# Chapter 10
# Micro- and Nanoelectronics in Romania from an international perspective

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## 10.1. INTRODUCTION: THE BIRTH OF THE SEMICONDUCTOR INDUSTRY

Micro- and nanoelectronics appeared and developed primarily through industrial research. The transistor effect that constitutes the foundation of the industry was a serendipitous discovery during a detailed study on the conductive properties of Germanium - a semiconductor material - conducted in 1947 at the *Bell Telephone Laboratories, Inc.*, an organisation whose ownership was evenly split between the *Western Electric Company* and the *American Telephone & Telegraph Corporation* (AT&T)[1].

The resulting device, the transistor, has been industrialized without delay, both by electronic equipment manufacturers, for their own use, and also by the producers of vacuum tubes (both electric bulbs and electronic valves) who understood that their technology would eventually be replaced by semiconductors (the valves almost immediately, the bulbs … nowadays)[2]: for example, in 19949 Motorola started a semiconductor research facility in Phoenix (Arizona), in 1952 CBS-Hytron was manufacturing considerable volumes of germanium-based devices in Lowell (Massachussetts), in 1953 General Electric built the first military-grade transistors, the *Germanium Products Corporation* (GPC) was the first to offer transistors commercially finding customers among the hear-aid manufacturers in 1952/53, Philco started supplying high frequency transistors for the computers of the National Security Agency and the United States Navy etc.[3]

[1] https://en.wikipedia.org/wiki/Bell_Labs#Origin_and_historical_locations
[2] http://www.transistormuseum.com
[3] Wikipedia in English: *Philco.*

Similar research took place in the same period of time in Europe, where Herbert Mataré and Heinrich Welker, working in the Westinghouse subsidiary in France, built in June 1948, independently from the Bell Labs, a point-contact transistor (called „transistron” in their patent disclosure). Mataré went on founding in 1952 in Germany the Company INTERMETALL that exhibited IFA Düsseldorf in 1953 the first transistorised pocket radio.[4]

The commercial use of the transistors increased dramatically in response to the demand from the manufacturers of switch boards and military computers (1952), hear aids (1953), portable radios (1954) etc. In 1953 about 1 million transistors have been sold, by 1957 the market consumed about 30 millions.[5]

Several ideas have been put forward as to how to build several transistors in the same semiconductor crystal and interconnect them to make electronic circuits. It is generally accepted that the „integrated circuit” has been invented in 1958. This is the birth certificate of microelectronics. The name indicates that the transistors themselves had elements with dimensions in the range of a few micrometres; today, the advanced technologies build transistors with dimensions in the order of magnitude of 10nm, therefore the name was changed to nanoelectronics.

U.S.A. west coast universities, in particular the University of California at Berkeley and the Stanford University, became the focal point of academic research in semiconductors and engaged from the very beginning in a close cooperation with the numerous start-ups that established a vibrant industry in the San Francisco Bay area. For the next more than half a century, this area, known as the U.S.A. *Silicon Valley*, represented the centre of gravity of the semiconductor industry.[6] The sustained research taking place primarily in the industrial companies experienced frequently the highest research intensity, as a percentage of sales, from al industrial branches. This generates an unparalleled flux of innovation continuing uninterruptedly up to now. It is a specific characteristic of this industry.

## 10.2. ELECTRONICS IN THE SOVIET UNION

To understand the evolution of this industry in Romania it is useful to remember that fact that in the period under consideration the dominant power in the region was the Soviet Union. The Soviet Union was active in electronics almost from its inception. The victory of the Bolshevik revolution in Sankt Petersburg has been

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[4] See note 2.
[5] See note 3.
[6] Hoefler, D., *Silicon Valley in the USA*, Electronic News, January 11, 1971.

telegraphed on 12 November 2017 in the whole country and abroad.[7] Radio broadcasting started in 1921. V.I. Lenin recognized immediately the impact of this technology on propaganda and declared: „Every village should have radio! Every government office, as well as every club in our factories should be aware that at a certain hour they will hear political news and major events of the day. This way our country will lead a life of highest political awareness, constantly knowing actions of the government and views of the people…"[8]

