Challenges for Semiconductor Manufacturing in Brazil

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Abstract
Semiconductor component design and manufacturing imposes a severe barrier to the further development of the Brazilian electronics industry. Several challenges to be faced to enable the settlement of semiconductor manufacturing facilities, such as human resources shortage, lack of a supply chain and market access, are identified. As a consequence, nowadays semiconductor manufacturing activities are neither economically nor technically viable. To start changing this scenario, a comprehensive initiative involving industry, government and academia is proposed.

1. Introduction
This paper discusses the challenges for developing the semiconductor manufacturing industry in Brazil. First an overview of the present status of the sector is given. Different aspects are addressed, such as market, human resources shortage, lack of a local production chain, and existing barriers for client and supplier development. Based on the present scenario of the local and global semiconductor manufacturing industry, an approach for fostering the development of the sector in Brazil is proposed.

2. Brazilian Semiconductor Sector
Nowadays, there are virtually no semiconductor design and manufacturing activities in Brazil, and nearly all components used by the electronics industry are imported. In the year 2000, semiconductor component imports totaled more than US$ 4 billion, representing 2% of the worldwide semiconductor sales, while local production amounted barely US$ 80 million. In 2001, the import of semiconductor components not mounted on boards or in finished products is projected do jump from US$1.9 billion in 2000 to US$2.4 billion. They are expected to be incorporated to information systems (56.8%), telecommunication products (23.9%), automobiles (10.3%) and consumer electronics (8.9%) [1].

Global sales reached an all-time record high of US$204 billion in the year 2000. The Americas being the largest market region (30.5%), followed by Asia Pacific (24.1%, including China), Japan (23.9%) and Europe (21.2%) [8].

<table>
<thead>
<tr>
<th>Table I: Brazilian Semiconductor Imports in year 2000 (in US$ millions) [2]</th>
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<tbody>
<tr>
<td>Semicond. Components</td>
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<tr>
<td>Semicond. on Assembled Boards</td>
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<tr>
<td>Semicond. in Finished Products</td>
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<td><strong>Total</strong></td>
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Today local Brazilian semiconductor manufacturing is limited to a few small companies in the power semiconductor components sector, such as Semikron and Aegis, but there is no local
integrated circuits production. These firms supply local companies, mainly in the automotive and UPS (no-break) sectors, and export small quantities, but the total revenue is quite small (approx. US$ 20 Million in 2000). There is also a small producer of solar cells (Heliodinamica). Other local manufacturing activities are restricted to back-end processes, such as packaging and testing of memory modules [1], as that done by Itaucom company.

Table II: Semiconductor Component Imports in 2001 (projection, US$ millions) [1]

<table>
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<tr>
<th>Component</th>
<th>Value</th>
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<tbody>
<tr>
<td>Information Systems</td>
<td>1,370</td>
</tr>
<tr>
<td>Telecommunication</td>
<td>578</td>
</tr>
<tr>
<td>Automotive</td>
<td>249</td>
</tr>
<tr>
<td>Consumer Electronics</td>
<td>214</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,411</strong></td>
</tr>
</tbody>
</table>

On the other hand, the Brazilian semiconductor market is expected to surpass the US$ 7 billion mark in 2005 [2]. This makes up a long term structural deficit, not subject to monetary fluctuations, since there are virtually no local production facilities, and electronics demand is continuously growing.

Not only is there deficit in the commercial balance for electronic components, but the local market itself is underdeveloped. Companies in the electronics sector usually do not develop ASICs to incorporate extra value into their products. This has a negative impact on the overall competitiveness.

The very few integrated circuits designed in Brazil are ordered and used by foreign companies in foreign markets, as it is successfully done by Motorola design center in Brazil.

The opportunity for semiconductors is related to the development of the electronics sector as a whole. Stimulating the incorporation of ASICs in products without stimulating local design and manufacturing of these components will boost the commercial deficit and limit the long term prospect for several business, imposing a severe penalty to the nations economy.

For the short term, local design of integrated circuits with international quality standards should be sought. Support for incorporation of such integrated circuits in products of the electronics industry must also be provided. For medium and long term, other actions to consolidate the basis for the attraction or development of a production facility (foundry) should take place. This paper focuses on the long term goal.

