Smart Card Manufacturing

1. SMART CARD ARCHITECTURE

A microprocessor smart card's internal architecture is similar to that of a PC. The familiar building blocks of PC's are present in this type of card: CPU, ROM, RAM, I/O port and EEPROM rather than a disk for storage.

1.1 CPU

The CPU is usually an 8-bit microprocessor with a 16-bit address bus. This makes it possible for this type of card to address up to a maximum of 64 k. The speed of the CPU typically lies in the range 5-8 MHz.

1.2 Random Access Memory (RAM)

The RAM is volatile memory that requires power to maintain the data. It provides working storage for the CPU. The size of the RAM is usually limited to about 256 bytes. The reason for this small size is that RAM takes up more space per byte than EEPROM or ROM and is thus deliberately kept small to meet the specifications for smart card chips, which are limited in area to 25 square millimetres. Accessing data in RAM is much faster than retrieving it from other smart card memory types.

1.3 Read Only Memory (ROM)

The ROM contains the card's operating system and is loaded during the chip production stage. The software loaded is called a ROM mask. It stores a number of resident applications, including the real time operating system. The ROM size can vary from a few kBytes to about 32 kBytes, depending on the operating system functions.

1.4 Electrically Erasable Programmable Read Only Memory (EEPROM)

This is a non-volatile memory that is used to hold all data and programmes, much like a PC's hard disk. The operating system provides file protection by restricting access to the EEPROM. The contents of the smart card's EEPROM are re-writable and are used to store information such as subscriber profiles, passwords, electronic wallets and various files. EEPROM can vary in size and is based upon the needs of the application. Commonly available EEPROM sizes vary from 2 kBytes to 32 kBytes.

1.5 I/O Port

All of the preceding elements are connected to an I/O hardware component called the Universal Asynchronous Receiver Transmitter (UART). The UART is in turn connected to the pins that physically interface with the smart card reader. The I/O port is used to transfer the data in a serial fashion, bit by bit, to and from the smart card. The default speed is 9k6 bits/sec, with some cards able to support higher speeds.

1.6 Co-Processor

More advanced smart cards are provided with a co-processor that performs the exponential and modular operations on integers when processing encryption procedures, for example with digital signatures.

2. MANUFACTURING OVERVIEW

The smart card manufacturing process can be sub-divided into a number of steps:

- Chip fabrication: Performed by a number of vendors such as: Atmetal, Hitachi, Infineon, Philips and SGS Thomson
- Chip module preparation: Prepares the microprocessor in its core 25 square millimetre structure. Integration into a module then takes place.
- Plastic card manufacturing: Prepares the plastic part of the smart card
- Embedding of the chip module into the plastic card: Bonds the chip module to the card to form a smart card

These and related processes are described in the following sections.

3. MICROPROCESSOR MANUFACTURING

The microprocessors for many advanced smart cards are supplied by a number of manufacturers, among them Philips.

The final phase of the chip fabrication process is the modularisation of the silicon wafers into individual chips. The microprocessor vendor then loads each manufactured microprocessor with its ROM code that has been developed by the CA vendor. A serial number and manufacturing information is added to the chip and a fuse is blown to prevent any further changes being written to it.

The microprocessor production time is typically 11 weeks.

4. SMART CARD MANUFACTURING

The smart card manufacturing process is split into two phases:

4.1 Plastics

Several types of plastic are used for smart cards. Each plastic has particular characteristics that need to be taken into account when selecting a particular application. The most widely available and cost-effective material for smart cards is Poly Vinyl Chloride (PVC). The following table summarises the different types of material in current use for smart cards:

	PC	PVC	ABS
Name	Polycarbonate	Poly Vinyl Chloride	Acrylonitrile Butadiene Styrol
Average Life Expectancy (years)	> 10	2-5	4
Environmental Hazards	None	Chlorine compound present	Benzene is a carcinogen
Temperature Range (deg C)	-40 - +120	-5 - +65	-25 - +85
Use	ID Cards	Credit Cards	Mobile Phones
Mechanical Properties	Susceptible to scratches	Poor temperature resistance	Limited colour acceptance
Processing Considerations	Not suited for thermal printing	Versatile	Limited thermal printing suitability
Cost	High	Low	2 x PVC card