It is therefore understandable that the soviet government undertook important investments in developing and disseminating radio technology, although the theory was putting the accent on the heavy, machine building industry. In 1922, Moscow had world's most powerful radio broadcasting station and it was the first one to start short wave broadcasting.[9] Mechanical TV was initiated in 1931[10] and electronic TV in 1937 – initially using RCA equipment imported from U.S.A., soon to develop own products. The Second World War interrupted the progress, but the activities have been restarted immediately after the war. Soviet technologists invented the 625 lines / 50 Hz standard and used it in broadcasting starting from 1948 - before being adopted by CCIR[11] as an international standard.[12]

## 10.3. ELECTRONICS AND MICRO/NANOELECTRONICS IN ROMANIA UNTIL 1989

The first companies building electronic equipment have been started in Romania between the two world wars. Radio broadcasting has been started on 1 November 1929 by the Radio-telephonic Broadcasting Company (*Societatea de Difuziune Radio-Telefonică*). In 1941 se there are three registered radio receiver manufacturers: *AFA Arad*, *Iron Arad* and *S.A.R. Philips* in Bucharest. They stop manufacturing during the war because it was impossible to import piece parts. At the end of the war, the activities restarted at a low level, but the industrial evolution took a peculiar trajectory as the iron curtain fall on Europe.

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[7] Julian Hale, Radio Power, Paul Elek, London, 1975, quoted in https://zeltser.com/early-stages-radio-broadcasting-history/#ussr.

[8] B.H. Rujnikov, *Tak Nachinalos*, Iskusstvo, Moscow, 1987, p.169, quoted in https://zeltser.com/early-stages-radio-broadcasting-history/#ussr.

[9] Julian Hale, *Radio Power*, Paul Elek, London, 1975, p. 17, quoted in https://zeltser.com/early-stages-radio-broadcasting-history/#ussr.

[10] https://en.wikipedia.org/wiki/Timeline_of_the_introduction_of_television_in_countries.

[11] *Comité consultatif international pour la radio, Consultative Committee on International Radio or International Radio Consultative Committee.*

[12] *M.I. Krivocheev – an engineer's engineer*, EBU Technical Review, Spring 1993, p. 27.

On 11 June 1948, the main „means of production" – that included the main industrial companies - have been nationalized. *S.A.R. Philips* has been merged with *Radiomet*, *Starck* and *Tehnica Medicală* to form the new state owned company *Radio Popular*, that starts selling in 1949 a radio receiver, code name *S49U Record*, using designs and piece parts from the Soviet Union.

Romania adopted the planned economy, launching up to the end of 1989 one six-year plan and seven five-year plans. A few elements of interest for this discussion are presented below, without intending to be exhaustive (the entries related with the micro/nanoelectronics are highlighted in bold letters):[13]

1. 1951–1955. *Radio Popular* manufactures radio receivers with piece parts imported mostly from USSR, Czechoslovak Republic, Hungarian People's Republic or German Democratic Republic; it started manufacturing mechanical piece parts, magnets, chemical potentiometers, coils and capacitors for its own use.
2. 1956–1960. The TV is introduced in 1956, about in the same time with the other European countries (e.g., after The Netherlands, Germany, Czechoslovakia, UK – Northern Ireland and Italy, but before Finland, UK – Wales, Bulgaria and Ireland).[14] In 1960, *Radio Popular* becomes *Uzinele „Electronica"* following an Order of the Ministry of Heavy Industry (*Ordinul Ministerului Industriei Grele nr. 760.150*).
3. 1961–1965. The radio receivers are modernized; *Electronica* receives funding and engages considerable investments, it starts manufacturing transistors, semiconductor diodes and new capacitors; it introduces radio receivers using its own design with a bill of materials with 96% of Romanian components produced in Romania.[15] In 1961, it starts manufacturing black-and-white (BW) TV sets upon a CSF license and in 1964 introduces colour TV sets. **Following the Decision of the Council of Ministers from 12 mai 1962 (*Hotărârea Consiliului de Miniștri nr. 438 din 12 mai 1962*), the department producing components at „Electronica" is spun off as the Enterprise for Radio Components and Semiconductors *(Întreprinderea de Piese Radio și Semiconductoare – IPRS Băneasa)*. *IPRS Băneasa* acquires French and German licenses for discrete devices (diodes, transistors, thyristors)**.
4. 1966–1970. Radio receives and TV sets made in Romania are exported in Germany. Further companies are established: the Enterprise for Metrology Equipment and Industrial Electronics (*Întreprinderea de Aparate Electronice de Măsură și Industriale - I.E.M.I*) in 1968; the Ferrites Factory Urziceni (*Fabrica de Ferite Urziceni - F.F.U.)* in 1969 using Plessey licenses; the Computer Factory FELIX (*Fabrica de Calculatoare*

