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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
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BRASIL'S NATIONAL POLICY

ON

NEW MATERIALS

Roberto C. Villas-Bôas*

* paper prepared for the UNIDO's Department for Industrial Promotion, Consultation and Technology, December 7-10, 1987, Viena. The author is Associate Professor of Metallurgy, Federal University of Rio de Janeiro, and Secretary of State on New Materials, Ministry of Science and Technology, Brasilia, Brasil.

INDEX

ABSTRACT

This paper presents an overview of the ressonings behind New Meterials developments, exposes the brazilian national policy on New Materials analysing the sectorial panorama on:

*New Metal Alloys

*Advanced Ceramics

*Quartz and Silicon

*Engineering Polymers

*Composites

In each of these sectors, the role played by local industries , research centers and universities as producers, R+D developers and education conductors are described.

The general guidelines of each of the aforementioned sectors are discussed regarding human resources, R+D infrastructure,reliability and quality assurance,pilot plant and industrial promotion units. Identification of immediate R+D opportunities are attempted .

Matrices of the financing expectations of the research activities, training and education,planning and assessment studies are presented,by financing source as well as by individual sector.

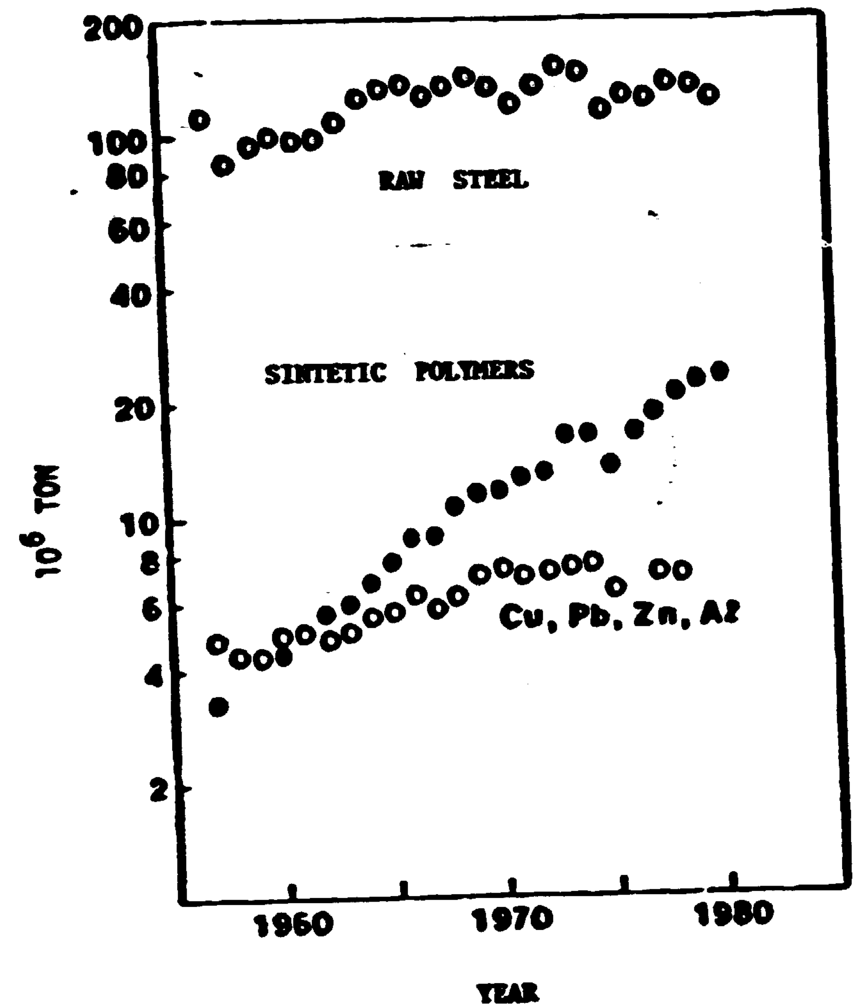
Finally, several constraints for the use of New Materials in Third World countries are discussed .

0. Introduction

Within the last two decades worldwide developments in materials technology have been producing new metal alloys,fine ceramics products, engineering polymers, as well as hybrid material composites that are replacing the more traditional metal products at a remarkable rate.

New Materials can be viewed as substances,or combination of these, known or developed from the incorporation of first principles to the preparation, fabrication and utilization of new or old applications , however always presenting new criteria in their build-up . There is an implicit or explicit utilization of innovative project, manufacture and utilization reasonings towards quality and reliability of use .

Figure 1 shows a comparison between the production of raw steel , sintetic polymer and non-ferrous metals in the United States, from 1955 to 1980, and may be utilized to draw attention for the rate of industrial efforts linked to these materials .



