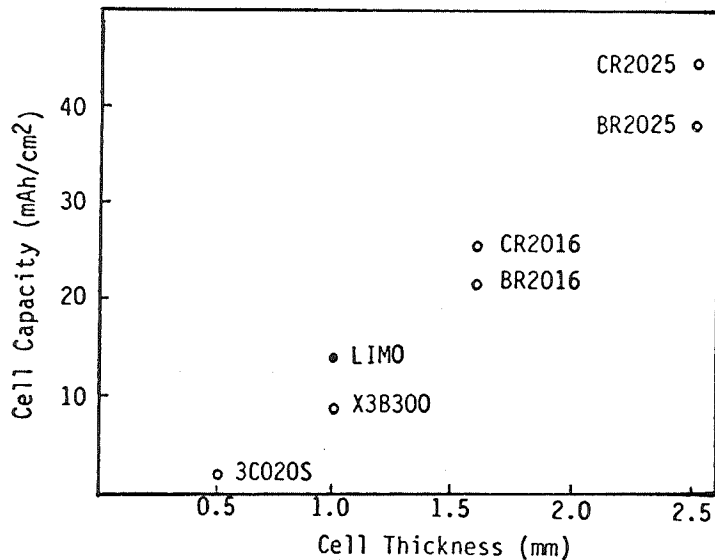


Figure 5. Nominal Cell Capacity per Square Centimeter Versus Cell Thickness for Primary (o) and Rechargeable (●) Cell.

The LIMO TLOP cell has a theoretical capacity of 14 mAh/cm² and can deliver 90% of this capacity at greater than 2 volts over a wide temperature range with loads equal to thirty two TSOP SRAMs. Recharge of the LIMO cell takes place from 3.2 to 3.7 volts and these cells have been charged and discharged more than 100 times with retention of greater than 50% of their initial capacity. Figure 6 is an overlapping series of charge/discharge plots of a LIMO cell. Figure 7 is a cross-sectional view of a LIMO cell.

RECHARGEABLE TLOP CELLS IN PC CARDS

SRAM PC cards with rechargeable TLOP cells, such as the LIMO cell, are capable of being recharged, while in use, from the host computer's power. This results in SRAM PC cards in which battery back-up is automatically maintained from the perspective of the periodic user. The TLOP cell's length and width can be customized for specific PC card applications. For instance a 4.5 by 7 cm TLOP cell could be surface mounted on one side of a PC card's circuit board and sixteen TSOP SRAM could occupy the other side. If this TLOP cell were a LIMO cell it would have a capacity in excess of 420 mAh or more than three times a CR2025 coin cell.

OPTIONAL LOW BATTERY VOLTAGE INDICATOR

To provide the user with the confidence that the battery has sufficient charge, an electrochromic low battery voltage indicator could be mounted in the battery location on the end of the PC card. Prototypes of voltage indicators installed in commercially available PC cards are shown in Figure 8. The indicator would also allow stored PC cards to be visually scanned to insure data retention in a fraction of the time required to sequentially insert the PC cards into a host computer for battery status verification. Electrochromic displays offer the advantage of a nonvolatile display requiring no refresh current. This combination of a rechargeable TLOP cell and an electrochromic low battery voltage indicator will result in SRAM PC cards being entrusted with information storage in applications involving only periodic updating or editing.

CONCLUSION

Solid electrolyte technology now exists which makes possible the manufacture of rechargeable cells with the thickness of TSOP components. These thin large-outline cells, called TLOP cells, can be permanently installed in SRAM PC cards and will free the periodic PC card user from having to "feed" their PC cards with coin cells.