[13] http://proradioantic.ro/index.php?x=articole&id_stire=66.
[14] https://en.wikipedia.org/wiki/Timeline_of_the_introduction_of_television_in_countries.
[15] http://enciclopediaromaniei.ro/wiki/Radioreceptoare_românești.

*Electronice FELIX - F.C.E. FELIX*) in 1970 using licenses from FRIDEN and CII. Likewise, the research and development is strengthened through the Computing Technology Institute (*Institutul pentru Tehnică de Calcul* - ITC) and **the Research and Design Center for Electronic Components (*Centrul de Cercetare Proiectare pentru Componente Electronice -* CCPCE) attached to *IPRS Băneasa***.

5. 1971–1975. In 1972 the Council of Ministers decides the establishment of further companies: *Tehnoton* Iaşi for consumer electronics and professional communication equipment; and *Conect* Bucharest for connectors, switches, mechanical piece parts and electronic manufacturing equipment. The export of radio receivers increases from 6.100 units in 1966 to 225.753 units in 1973.[16] Radio receivers are exported in U.S.A., Yugoslavia and France, TV sets in Germany, Albania, Morocco, Greece, Senegal, Lebanon and Jordan. On 1 January 1973, following the decision of the Council of Ministers, the departments building passive components of *IPRS Băneasa* are spun off as the Enterprise for Passive Electronic Components (*Întreprinderea de componente electronice passive - ICEP Curtea de Argeș*). **In 1974, *CCPCE* becomes the Research Institute for Electronic Components (*Institutul de Cercetări pentru Componente Electronice - ICCE*) involved, among other topics, in the development of p- and nMOS processes for memories and logic ICs as well as in analogue ICs (operational amplifiers). *IPRS Băneasa* starts manufacturing TTL (Transistor-Transistor Logic) integrated circuits (ICs), upon a SESCOSEM license, for third generation computers and industrial automation. TV manufacturing will be based on ICs produced in Romania**.
6. 1976–1980. The government launches the first Special program for consumer electronics (*Program special pentru Bunuri de Larg Consum electronice*). TV sets are exported in Germany, Austria, Israel, Morocco, Switzerland, Ivory Coast, Polish People's Republic, United Kingdom, The Netherlands and Czechoslovak Socialist Republic. *ITC* launches the minicomputer „The Independent" built using TTL- ICs that will be exported in several COMECON countries and China, remaining in production till 1989. ***ICCE* opens a micro-factory in 1979. *IPRS Băneasa* develops in-house and manufactures analogue ICs for TV sets and for general use (operational amplifiers, voltage regulators, sensors etc.)**.[17]
7. 1981–1985. The government launches the second Special program for consumer electronics. The Enterprise for Industrial Electronics

[16] See note 13.

[17] Vătăşescu, A., Bodea, M. (ed) *Circuite integrate lineare* (4 vol), Ed. Tehnica, Bucuresti, 1979, 1980, 1984, 1985.