The trend in the global semiconductor market suggests that in mainstream process technology only high capacity, multi-billion dollar production facilities will stay competitive. For instance, the annual 2001 survey of the Fabless Semiconductor Association (FSA) emphasizes the dominance of the three major pure-foundry players: Taiwan Semiconductor Manufacturing Co. (TSMC), United Microelectronics Corp. (UMC), and Chartered Semiconductor Manufacturing. Together they are expected to process more than 75% of the wafers demanded by fabless chip companies in 2001 [3].

Theoretical models also show that larger foundries working on 12 inch wafers are economically more viable than smaller ones, suggesting that facilities with planned capacity not smaller than 20K-wafer starts per month (ws/mo) should be chosen[4]. 20K ws/mo is a huge amount, considering the present demand of the Brazilian ASIC market.

Furthermore, the lack of a local supply chain for the semiconductor industry burdens consumable and maintenance costs, imposing an obstacle for the settlement of production facilities.

Another barrier is the lack of qualified personnel. According to
estimates of the Brazilian Ministry for Science and Technology (MCT), until the middle of 2000 there were only 176 persons with M.Sc or PhD degrees in microelectronics in Brazil. We feel the estimate is conservative, but there is no doubt an urgent need exists for an effective governmental policy concerning the issue of human resource shortage in an area crucial to the Brazilian economy.

Nowadays, precise and detailed data related to the Brazilian semiconductor market is not available or is very difficult to be retrieved. So, a market study for the Brazilian semiconductor components market is also demanded. Furthermore, there are no clear governmental policies for the sector.

3. A Brazilian Initiative for the Sector
Considering the present status of the semiconductor components sector in Brazil, discussed above, one would have to conclude that the settlement of a manufacturing facility is neither economically nor technically viable. To change this scenario, an initiative covering the different aspects of semiconductor manufacturing is demanded.

The initiative should include:

- Program to Qualify Human Resources
- Research and Development (R&D)
- I.C. Prototyping
- Client Development
- Support Supply Chain Development

Due to its multidisciplinary and comprehensive character, to be successful such an initiative has to be a collaborative work between industry, government and academia. The institutions involved should build up a nationwide structured collaborative network. In this high-technology and highly competitive industry, isolated initiatives, such as fiscal incentives, can not be successful. Studies show that subsidizing infrastructure or education is by far more effective than simply subsidizing firms[9].

Brazilian universities and research centers already have facilities for human resources qualification and R&D, although some of them are suffering from budget shortage and need some maintenance to become fully operational. These facilities should receive investments, in order to be able to develop their work properly.

Nowadays, prototyping is not available in Brazil. Prototyping is important, because it gives an opportunity to develop new devices and microstructures, which can be done only with a close interaction between electronic system designers and silicon processing specialists. Prototyping also establishes a link between the research community and industry, assuring that R&D critical to the growth of the technology industries will be developed, and not only in areas of interest to academia. In addition, prototyping is a proof of competence, showing local expertise mastering all steps involved in semiconductor production, from design to manufacturing. So, the construction of a prototyping facility should be considered.

To optimally outsource the investment in the prototyping facility, avoid obsolescence and help the initiative to accomplish its mission, the center offering prototyping should also develop research projects in areas of interest common to both academia and the industry. In fact, the process stability required for CMOS VLSI prototyping is not compatible with the flexibility demanded by research work.

Therefore, this center should house two work areas: besides the main cleanroom, to be used for prototyping, the center should include an area for research and process development. Besides equipment specific for research and
process improvement activities, some equipment installed in the main clean room should be duplicated in this area (the equipment with critical requirements referring to process stability and therefore inadequate for research and training courses). In the case of process improvement activities, when the process developed in this lab is mature, it can possibly be transferred to the main cleanroom and incorporated to the technology used in prototyping.

The area for R&D can be smaller and simpler than the area used for prototyping, with less stringent constraints regarding clean air quality and clean room layout. Using this approach, the inclusion of the area for R&D would not burden construction cost significantly, but represent valuable space for R&D and activities demanded for process upgrade.

The prototyping facility should be a multi-user center, operating in network with associated institutions, to offer industry and academia integrated systems design and prototyping, besides development of semiconductor process technology steps, new materials, and development of integrated electronic devices and their microstructures.

For faster technology acquirement and facility implementation, it is desirable to establish a partnership with a player that can provide access to a base-line technology, that will serve as a starting point. Due to its flexibility and market dominance, a CMOS-Process should be chosen.

