

Consumer Product Opportunities Increase for Chip Makers

Over the next 10 years, most new opportunities for semiconductor vendors will lie in consumer products. Some of the most exciting will be ultra-thin cameras, smart pills and new kinds of personal electronic device.

Semiconductors have been at the heart of electronic products for over 40 years. Semiconductor chips now enable a wide range of products, from PCs and cell phones to digital cameras and airbag systems in cars. The big questions for those involved in the semiconductor industry are: What's next? Which new applications will emerge to expand the range of semiconductor-enabled products? While nobody can answer these questions with certainty, we can identify trends in user requirements and emerging technologies, leading to several future scenarios. We can also identify products to fit these scenarios and examine factors that would push or inhibit adoption. This is the approach taken in this Spotlight.

High-Volume Opportunities Lie in Consumer Goods

Many electronic products that will emerge over the next few years are likely to be targeted at consumers. Music systems, cell phones are the most popular types of personal electronic product today. But this will change dramatically over the next 10 years. For example, smart clothes made from new fabrics will support changing patterns and colors. Teenagers could be walking around with moving images on their T-shirts or fashion logos that change to suit the occasion. These products will require flexible interconnect technologies that are likely to be manufactured using low-cost polymer-based reel-to-reel production technologies. The same approach will be used for many emerging electronic products, including organic light-emitting diode (OLED) and light-emitting polymer (LEP) displays, electronic paper, intelligent labeling and bank notes. Healthcare and medicine are also likely to experience strong growth, with innovative product introductions. Smart clothes with integral sensors could also enable ongoing health monitoring.

Personal entertainment will probably be taken to the next level with the small-size and high-quality images provided by head-mounted and retinal imaging display technologies. Personal area networks will share and route information among users through ad-hoc mesh networking systems.

Camera technology is advancing rapidly through the development of electronically enhanced lenses. This will allow ultra-thin cameras to be made, finding application in many new sensor applications from biometrics to automotive distance sensing. Coupled with a small display, this technology is also likely to find use in smart glasses. In addition to vision correction, these systems would support zooming, night vision and distance measurement. Given the right fashion conditions, this glasses market could be worth over \$1 billion per year.

Where Will the Power Come From?

The systems discussed above will all require electrical energy sources. We expect continued advances in low-power design to result in improved efficiency, but significant portable energy sources will still be

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required. Batteries are often too large and heavy, but battery energy capacity will improve, albeit slowly. Kinetic and bio energy sources currently offer very low energy capacity and are unlikely to be developed within the next 10 years. Micro fuel cells offer an alternative power source for mobile devices and could provide 10 times the energy capacity of lithium-ion batteries (see "Micro Fuel Cells Power Mobile Devices"). Working prototypes have been demonstrated and production is expected in 2005. Mass rollout first requires infrastructure issues to be solved. For example, customers must be able to find stockists for fuel cell cartridges. We believe it will take up to 10 years before fuel cells are widely used.

Products Get Even More Personal

Another area of personal electronics is the smart ID. Fears of security, terrorism and illegal immigration will drive the slow adoption of smart ID cards containing biometrics and securely encrypted personal data. Such systems, probably based on smart card and radio frequency ID (RFID) technologies, could generate semiconductor revenue of almost \$1 billion annually.

Smart pills that can be swallowed or embedded under the skin will be developed. These will facilitate diagnosis through image and chemical analysis. They will also be able to dispense several different medications, making them appropriate for elderly people who forget to take specific types of pill at set times. Later generations of these pills will synthesize drugs from basic chemical components, bringing significant economic benefits to the pharmaceutical industry. We estimate that a market will exist for at least 2 billion smart pills per year by 2015.

Home Entertainment Systems and White Goods

Home entertainment will undoubtedly increase in popularity. Though music and video distribution systems are changing, the real boom in digital content will not happen until home appliances have been standardized to allow interoperability, especially between PCs and consumer electronics equipment. But content owners will resist this, requiring strong safeguards of their intellectual property. Resulting home entertainment systems will need end-to-end encryption for copyrighted material across the range of media types; for example, CD, DVD, wired, wireless and hard drive. The algorithms for these future encryption schemes will evolve over time. One thing is clear: they must be able to be corrected quickly if security is cracked. This suggests some form of downloaded functionality that can be updated during the lifetime of the equipment.

The world is experiencing increased energy problems beyond those experienced in portable systems. The undercapacity of many of the developed world's power systems is well known. Non-renewable energy reserves will continue to be depleted, leading to increasing energy costs. This will drive the demand for electronic products that consume less energy. Applications include washing machines that clean at low temperature and without water and cookers with integral microwave accelerators. New home appliances will monitor health and save valuable time. These are powerful drivers that will push the technologies into widespread use.