(*Întreprinderea de Electronică Industrială I.E.I.*) is spun off from *Electronica*, which continues providing TV seta (BW and colour), radio receivers, amplifiers and boxes, spares as well as technical assistance and service. Exports go to The Netherlands, U.S.A., France and Switzerland. **The company Microelectronica (*Microelectronica*) is established on 1 July 1981 to manufacture MOS (Metal-Oxid-Semiconductor) ICs. *IPRS Băneasa* develops and introduces LSI (Large Scale Integration) ICs ad microcontrollers in I2L (Integrated Injection Logic) technology**.

8. 1985–1989. *Electronica* is chartered to coordinate the third Special program for consumer electronics. Transportable TV sets are exported to The Netherlands, Germany and France. **In 1988, *Microelectronica* manufactures Z80 microprocessors and 16k RAM (Random Access Memories)** used, among other applications to build Home Computers at *F.C.E. FELIX*.

As seen above, the micro/nanoelectronics entities include the industrial manufacturers *IPRS Băneasa* and *Microelectronica*, and the research institute *ICCE* that was also operating a mini-factory. Investments planned and executed over 40 years resulted in an electronics ecosystem (including the micro/nanoelectronics) that in 1989 had 33 entities, industrial companies and research institutes, with approximately 15,000 – 20,000 employees.

In addition, there are higher education programmes at several Universities throughout the country (in Bucharest, Timişoara, Cluj-Napoca, Braşov, Iași) and a large number of high schools with technical profile as well as vocational training centres. An example for the latter is the Electronica Education Group (*Grupul Şcolar „Electronica”*) with a very large campus composed of 11 buildings, one of the largest in Romania, that had in 1981 more than 4,000 students admitted by examinations with an acceptance rate of 12.5% - 33%.[18]

## 10.4. AN ASESSMENT OF THE ROMANIAN MICRO/NANOELECTRONICS IN 1989

Undoubtedly, over about 40 years, Romania was able to make progress and create an ecosystem with all necessary functions: an industrial infrastructure vertically integrated along the whole value chain, including manufacturers of electronic components (discrete and integrated, active and passive) and equipment (consumer - radio receivers, TV sets, computer, industrial automation), as well as service providers; academic and institutional research and development facilities; and an education system

[18] http://www.proradioantic.ro/index.php?x=articole&id_stire=200.

producing quality talent in sufficient numbers. This ecosystem implemented a few ideas that became widely accepted in modern times; for example, the innovation took place in mixed manufacturing/research facilities (*lab-fab*): the institutes operated mini-fabs, and the companies innovated in their own manufacturing lines.

From our perspective it is very difficult, perhaps even impossible to assess the global positioning of the Romanian micro/nanoelectronics in 1990, although we do not rule out completely that specialists in economy may be able to overcome the numerous difficulties. Enough to say that usual metrics - sales number; profitability; cash flow; R&D intensity; return on net assets; earnings before interest, taxes, and amortization etc. - cannot be applied to this planned economy with a non-convertible currency. A few characteristics are however recognizable:

- The defining element between 1950 and 1989 has been the State monopoly on entrepreneurship. The States is the only one who can decide upon start-ups, mergers, spin-offs, investments, license acquisitions, the one who assigns companies specific responsibilities for products and markets in order to avoid any „duplication" – in fact completely supressing competition. These activities are based upon executive decisions taken at the level of the Council of Ministers. Obviously, this system could produce technical talent, as long as the circulation of the scientific and technical information and publications could not be completely disrupted, but it did not allow any competence in management and business administration, since the companies were obliged to strictly follow the political guidance of the communist party in power, not could it generate any marketing know-how, because the industry had to follow decisions issued by the powerful State Committee on Plan and by the State Committee on Prices. The system strongly inhibited the individual initiative and ingenuity - although it did not succeed in completely supressing them.
- The economic reporting mechanisms were totally focused on quantitative indicators because the primary objective of the propaganda was to demonstrate growth. The only situation in which quality mattered was for the exports because they were exposed to the competitive pressure on the external market (one can notice here the virtues of free market and open competition in imposing higher standards). Ad-hoc metrics have been introduced with the propagandistic goal to demonstrate that the economy fulfilled or exceeded the planed objectives. One such metric was the „global production", in which an integrated circuit was not accounted for by its manufacturing cost or by its selling price, but by an abstract algorithm, in which the number of transistors on the chip was multiplied by an imaginary „unit value" of each transistor and by a quite arbitrary „coefficient of technological difficulty" to build it - obviously, the results could be inflated as much as the propaganda wished, but was totally meaningless economically.