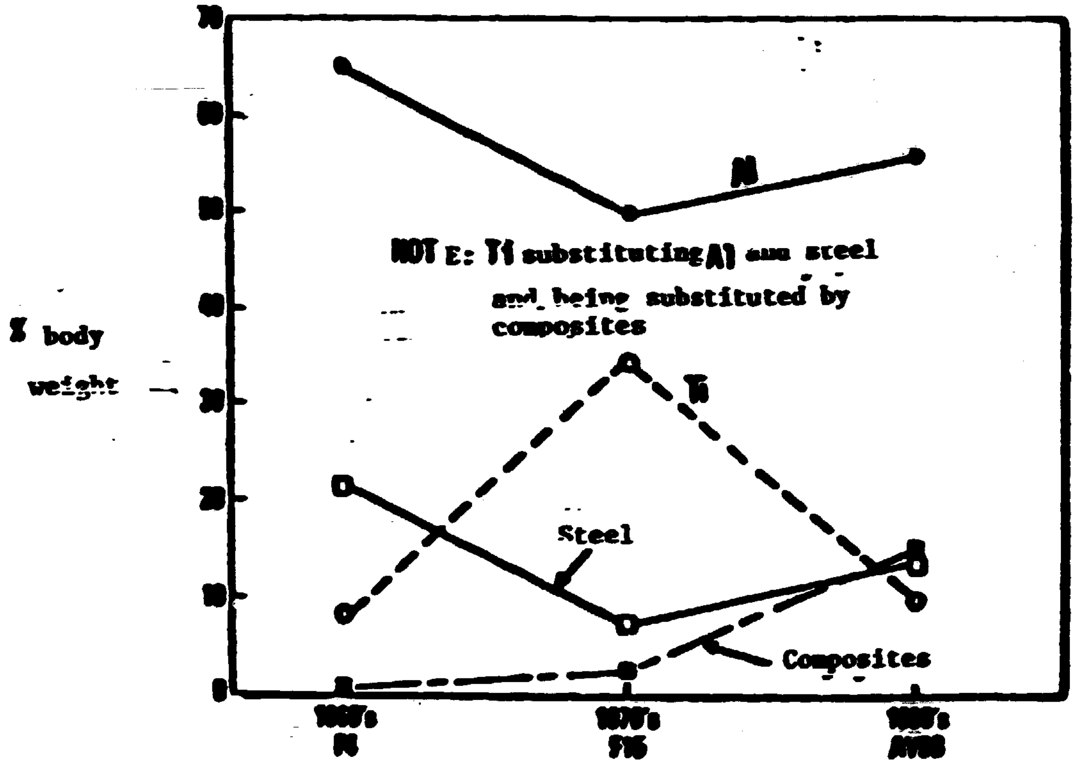
Fifure 1.- Raw steel , non-ferrous and sintetic polymers production in the United States.

Source: Materials and Society, vol.8,no.2,1984

New materials development efforts are primarily tailored to :

A) promote substitution towards a more rigorous specification materials application.

B) promote substitution of vulnerable or critical ores or metals.



Fifure 2.- Structural Materials in Military Aircrafts
Source: Materials and Society,vol.8,no2, 1984

Figures 1 and 2 illustrate the substitution of materials that occurred in a short time span .

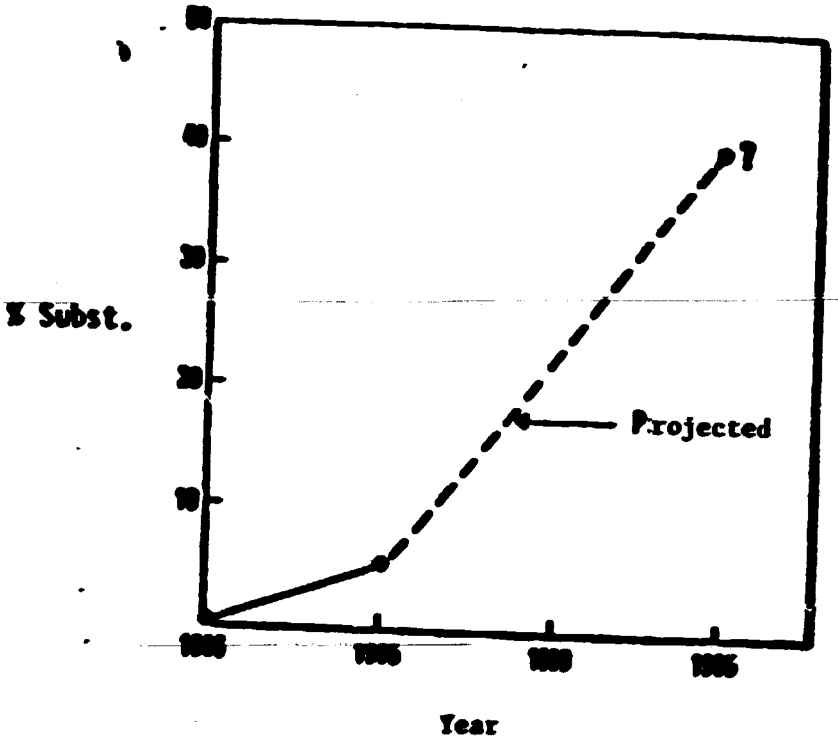


Figure 3.- Substitution of Copper by Optical Fibers in telecommunication systems .

Source: Materials and Society,vol.6,no2,198.

As for promoting substitution towards a more stringent material specification,either for a novel or old application,several research and industrial facilities are engaged all over the world in market searching and opening of opportunities related to the high technology fields,such as aeronautics,informatics,micro-electronics, etc...

As for promoting substitution of vulnerable or critical ores and/or metals, government efforts of the industrialized countries are envisaging to change the profile of dependability of the central economies from traditional sources of supply.

In both cases the underdeveloped economies do tend to suffer. In the first case due to the fact that either it has to rely its industrial basis on ,so considered, "second hand" materials or to import process or product technology to match with such new development -since its R+D infrastructure in the materials area lags far behind that of the industrialized countries-. In the second case, the situation is such that,very often, a metal or ore that is being substitute is a good export item of a industrializing country.

Hence the problems that face the developing countries to at least partially match such a situation are not of a trivia nature: they have to secure a position that is vital to their balance of payment in foreign currency, from the exporting commodities, and, also to prepare themselves to deal with the introduction of new materials in their own domestic economies.