Workplaces and the Wider Environment Set for Change

The work environment will also see great change over the next 10 years. More automation of physical labor will occur, requiring instrumentation, sensors and distributed intelligence. But this will not be evenly distributed across all work types because economy of scale will be a main requirement. Technologies that eliminate the need to travel will also grow in importance. We expect to see major growth in applications such as advanced videoconferencing (with "virtual avatars" of remote participants), remote field service and telemedicine. Personal productivity will be addressed through speech recognition and possibly

through intelligent desktops that connect to PCs and large displays on walls dividing workstations. Employees are also likely to carry more instrumentation for ID purposes and building access, as well as stress-level sensors, for example.

The wider environment will also see many changes over the next several years as “ubiquitous computing” takes off. Intelligence will be built into our cities, typified by security cameras that are capable of automatically assessing security threats and other crimes. Buildings and bridges equipped with arrays of sensors will be able to detect structural stresses, fire and intruders. Shopping areas will become “aware” of who we are and which products we prefer. Cars and highways will make growing use of processor-based intelligence for safety, entertainment, navigation and traffic control. Buildings and people at large public gatherings will be screened for explosives and chemicals through sophisticated sensors and behavior analyzers.

New Technologies Will Be Needed

The products and environments outlined above will need semiconductors and related devices that are more advanced than those available now. Many will evolve from today's devices along the progression laid out in Moore's Law. Other technologies of particular note are micro-electromechanical systems (MEMS), electronic system-level design tools, embedded programmable logic, micro fuel cells, LEPs and OLEDs. For further details, see “New Openings as Semiconductor Innovation Sets the Pace”.

Bottom Line

A large number of products enabled by semiconductors will emerge over the next 10 years. Consideration of these leads to the following observations:

- Following a trend of the past several years, an increasing number of these emerging products will be purchased by consumers rather than enterprises or governments. By 2013, 50 percent of semiconductors will be bought for use in consumer products (0.8 probability). This compares with approximately 40 percent today.
- The overall value of all products discussed will not have an overwhelming impact on the semiconductor industry, despite several high-volume categories. No up-and-coming application comparable to the PC and cell phone and their derivatives has been identified. The big opportunities of the next 10 years are in complete systems that combine IP and systems knowledge, not in chips alone. Semiconductor vendors must therefore refocus their businesses from silicon to systems.
- The end of Moore's Law for bulk silicon will be in sight by 2013. Vendors and immediate users of semiconductors must plan for the use of next-generation semiconductor technologies such as molecular transistors. System design knowledge using these technologies does not yet exist, suggesting large rewards for those organizations that can develop it. Large-scale industry restructuring is likely in view of these changes.
- Most of the emerging product opportunities need considerable economy of scale to drive cost reductions. Integration beyond semiconductors will play a role in this cost reduction with biochemical, chemical, mechanical and optical integration.

- Interconnection and communications are a theme of most of the products identified. It is likely that communications and other services will represent a larger market than the individual products.

Features

“Personal Devices Get Intimate in Smart Clothes and Handbags” — Personal electronic products will grow, but only when usability problems are solved. **By Nigel Deighton**

“Thinner Cameras to Drive Mass Applications” — New image processing techniques will enable thinner cameras for a wide range of applications. **By Martin Reynolds**

Smart Cards, Smart IDs and the Semiconductor Industry — Smart IDs offer considerable growth opportunities for the coming decade. **By Martin Gilliland**

“Smart Pills Could Prove Sweet for Semiconductor Vendors” — Smart medication pills could develop into a large “disposable electronics” market of over 2 billion pills per year by 2015. **By Jim Tully and Serena Hsu**

“CE and PC Industry Cooperation Brings the Digital Home Closer” (<http://www.gartner2.com/rpt/rpt-0803-0070.asp>) — The digital home will only become a reality after the development of true interoperability standards. **By Van Baker**

“New Lifestyles Drive Innovative Home Electronics” — Innovative products will enter widespread use in the home to the benefit of our health and time. **By Dorothy Lai and Hiroyuki Shimizu**

“Future Work Sites Will Generate Semiconductor Growth” — Automation and communication will underpin new opportunities in the workplace. **By Jackie Fenn**

“Hundreds of Small Steps Lead to Ubiquitous Computing” — Increased intelligence in the environment around us will improve our security and convenience. **By Alexander Linden and Martin Reynolds**

“Radio Frequency ID’s Evolution to Smart Dust” — Magnetically coupled power could drive a new range of RFID-enabled products. **By Martin Reynolds**

Recommended Reading and Related Research

“Micro Fuel Cells Power Mobile Devices” — Micro fuel cells are set to satisfy the needs of power-hungry mobile devices. **By Jim Tully and Rafe John Graham Ball**

“New Openings as Semiconductor Innovation Sets the Pace” — Semiconductor technology is adapting to consumer demands, with smaller companies showing the way. **By Jim Tully**