- The education system supporting the developments was rather performant, especially in STEM (Science, Technology, Engineering, and Mathematics). Graduates enjoyed social recognition, and engage in careers that represent an honourable alternative to a political career in the communist party intertwined with the State hierarchy. Students and researchers had a strong motivation to exploit to the maximum any access they could get to a publication or any other source of information from abroad. The system produced world recognized scientists and technologists (like the similar education systems in the Soviet Union and in the other socialist countries).

If the level of performance of the education seems to us almost impossible to quantify, the anecdotic evidence indicate that it had some real capabilities:

- Products that could be successfully exported over longer periods of time, featuring competitive characteristics - performance obtained in the first place through technical ingenuity, in spite of limited or no access to the most advanced technologies often under embargo;
- Capability to innovative demonstrated by an important number of articles and papers at peered reviewed conferences and in journals with strict acceptance criteria on both sides of the iron curtain. Patents have been proposed and issued, although their economic importance was doubtful in a system in which all companies and all the Intellectual Property had the same owner, the State, that also decided which entity will be chartered to build which products in any given domain;
- Launching the Annual Semiconductor Conference (*Conferința Anuală de Semiconductoare - CAS*) in 1978; today, it enjoys sponsorship from IEEE,[19] the international organization with undoubtedly the highest authority in the field that in 2018 granted this honour to only four conferences in Europe;[20]
- Prestigious careers and the remarkable professional results of several specialists in diaspora. Strangely enough, many of them have in common a certain restraint in becoming visible, being often known only in the narrow circle of specialists in their own discipline – for example, the Wikipedia category „Romanian electronics engineers" (*Categorie: Electroniști români*) only lists nine names, both in the country and in diaspora. Likewise, among the about 1400 Europeans listed among the IEEE Fellows, only 14 are educated at the Romanian schools, although not all of them in micro/nanoelectronics. Nonetheless, there is a considerable number of professors at leading universities, there are editors of important international

[19] IEEE stays for „Institute of Electric and Electronic Engineers", heving more as members engineers, scientists, and allied professionals. These include computer scientists, software developers, information technology professionals, physicists, medical doctors, and many others in addition to IEEE's electrical and electronics engineering core. For this reason the organization no longer goes by the full name, except on legal business documents, and is referred to simply as IEEE.

[20] In the order of the ancienity as seen in 2018: ESSDERC (48 the edition), CAS (40th edition), EuMIC (14th edition) și Baltic-URSI (first edition).

journals, there are authors of reference books, there are several recipients of significant awards (e.g., in the last two-three years, the IEEE Andrew Grove Award, the Andre Blondel Medal, the Cambridge University Silver Medal, the SEMI Europe Special Service Award etc.).

## 10.5. CURRENT STATUS OF ROMANIAN ELECTRONICS AND MICRO/NANOELECTRONICS

In 1990, the Romanian industry has been exposed abruptly to the international competition, making painfully clear that there is a significant difference between technical competence and economic competitiveness. The Romanian micro/nanoelectronics entered the global competition with insurmountable disadvantages, among which: the policies were defined and implemented in a fully centralized decision-making process following essentially political objectives; the industry had to cover a product spectrum responding to all internal demands irrespective of any considerations regarding the economic efficiency; it suffered from severe limitations in the circulation of information and people; convertible currency for capital investments was in very short supply.