Thus, such new materials developments, viewed as an amelioration of the raw materials crises of the industrialized countries, may cause a deepening economical crises for the third world.

1. New Materials in Brasil

It is clear that such third world countries that intend to maintain or even improve a given position of competition in the world market must closely follow whatever is happening in relationship to the novel materials basis that is under way around the industrialized world.

Those advanced third world countries that posses a reasonable sophisticated industrial infrastructure have already an expressive part of their domestic industry severely affected from options and estrategies defined within the industrialized countries economies. It is not a small lot of already substituted materials that mades up the day-to-day activities in the advanced third world economies.

'rom the Brazilian perspective three are the main points to justify a national policy towards new materials:

- There are in the country very important world ore reserves of estrategic minerals:
  - o Quartz (95%)
  - o Niobium (86%)
  - o Titanium
  - o Berilium
  - o Rare earths, and others.

Since these raw materials are of fundamental importance for several Hi-tech applications, there is a danger to import the artifacts having the materials made up of these estrategic minerals if no policy towards new materials development is not implemented.

- There exists a scientific and technological capability within the country that may be considered a good seed for such R+D effort. Although a considerable increase in number of researchers is envisaged, the already existing professionals are qualified to undertake the initial steps towards the creation of new materials technology.

- The national market is internationally quoted as one of the most promissing markets for hi-tech products and artifacts. In fact, the country does have indigeneous industries that use and even develop new material products.

1.1 New Metal Alloys

Metal materials have been the most prominent target for non-metallic new material substitutes. However, due the inherent sinergisms of their properties and peculiar characteristics, metals and their alloys are maintaining their competition on a vast gamut applications.

Due to its ore resersves, Brasil has to undertake its own path towards being an industrial and technological center for the development of new metal alloys. Such new metal alloys are being employed in the electronics, aeroespacial, oil extraction, chemical and petrochemicals, automobil, steel making, nuclear and biomedical activities.

At the traditional metal industry level, crude steel predominates the Brazilian metal production. Figure 4 shows the growth of such industrial branch, and figure 5 illustrates the location of the steel plants over the country.

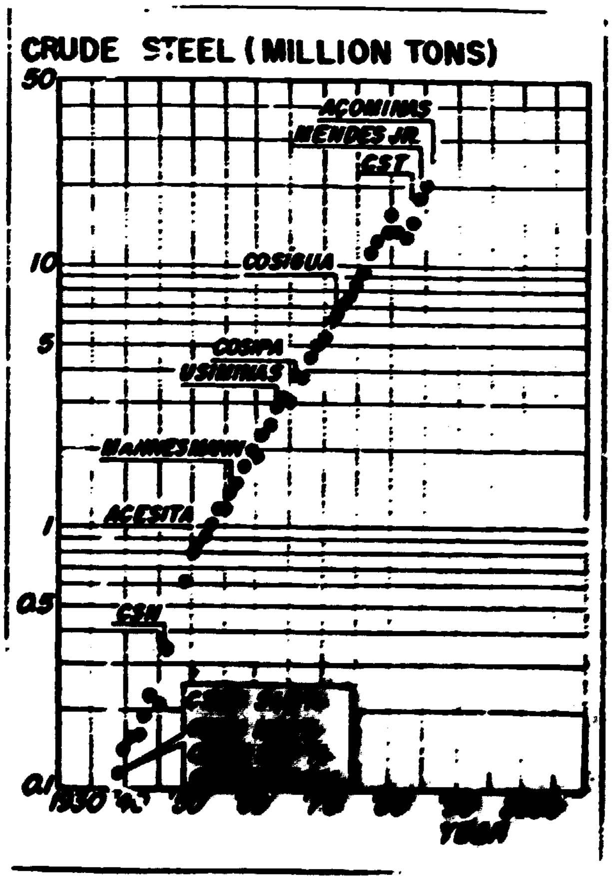


Figure 4.- Growth of Brazilian crude steel production
Source: Metalurgia international, Vol. 1, No.1, October 1987

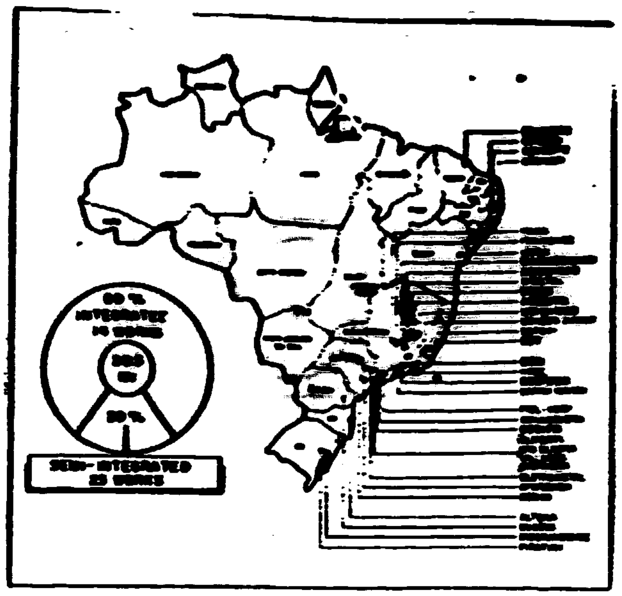


Figure 5.- Location of the brazilian steel plants.

Source: Metalurgia International,vol.1,no 1,1987

Secondary refinig and laddle metallurgy processes,widespread among the country producers,allow the production of steels holding a high degree of cleaniness for stringent applications.

Figure 6 shows the main existing laddle processes in the brazilian steel industry .