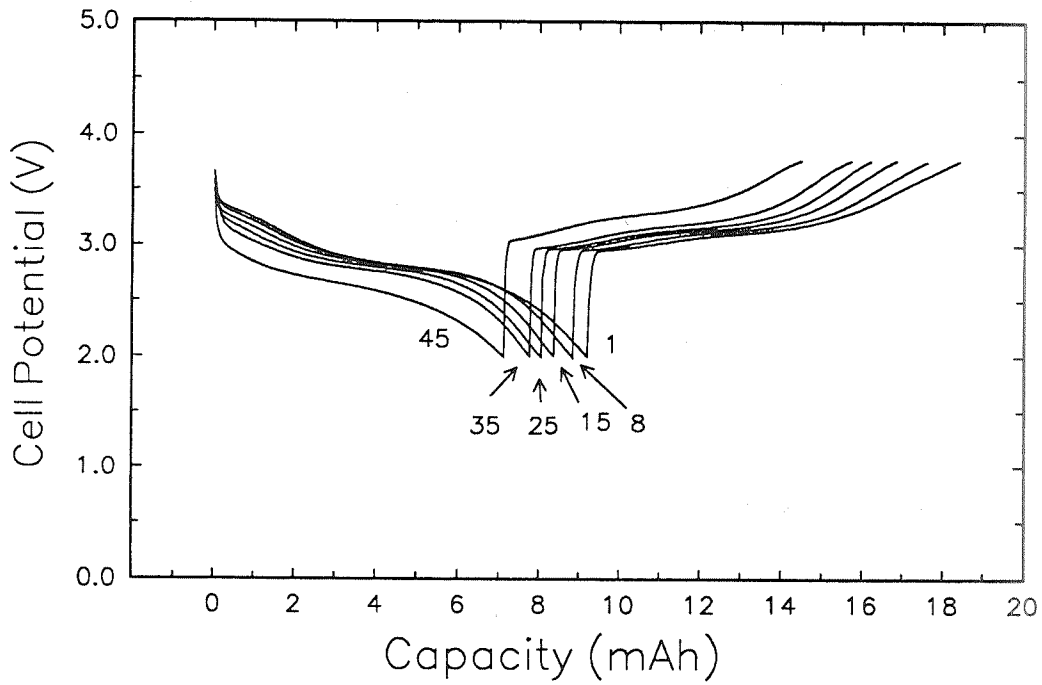


Figure 6. Overlapping Charge/discharge Plots of a LIMO Cell with Cycle Number Indicated.

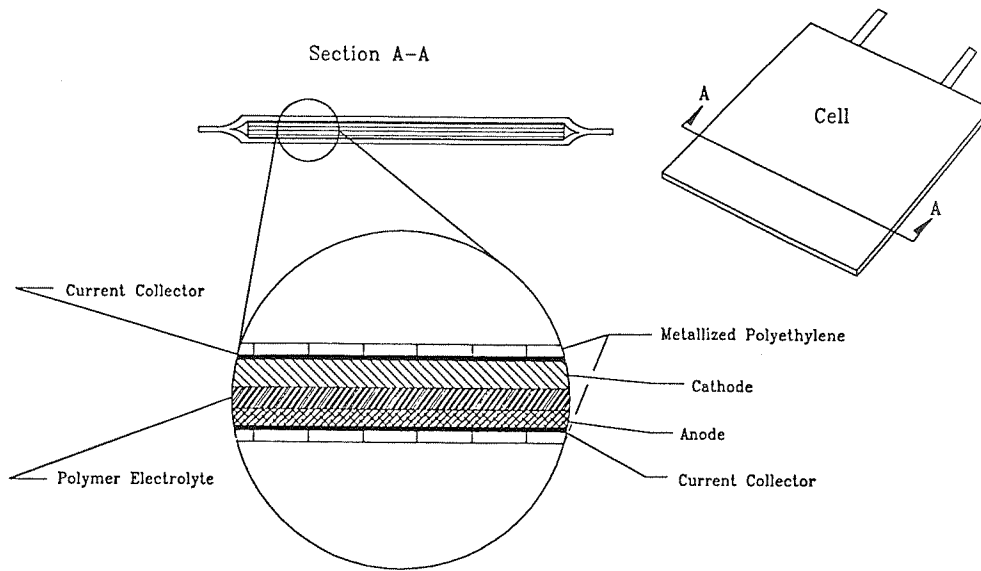


Figure 7. Cross-sectional View of LIMO Cell.

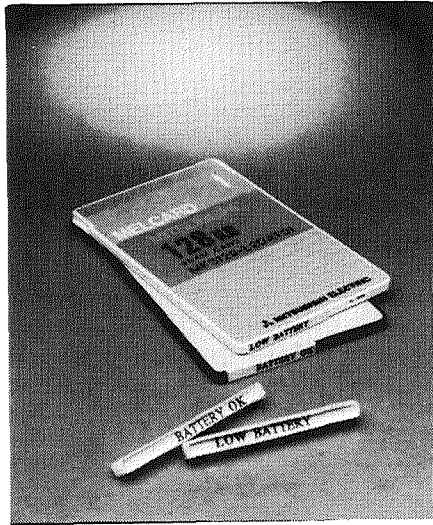


Figure 8. Prototype voltage indicators assembled and installed by EIC Laboratories.