In fact, the events from 1989 have been followed by a relatively confusing period. The efforts to „privatize" the companies resulted in all kinds of speculations, the conversion to a market economy produced inconclusive results, and the result was that the Romanian micro/nanoelectronics suffered a real collapse.

In the last about 15 years, Romania had in general a positive evolution, among other thanks to the support received after joining the European Union in 2007:

- Romania got access to financing instruments supporting European priority policies that included the regional development, increased investments in research and innovation – especially in the academic and institutional areas, but in the last years also with a pillar supporting industrial innovation in key enabling technologies that unavoidably include micro/nanoelectronics. The European funds facilitated investments, especially in R&D infrastructure, although their use, up to now, has been sub-optimum. One can speculate as to what were the reasons, but this will probably not help too much in shaping the future. They also implicitly forced some strategic prioritization of the national objectives and a rather rigorous implementation of supervisory and control mechanisms.
- Romania succeeded to rescue a competence in institutional research: in 1991, it established at the *University „Politehnica" Bucharest* a *Center for Microtechnologies (CMT)* that merged in 1996 with *ICCE* to become the National Research and Development Institute for Microtechnology (*Institutului Naţional de Cercetare-Dezvoltare pentru Microtehnologie – IMT Bucureşti*). It got international visibility, actively participating in the

European programmes and publishing impactful research results recognized by international awards.[21]

- At the same time, global industrial leaders invested in Romania. They established manufacturing sites and R&D centres both in traditional industrial branches like automotive (Renault-Dacia, Bosch or Continental), and in micro/nanoelectronics (including, without being exhaustive, Infineon, NXP, Bosch, Honeywell, Flex, eSilicon etc.). The foreign and domestic investors are involved in all essential steps of the value chain.

The current situation in Romania presents some strengths, suffers from some weaknesses, and has some open opportunities that, in order to be exploited, requires to mitigate some threats. Here is how a Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis could look like, understanding that the attempt shown below took place from a rather personal perspective, to some extent subjective, that is prone to improvements through a thorough process:

**Strengths**

– Theoretical and some industrial competences supported by institutional research and foreign investment
– Talent: long-standing tradition of scientific excellence, performant education at all levels
– Lower costs, much under the European average
– High quality diaspora staying in touch with the country.

**Weaknesses**

– No industrial entity ever reached the economy of scale was because it was chartered to satisfy any national demand
– Investments initially promising could not keep up with the state of the art because of severe limitations in budgetary means
– Competence loss through emigration, especially after 1990: 17 % of the primarily educated and professionally active population is in diaspora.

**Opportunities**

– Continue attracting foreign investors to rescue industrial units or create new ones, taking advantage of the available low cost talent
– Build upon the reputation of competence in software, with both national and foreign actors
– Duplicate in other industries the emblematic success in automotive (e.g. in financial services etc.)

[21] http://www.imt.ro/about/history.htm.

– Reverse the migration flow by involving diaspora in rebuilding a competitive industrial infrastructure
– Improve the absorption of the abundant European funds available to Romania.

**Threats**

– Investments based exclusively on low cost will quickly leave the country when the advantage diminishes
– Talent depletion through continued massive emigration
– Unsustainable quality in research and higher education by failing to attract top talent in Universities
– Wasting available financial resources by diverting them from the intended purpose through corruption.

## 10.6. TOWARDS A STRATEGY IN MICRO/NANOELECTRONICS IN ROMANIA

Between the two world wars, in the building of the modern Romania there have been three approaches pursued by the political parties in that time, expressed and short and pregnant formulae:

– „eminently agricultural country": Romania lacks an industrial vocation and should stick to its natural resources, primarily to the agriculture;
– „through ourselves": Romania shall conquer modernity through its own efforts;
– „open doors": Romania's progress will take place through massive foreign investments.