PROCESS	HEAT/SIZE (t)	COMPANY
POWDER INJECTION	85/100	COSIPA
	[illegible]	USIMINAS
	80/100	VIBASA
	25	VILLARES
WIRE INJECTION	200	CSN
	280	CST
RH	85/(180)	USIMINAS
	100	COSIPA
LADLE DEGASSING	42	COSIPA
TAP DEGASSING	110	VIBASA
VACUUM-INGOT TEEMING	110-230	VIBASA
LADLE FURNACE	85	MENDES JUNIOR
	100	CSN
	(180)	USIMINAS
ASEA-SKF	75	VILLARES
	50	PIRATINI
VAD/VOD	26	ELETROMETAL
VOR	75	ACESITA
AOD	35	ACESITA

Figure 6.- Main laddle metallurgy processes in the Brazilian steel industry

Source:Metalurgia International,vol.1,nol,October.1987

Controlled rolling of high strength low alloy steel (HSLA) is being widely used at the Brazilian steel mills to produce plates for large diameter line pipe and offshore platforms. It is expected the incorporation of the thermomechanical control process (TMCP) in Brazilian plate mills in a near future. Such technique being mostly applied to steels containing microalloy additions such as niobium is well suited to the country.

Continuous annealling, offerring a relatively low cost method of producing high strength cold rolled steel, having good formability characteristics, was introduced in Brasil, at CSN, this year.

Figure 7 illustrates the volume and variety of products made by the Brazilian steel industry in 1985.

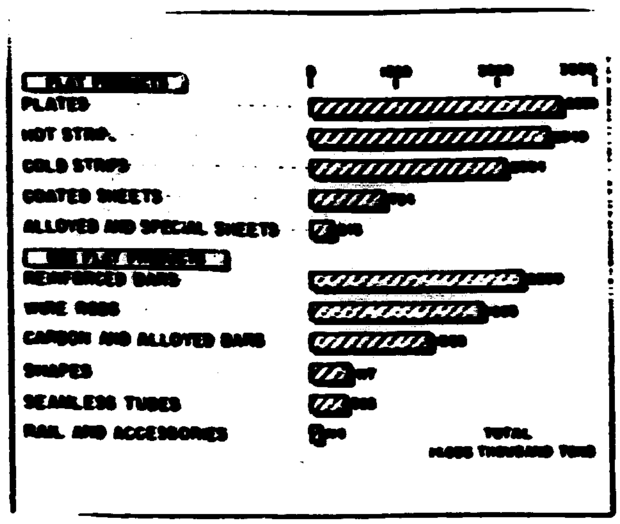


Figure 7.- Volume and variety of products made by the Brazilian steel industry in 1985.
Source: Metalurgia International,vol.1,nol, October 1987

At the new metal alloy materials side, considerable progresses have been made by several Brazilian enterprises:

- o Special steels: Villares, Aparecida, Piratini, Eletrometal and Acesita
- o Special alloys: Eletrometal, Metal Leve
- o Nodulizing iron: Fundiçao Tupy, COFAP

Regarding R+D Facilities:

- o Iron and Steel Making: Usiminas, CSN, Aços Villares all having their own R+D facilities; COSIPA, ACESITA, Piratini, Aparecida and Eletrometal, all have R+D nuclei that together with public research centers and universities facilities develop their own R+D needs.

• Pure metals and special alloys : FTI(Fundaçao d. Tecnologia Industrial),CTA(Centro Tecnico da Aeronautica),CETEC(Fundaçao Joao Pinheiro),CVRD(Companhia Vale do Rio Doce),IPEN(Instituto de Pesquisas Nucleares),IPT(Instituto de Pesquisas Tecnologicas) are government and company research centers that develop intensive R+D efforts .CBMM (Companhia Brasileira de Mineraçao e Metalurgia) develops R+D projects dealing with Niobium applications through several research grants with brazilian and foreign universities and research institutions and ,as well, conducts propertary research on more sofisticated Nb products .

Regarding R+D at university facilities, as well as training and education,several metallurgical and materials engineering departments and physics departments are engaged on special steels and new metal alloys :UFRG(Universidade Federal do Rio Grand do Sul),USP(Universidade de Sao Paulo),UFSCar (Universidade Federal de Sao Carlos),UNICAMP(Universidade de Campinas), UFRJ/COPPE(Coordenaçao dos Programas de P´os Graduaçao/Universidade Federal do Rio de Janeiro),IME(Instituto Militar de Engenharia),PUC-RJ(Pontificia Universidade Cat´olica -Rio de Janeiro),UFMG(Universidade Federal de Minas Gerais) .

Figure 8 shows,in a matrix way, the several new metal materials being investigated .

MATERIAL \ INDUSTRIAL SECTOR			AEROSPACIAL	NUCLEAR	MILITARY	AUTOMOBIL	STEEL MAKING	CHEM./PETROCH.	ELECTRO-ELECT.	[illegible]	PETRO-EXTRACT.
CONVENTIONAL	STEELS	special	•	•	•	•	•	•			•
		ultra-high resis. tenacity	•		•	•	•	•			•
		stainless	•	•	•		•	•	•		
		[illegible]		•	•	•	•	•			•
		ultra-high purity			•	•	•				
		cold. control. microstructure			•	•	•				
		microalloyed			•	•	•	•			•
	ALLOYS	Al	•	•	•	•		•	•		•
		Mg	•	•	•	•					
		Ti	•		•			•		•	•
		Fe	•		•			•		•	
		Sn				•		•	•		•
		Cu							•		
		Ni	•	•				•	•	•	•
		Others							•		
	Superalloys		•	•	•		•	•			•
	Cast Iron				•	•					
STRATEGIC	Zr			•				•			
	Be				•						
	RareEarths			•	•				•		
	Refractories		•		•	•	•	•	•	•	
	Nuclears			•							
	Fiber Reinforced		•		•						
ADV	Superconductors								•		
	Amorphous Met.Alloy			•					•		
	Memory Effect Met.Alloy		•			•			•	•	

Figure 8.- Industrial applications of new metallic materials

Source:"Tend^encias e Perspectivas na Area dos Novos Materiais",Associaçao Brasileira de Metais,ABM, Julho,1987 .