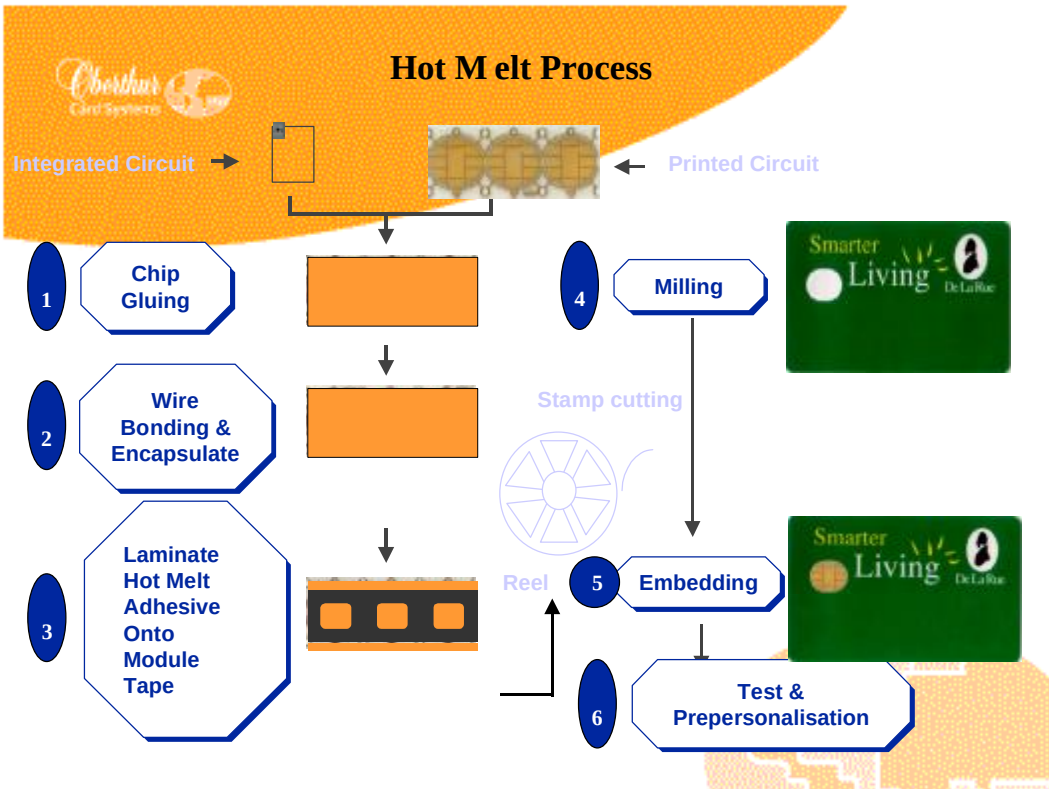
This phase is performed by a number of manufacturers, two examples of who are: Oberthur and Schlumberger. They produce the plastic cards according to the ISO 7816 standard for smart cards. The plastic for smart cards is usually derived from PVC or ABS sheets. The resulting card forms the supporting device for the microprocessor chip. The card manufacturer is also responsible for printing the customer's artwork onto each card, in a silk screening process.
The smart card plastics production process typically takes 6 weeks, provided that approved artwork is available.

4.2 Embedding

In this phase, the microprocessor or chip is mounted onto a plate (the visible gold-coated square) on the finished smart card. The necessary bonding wire connections between the chip and the plate are also made during this process. The completed assembly is known as a module.

The plastic card is next treated to receive the module: for laminated PVC cards, a cavity is milled into the plastic. ABS cards already have this cavity (created during the moulding process). The module is then glued into the cavity in a potting process.

These processes are illustrated overleaf:



A serial number is next programmed into the chip and all cards are electronically tested. Random ISO 7816 sample tests are performed on each manufactured batch of cards. The smart card is then pre-processed to create a so-called "virgin" smart card. Finally, a file is prepared of the serial numbers of all smart cards produced in a given production run.
The embedding phase usually takes 3 weeks.

5. MANUFACTURING TIMELINE

The following table summarises the typical durations of the processes in preparing smart cards for use:

PROCESS	**DURATION (Weeks)**
MICROPROCESSOR PRODUCTION	11
PLASTICS PRODUCTION	6
EMBEDDING	3
SECURITY ELEMENTS PROCESSING	1
NON-SECURITY ELEMENTS PROCESSING	1
TOTAL	22

The lead time for ordering smart cards is typically 16-18 weeks, assuming that all control documentation has been correctly completed.

Manufactured smart cards are usually batched in boxes containing 500 cards. A maximum of 10 such boxes can be contained within 1 shipping carton.