It is quite obvious that each of these approaches underlines an important element of a national strategy, but it is also obvious that none of them can be used exclusively, in each and every situation. Strategy generally involves

- setting goals,
- determining actions to achieve the goals,
- and mobilizing resources to execute the actions[22]

**Goal**

*It can be accepted that the micro/nanoelectronics in Romania had the goal to assure the access to advanced technology for the national industry.* The access was hindered or even prevented by various restrictions: embargo, access to convertible

[22] Freedman, L 2015 Strategy: a history. Oxford: Oxford University Press, quoted after https://en.wikipedia.org/wiki/Strategy#cite_ref-3

currency (real or caused by voluntary policies) or other limitations cause by the position of the country behind the iron curtain.

*What could be an objective that Romania could pursue when it enjoys unrestricted access to the global market resources*? This is the primary – and perhaps the most difficult - challenge to be addressed when defining a Romanian industrial policy in micro/nanoelectronics.

A possible answer could be to establish *Romania as a significant contributor to the future security and prosperity of the European Union*, of course assuring at the same time the national security and prosperity,

For the specialists in micro/nanoelectronics it is more than obvious that *this technology is the foundation of all the industries of the future*. They have the challenging task to convince the political decision makers that it is vital to master this technology and implement it industrially. Even today, the Member States of the European Union are hesitant to engage in the global competition, and the private sector – in the countries in which it exists – is far from enthusiastically engaging in a sector needing important capital investments, patience and tenacity before reaping the economic benefits.

Romania chairs the Council of the European Union in the first half of 2019, when important decisions could be made regarding the assignment of the EU budget in the future framework programme, Horizon Europe, 2021-2017. It has the possibility to contribute to the European industrial renaissance, especially in regard to micro/nanoelectronics, while also assuming a constructive role, commensurate with its ambitions, and, in the process, improve its current position as the last European country with regard to innovation. It is in the interest of Romania to recognize this opportunity and act fast upon it. *Those who will move first will enjoy the fruits*.

**Actions**

*Right now, Europe lost contact with the most advanced technologies because of cronic underinvestment.* Since about 15 years, the investments in Europe represent no more than 3% of the global investments. Consequently, in Europe there is the smallest installed semiconductor manufacturing capacity among all regions active in micro/nanoelectronics, and its weight diminshes continuously. But no industry can be competitive and no country can be defended in front of aggression without micro/nanoelectronics. If this basic truth would be accepted, it would be obvious that it is necessary to reverse the down trend of this industry in Europe by sustained investments, to reach the economy of scale that would generate profitable growth, being therefore sustainable.

Ones and again, one or another European organization, High-Level Group or Task Force highlighted the strategic disadvantage resulting from satisfying the continuously increasing demand for mainstream micro/nanoelectronics by importing components, while European manufacturers continue specialising in niche products.

Unfortunately, the proposed remedies have been inefficient. There is a political constraint not to treat preferrentially a specific domain (EU cannot pick up winners!). Recently, the European Commission confirmed that a proposal by four Memebrs States to support with about 1.75 million euros investments in micro/nanoelectronics with a total volume of about 6 billion euros qualifies as a „Project of Common European Interest" as per Art. 107.3 (b) of the Treaty of the Functioning of the European Union, therefore it is compatible with the internal market.[23] Related to this decision, three European semiconductor manufacturers - Robert Bosch, ST Microelectronics and Infineon – announced intentions to invest in expanding their semiconductor capacities. While saluting this development as an important step in the right direction, it has to be noted that this three-year project represents at best no more than a couple of percentage points of the world-wide R&D expenditure or capital expenditure, that are now in the range of about 100 billion dollar per year.