The general guidelines on the new metal alloys programme are

- o **Human resources:** due to the forecasted increasing demand for R+D activities it is expected an increment in the qualification of human resources at the post graduates[*], higher qualifications at the undergraduate and technician levels are needed. Areas related to metallurgical engineering, materials science, solid-state physics and chemistry, as well as quality control systems and technological management are to offer more enrollment.
- o R+D Infrastructure: There exists within the country a primary R+D infrastructure that needs an adequate articulation in terms of managerial capability to maximize the scientific and technological potential developments; as well some identified institutions do need equipment repositions and some others are facing the need for more sophisticated and advanced equipment. Spare parts for the standard as well advanced equipment are still a problem within the country.
- o Immediate opportunities for R+D linked to market needs:
  - oo Special steels: High-technological application stainless steels; high-purity; microalloyed and rolling controlled microestructure
  - oo Special alloys: Aluminium, titanium, magnesium, berilium, copper, barium, galium, litium special alloys and pure metal
  - oo Noble metals: High-purity gold and gold alloys for medical and dentistry applications; pharmaceutical applications and electronic applications.
  - oo Superalloys
  - oo Amorphous Alloys
  - oo Lantanides: High purity oxides;
  - oo Pure metals: Tungsten, talium and zirconium
- o Assurance of quality: Industrial quality; standards and reference metal materials; management of quality control systems.
- o Assembling and production: To secure effective ways and procedures to install and assist at the start-up phase industrial enterprises to produce or implement the outlined guidelines.

1.2 Advanced Ceramics

The fine ceramics world market was estimated to be around a 5 billion dollars figure in 1985. Of these, around 2 billion dollars are estimated to correspond to the figure attached to micro-electronics substrates and 1 billion dollars to ceramic capacitors.

NOTE:(*) ;at the industrial level,besides post-graduates higher qualifications at the undergraduate...

In the next 15 years the foreseen expansion of such market is around 10% to 20% per year, being the ceramic [illegible] market increasing of the order of [illegible] per year, the advanced structural ceramics market by 15% per year and the [illegible] market by 20% annum.

The Brazilian ceramic industry, the traditional, not the advanced, is [illegible] ranked second in the world, after Italy,with a production level around [illegible] square meters.

At the advanced ceramic level, the Brazilian market is estimated to be of the order of 300 million dollars, being a substantial share of this market, [illegible] to 90% held by local industries producing substrates, varistors, [illegible], [illegible] capacitors and piezoelectric components. The remaining market is on the special refractories, mechanical seals, thread-guides and others.

However, several products are still imported as sensors, ferrites, tubes for sodium lamps, ferrites, catalysers, cutting tools, and some special refractories.

Around twenty industries are producing for this market; half are multinationals and the other half genuinely national.

Of the national companies, two are engaged in the ceramics for electronics, seven in thermo-mechanical and one in optical fiber.

In the production of special ceramic powders Brasil has:

- Alumina: Metal leve (Pilot plant); UFSCar, IPEN, UNESP (R+D efforts)
- Zirconia: IPEN (10 t/y pilot plant); UFSCar, UNESP, IPEN (R+D efforts)
- Titania: TIBRAS (Industrial production of T_1O_2 pigment); CVRD (R+D efforts)
- Niobio: CBMM (Optical and crystal grade industrial production)
- Silica: CVRD (R+D efforts and pilot plant for quartz powder)
- Lanthanides: Nuclemon, CVRS (R+D efforts)

The following are some producers of advanced ceramics products:

- Optical fibers: ABC-XTAL
- Isolating parts and heating elements: Carborundum, NGK, BOSH
- Capacitors: CERTEC, [illegible], Thomson-CSF, Vitramon
- Sensors:MITEC, [illegible]
- Substrates: COORS, NGK
- Special parts of Al_2O_3: COORS, Keramus, Procer
- PZT: Thornton-INPEC
- Varistors: VC VAR
- Thread-guides: CIL and others

Regarding R+D facilities for advanced ceramics, a lot has to be done in terms of acquisition as speciliazed equipment for specific purpose applications. However, some research institutions do posses a good R+D standard:

- o Nuclear Ceramics: CDTN, IPEN
- o Optical Glasses: CETEC
- o Structural Ceramics: CTA, IME, IPEN, UFSCar, COPPE/UFRJ (Film depostion).
- o PZT: IPqM, UFSCar, CETEC
- o Ceramic characterization: COPPE/UFRJ, USP, INT, IPT, USP
- o Powder: IFQSC, UFSCar, IPEN, CETEC
- o Ferrites and Biomedical: INPE
- o Superconductor: CBPF, UFSCar, UNESP, UNICAMP, USP, IPEN

Regarding training and education:Technicians (Senai), undergraduate level in ceramics (UFSCar, UFPb, UFSC), post-graduate (USP, IME,UNESP,UNICAMP).

For a general view of functions, properties and applications of advanced ceramic materials, Figure 9 provides such an overview of the sector.