Besides technology transfer, the association with this partner can also bring political benefits. If the partner is a major and well-known player in the semiconductor industry, the partnership will also help exposing the initiative through mass communication media (TV, newspaper, radio, etc.), which is important to the governmental instances supporting the initiative.

Ideally, this technology transfer should include: i) support during cleanroom design, construction and certification; ii) operator training; iii) a full tool set for running a CMOS-Process; iv) process flow specification; v) support during process integration (including process recipes and tool qualification). If possible, a technical liaison should assist the first runs, for fast clearance of problems related to process flow, tool qualification, contamination or tool operation.

This process should serve as a base-line for prototyping and for developing new process technology, devices and microstructures. Thus, it does not have to be a state of the art process. A 0.8µm or 0.5µm CMOS-Process should be well suited for the beginning. Through its activities the center should be able to upgrade the process. A state-of-the-art process would be too expensive and is not mandatory at this stage. It is preferable to start with a base-line process and upgrade it according to market opportunities, like exploiting market niches or developing partnerships with global players for research projects.

Flexibility is a key word. It may take two to three years until the facility starts up. In the meantime the market may change significantly. Technology will certainly change during center life-time. This re-enforces the choice of a flexible base-line process, like a sub-micron CMOS process.

Strategic sectors where the center can be globally competitive have to be identified. For low-volume and high-variety production circumstances such as

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1 Mechanical / Electrical / Plumbing / Process (MEP) system components represent approx. 75% of facility cost. This infrastructure can be shared by both cleanrooms.
application-specific integrated circuit (ASIC), meeting due dates is very important and difficult, because wafers are processed in very small volume in adverse product mix[5,6]. The lack of a supply chain will add further problems to keeping a small turnaround time.

There is no market window for a Brazilian mass producer with a small number of product types, such as microprocessors and memory, where production capacity can be scheduled based on demand expectation. Furthermore, such production facilities demand high investments and a large number of engineers and technicians.

Hence, at start time, suitable market niches have to be sought. Projects that match demands with qualification of local human resources should be favored. There is local expertise in many key sectors, such as low-power, SIMOX, smart power and alternative dielectrics, among others. A key advantage of having local production, even in small scale, is the possibility to exploit tight cooperation between design team and process engineers, preferentially where mass production is not a key to economical success, but innovative product development support is the key to start new business. These activities should include partnerships with industrial and scientific centers worldwide, seeking global competitiveness and outsourcing. Multidisciplinary R&D projects, as for development of devices and products for the bio-medical industry could also be considered.

Given the current global reshaping of the fab business around very large and few megafabs, it is possible to make a case for small production facilities as the most viable, both technically and economically, to support new, innovative design houses, especially for those new and small volume applications not served by the large mainstream industry.

An important issue is funding. As stated above, nowadays a prototyping center can not be globally cost-competitive if settled in the Brazilian environment. Furthermore, the related cost of ownership is very high[7]. Thus, long term support from organizations and enough funding for the first years of operation should be provided. If this is not assured, there is a high risk that the initiative will get insolvent before it has a chance to change the Brazilian environment.

Through its activities, the initiative should foster client development. As discussed above, the Brazilian electronics industry usually does not develop ASICs for incorporation in its products. Supporting potential clients will help establishing a basis for the semiconductor industry development, besides improving the competitiveness of the electronics sector. Activities for client development should include support during design phase, such as training on CAD-Tools, on design methodology and making CAD-Tools available to the industry, as well as offering prototypes with reduced cost (subsidized).

If possible, the initiative should also include activities for fostering the development of a production chain. This is the most difficult challenge, because there is no demand outside the semiconductor industry for the chemicals and services involved in semiconductor production. Nevertheless, three of the major gas suppliers for the semiconductor industry worldwide (Air Products, Praxair and Linde) do have production plants in Brazil and do offer support services, although serving other industries, like the chemical and pharmaceutical sectors.
4. Conclusion
Several barriers to the development of the semiconductor industry in Brazil are identified. A nationwide initiative to develop the electronics industry as a whole, including human resources qualification, research and development (R&D) activities, prototyping and client and supplier development is proposed.

Such an initiative is judged to be urgent and a *sine qua non* step for the development of the sector.

The study of the challenges for semiconductor manufacturing in Brazil must be continued and a detailed study on market opportunities is demanded. This paper is intended to be a thought-provoking contribution to the discussion.

5. References