Nonetheless, these investments create opportunities in Europe both for the countries in which they are located and for the other countries, large or small, that pursue own strategies and can derive considerable benefits from engaging in cooperation with these projects. Romania is among those who could take advantage of this opportunity if it would conceive and implement an appropriate strategic programme. The Romanian Academy is currently leading a reflection process, essentially through some members of its Commission for the science and Technology of Microsystems, that organized in the last two years several meetings and debates, published articles, gave interviews, edited two books describing the context, and organized a forum involving leading personalities form the country and from diaspora that included a round table with representatives from the industry, institutional reaserch and higher education that explored strategic perspectives. It has been recognized that *Romania has a tradition, still has human and institutional resources, can gaint, at least partially, contributors from its high quality diaspora and has unrestricted access to the larges economy of the world: the common market of the European Union, and even more thanks to the free trade agreement already concluded by the EU.*

If course, an essential action item consists in indentifying or creating a private sector champion ready to engage in this adventure.

**Resources**

At the EU level, the total budget represent 1% of the GDP of the Member States, while the budget of the national governments represent in average 45.8% of the GDP. The already limited European means encompass several topics like common agricultural policy, regional structural convergence, research and innovation etc. In research and innovation the budgetary means are mostly dedicate to fundamental research, the remaining are thinly spread over several industries,

[23] European Commission, 18 December 2018, http://europa.eu/rapid/press-release_IP-18-6862_en.htm. The four Member States are France, Germany, Italy and the UK.

technologies, ecosystems – in fact too thinly to have a decisive impact. It is quite obvious that only the Member States have the means to make a difference.

At this point in time, the Romanian economy is not able to sustain a concentrated effort over 10-15 years that would change the European weight in the global competition. It faces similar possible scenarios as in the building of the modern states:

- A first approach, more or less similar with the „eminently agricultural country", would consist in limiting the ambitions to what already exists. While this will be the deefault outcome of not conceiving any policy, it would be conterproductive for the strategic objective formulated above.
- The second approach, equivalent to „through ourselves", would provide strong support to the national companies and institutions that survived. This would quickly appear as whishful thinking when comparing the Romanian assets with the entities existing in other european countries. For example, the research capabilities in Europe are seond to none in the world; IMEC in Belgium, CEA Technology operating the labs LETI, LIST and LITEN in France, the Fraunhofer Gesellschaft institutes in Germany, the VTT institutes in Finland, VTO in The Netherlands, Tyndal Institute in Ireland – they all have an excellent global positioning, operate on yearly budgets between 50 and 500 million euro, and have a lot of success and an excellent reputation. It can be noted that they all face the shortcomming of lacking an advanced lab-fab facility; some of them overcome it by relying on facilities operated by their industrial partners, but any arrangement with such an infrastructure available would be in a priviledged position - although the cost will be in the range of 10 billion dollars followed by yearly expenditures in the range of 1 – 2 billion dollars, and none of the existing actors is in the position to afford such costs
- The third approach, equivalent to „open doors", would benefit from an influx of financial means and, at the same time, complementary competences contributed by the foreign investors. However, it has been repeteadly demonstrated that if the only motivation of the foregn investments is to cut costs, then they will not be reliable partners for long term developments. Romania made this experience with a Nokia manufacturing facility, that changed location roughly every three years: from Finland to Germany to Romania and eventually to India

In fact, the most promissing approach would be a combination of the options listed above: the strategy must build upon the existing strengths, be carried aut by a serious national effort and succeed in attracting international participation.

The prerequisit is *first to be successful in obtaining a substantial national contribution. Then, the access to the European funding mechanisms has to be secured, including the connection with „important projects of common european interest" and the capability to combine various funding mechanisms. And last but not least, the project must identify a private company, or a consortium of the* *appropriate size, bringing appropriate know-how, and having the will to define and implement a convergent strategic vision.*

*Should these conditions be fulfilled, Romania would be in the position to engage on a road opened by Taiwan*. Taiwan is a country with a population comparable to Romania, without any industrial or energetic resources, that 30 years ago had an underdeveloped education and research system and a tiny GDP per capita. Taiwan pursued with tenacity a wise policy to invest and attract foreign investors, to recuperate its diaspora, and to patiently forge strong relationships with customers that ended up entrusting them the most substantive projects. *Taiwan is today the number one semiconductor manufacturer of the world*.

Romania would have an *incomparably better starting point to imagine a winning strategy.*