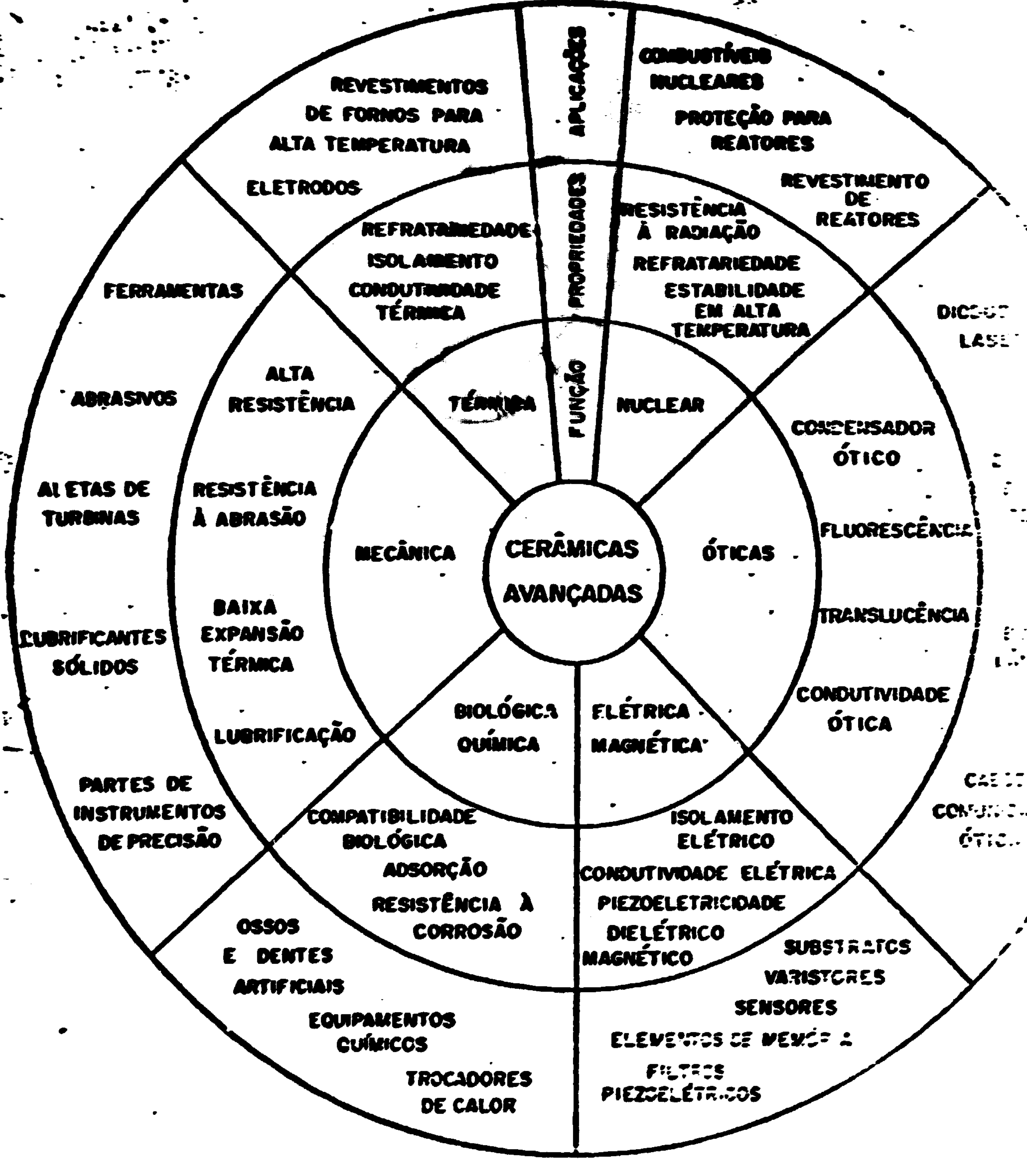


Figure 9.- Functions,properties and aplications of advanced ceramis. (in portuguese)
Source: "Análise Setorial do Segmento de Cerâmica avançada",NMAT/INT,1987.

The general guidelines on the advanced ceramics programme are:

- o Human Resources: expanding opportunities for ceramics will require more scientists, researchers and engineers with wide knowledge and an inter-disciplinary approach in advanced ceramics. Faculty members training programs are envisaged, specially through scholarship grants abroad. Libraries are deficient in advanced ceramics topics and must be given financial support in order to hold a sufficient number of books, magazines and journals related to the field.
- o R+D Infrastructure: Specialized equipment has to be provided as well as substitution of old fashioned ones that are working at their level of fatigue.
- o Immediate Opportunities in R+D:
  - oo Processing Technology: In order to connect processing variables, particle-size distribution, composition, temperature, to the desirable final properties of the advanced ceramic materials. The obtaining of ceramic powder through chemical route, specialy sol-gel techniques, are a need; sintering techniques.
  - oo Advanced Ceramic Products: Isolators, ferroeletrics, piezoelectrics, semiconductors; structural ceramics on Al_2O_3, Z_rO_2, T_iO_2, Sialons, nitrites carbites and their composites.
  - oo Chemically bonded Ceramics: including advanced cement pastes and concretes. These represent an outstanding potential for low-cost, net shape fabrication of ceramic structures.
- o Assurance of Reliability: The reliability of advanced ceramics is the single most important determinant of success in any application. Advances in brittle materials design, process control, non-destructive evaluation, crack propagation processes and life predictions are needed.
- o Quality Assessment: Purity and submicron size control of the sintetic prime substances for ceramic manufacture; physical and chemical control standardization procedures; chemical analysis control; reference materials.
- o Production Facilities: Pilot plant and industrial plants for Z_rO_2, Z_rOCl_2, TiO_2, lantaniedes, Al_2O_3, BeO, SiC, Si_3N_4.

1.3 Quartz and Silicon

Several are the industrial application of quartz and silicon, mainly on optics and electronics.

High-quality quartz reserves are located in Brasil, that holds 95% of the world reserves. It is the sole producer of blocs of piezoelectric quartz and the major producer and exporter of quartz pieces.

Cacex, the national exporting authority, establishes exporting prices ranging from 1,2 to 6,0 dollars a kilogram, the average exporting price being of the order of 1,3 dollar a kilo. Therefore, the financial benefits from quartz industrialization are occurring outside national borders.

Of the advanced materials that are made-up of quartz, the country detains own technology for cultivated quartz production (Cetec) and oscillators. ABC-XTAL industrial plant does produce cultivated quartz, although utilizing Motorola's technology, corresponding to near 1% of the world market.

Brasil does not hold technology for fused quartz production, importing products as diffusion tubes, optical glasses, etc....

ABC-XTAL manufactures optical fibers using CPqD-Telebras developed technology.

As for silicon, Brasil is one of the major world producers of metallurgical grade silicon, being almost all the production using quartz!

For the production of one kilo of metallurgical grade silicon, around 2,8 kilos of quartz are needed.

The country does not produce electronic grade as well as solar grade silicon, importing its needs on the form of final products. There is a factory called Heliodinamica that imports polycristaline electronic grade silicon and produces monocristaline plaques and solar cells.

Research and development are being carried out at Cetec and IPT research centers and at UNICAMP, USP, and IME university facilities.

The general guidelines on the quartz and silicon sector are:

- Human Resources: To promote training and education compatible to the needs of this sector.
- R+D Infrastructure: To provide for specialized equipment for those R+D institutions and universities.
- Immediate Opportunities for R+D
  - Technological Domain: High purity quartz powder, fused quartz, electronic and solar grade silicon.
- Quality Assurance: Industrial quality control systems to assess product reliability

- **Production Units:** To promote the installing of industrial units on high-purity powder quartz, cultivated quartz, oscillators, fused quartz, electronic and solar grade silicon.

1.4 Engineering Polymers

There exists some difficulties to identify an strategic positioning of the industry and research institutions in this area of engineering plastics in Brasil.

The trends in the research sector is very much conditioned by the stage of development of the nation's petrochemical industry. Thus, there is a search for identification of the worldwide tendency of such engineering plastic materials and how do they fit within the country's reality.

The actual meanings of such enormous generation of polymeric advanced materials worldwide do not seem to produce echoes on the national business enterprises, limited as they are to the still very weak market demand of such materials.

Notwithstanding, due to the great degree of internationalization of the internal Brazilian economy it is safe to admit, in a near future, a significant increase in demand for such advanced polymers; and when such a stage will be reached the expectations are that great difficulties are to be faced by the Brazilian petrochemical industries, since they are, in fact, already having problems in obtaining foreign technologies, due to the fact that the international market is extremely cartelized do not enhancing technical dissemination.

Two are the main advanced polymer applications: the reinforced ones, having excellent structural ~~problems,~~ adherency, the conducting and photo-active polymers; the second group may be called as "social application polymers", as the membranes (water purification, pollution control, dialysis) and bio-compatible materials (medical purposes).

The main R+D centers are: INPE, INCOR, CTA and CENPES; at the university level, UFRJ (IMA, biophysics and COPPE), UFSCar, UNICAMP.

The general guidelines for the advanced polymer programme are:

- Human Resources: Training and education at all levels is badly needed;
- R-D Infrastructure: Need to enlarge and equip the existing R-D centers and universities. It is foreseen that with the installing of petroquisa R-D facilities at the UFRJ campus, and subsequent operation, will act as a catalizer for major actions regarding advanced polymer research and training.
- Immediate Opportunities for R-D
  - Membrane processes and production
  - Bio-compatible materials
  - Reinforced plastics

- oo High-cristalinity polymers
- oo Homogeneous polimeric alloys
- oo Photosensitive materials
- oo Special adhesives
- oo Engineering plastics
- oo Polymers from alternative sources

- o <u>Reliability</u>: Process and product reliability systems and procedures are to be emphasized;
- o <u>Production Units:</u> To promote special polymer industrial units.

1.5 <u>Composites</u>

Composites are hybrid advanced materials composed of inorganic and organic substances having properties superior to those of the constituents alone. They are any combination of particles, whiskers or fibers in a common matrix.

Figure 10 illustrates the way composite materials may be formed.

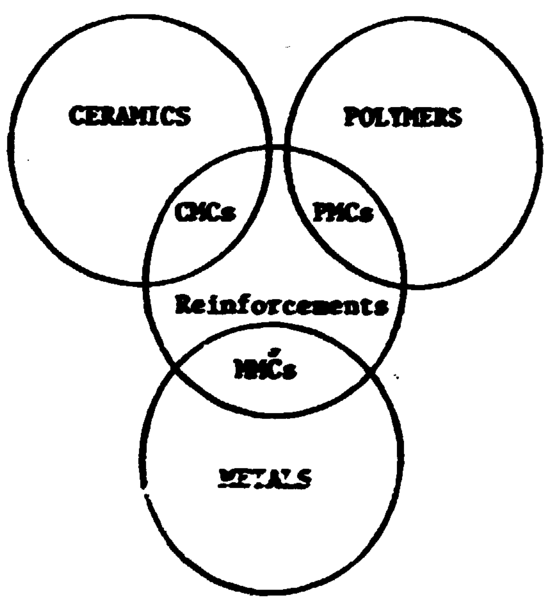


Figure 10.- The Way Composites Materials are formed.

Source:Office ot Technology Assessment

In Brasil composites were introduced by the aeronautical industry for structural purposes (pressure vessels, floors, rocket tubings, etc...). They consist of fiber and matrix combinations which yield superior strength and stiffne: as well corrosion and fatigue resistance being relatively expensive and typically containing a large percentage of high performance continuous fibers (such as high-strength glass, graphite, aramid, or any other organic fiber).

They are fabricated by a laborious process called "lay-up", typically involving placement of sequential layers of polymer-impregnated fiber tapes on a mold surface, followed by heating under pressure to cure the lay-up into an integrated structure. Automation is beginning to speed-up this process, but production rates are too slow to allow for a significant accomplishment.

Market opportunities are appearing outside the aeronautical and defense uses, as for the demand on glass fiber reinforced polyester resin . However, less than 2% of such materials may be classed as advanced and are used in the sporting goods and industrial equipment industries.

It is expected that within a decade, composite unibody frames could be introduced in limited production; as well, medical implants, storage and transportation of corrosive chemicals, weapons and military vehicle are considered to be near term markets.

Embraer produces structural composites for its aeronautical industry.

As for R+D facilities, CTA, IME and INPE are those working in advanced composites research. At university level, UNICAMP.

The general guidelines for the advanced composites programme are:

- o <u>Human Resources:</u> Training and education efforts at all levels, due to the very embryonic nature of the national capability in the area.
- o <u>R+D Infrastructure:</u> Still very modest and insufficient for long term programmes; needs to be installed and equipped.
- o <u>Immediate Opportunities in R+D</u>
  - oo <u>Processing Methodology:</u> Development of new, low-cost fabrication methods are critical for advanced composites, as well how process variables do affect final properties.
  - oo <u>Mica reinforced polymeric composites:</u> Mica flocs as an alternative to glass fibers.
  - oo <u>Boron, Carbon and Aramid Fibers</u>
  - oo <u>Inorganic Matrix Composites:</u> Aluminium

oo <u>Biomaterials:</u> Apatite as reinforcing agent for poliethilene matrix of ultra-high density (Orthodentical purposes) and PHB (Fracture Fixation).

oo <u>Delamination Control:</u> As the single most important mode of damage propagation; as well interphase control techniques in order to assess its influence on composite behaviours.

oo <u>Chemical Infusion:</u> To incorporate new properties to the matrix (conducting polymers, lenzes and biomaterials)

o <u>Testing Methods:</u> need for standardized testing methods and procedures to avoid, or hinder, variability in reported property values.

o <u>Industrial Units:</u> to promote adequate erection of industrial plants on needed advanced composite materials.

2. <u>Financing</u>

In order to have a start on the afore exposed policy the figures shown in Figue 11 are in effect.

VALUES IN MILLION CRUZADOS

FISCAL YEAR	1987					1988				
Areas \ Sources	MCT	FINEP	CNPq	SEI	TOTAL	MCT	FINEP	CNPq	SEI	TOTAL
Planning & Studies	10	5	-	-	15	15	5	-	-	20
Training & Education	6	10	192	3	220	40	15	394	3	452
R+D Infra-structure	74	30	-	-	71	130	50	-	-	180
R+D Projects	48	420	18	5	513	210	860	36	5	1.111
Reliability & Quality Assur.	12	5	-	-	19	25	20	-	-	45
Productive units Assistance	-	30	-	30	60	-	50	-	30	80
TOTAL	150	500	210	38	898	420	1000	430	38	1888

MCT= Ministry of Science and Technology

FINEP= Loan and Financing State Enterprise

CNPq= National Research Council

SEI= Secratary of State for Informatics

Values in 10^6 Cz$

Cz$1 = US$

Figure 11.- Budget for the new materials programme

Source: "O desafio dos novos materiais", Colecao Brasil ciencia, No. 2, MCT, 1987.

As for sectorial application, figure 12 shows the values in million of cruzados; the same observations holding for figures 11 and 12.

VALUES IN MILLION CRUZADOS

FISCAL YEAR	1987						1988					
Area / Source	NMM	AC	QS	EP	C	TOTAL	NMM	AC	QS	EP	C	TOTAL
MCT	46	44	15	30	15	150	122	98	73	92	35	420
FINEP	164	62	118	35	121	500	330	68	102	71	429	1000
CNPq	74,6	36,5	30,4	45,5	23	210	141,2	80	61,8	93	54	430
SEI	ND	ND	ND	ND	ND	38	ND	ND	ND	ND	ND	38
TOTAL						898						1888

NMM= New Metalic Materials

AC= Advanced Ceramics

QS= Quartz and Silicon

EP= Engineering Polymers

C= Composites

ND= not defined

Figure 12.- Area distribution of financial values

Source: "O desafio dos novos materiais", Coleçao Brasil Ciencia, No. 2, MCT, 1987

3. Constraints for the Use of New Materials

Several are the constraints imposed on a national policy regarding the development of efforts in advanced materials technology.

Besides those of a more strategic position exposed at the introduction chapt of this paper, others are:

3.1 Training and Education: The now-a-day demand for scientists, researche and engineers well trained in advanced materials technology and utiliza is lacking far most behind any supply. This holds true for the industri lized world, and in a most prominent way in the third world countries. It is recognized that education may show the most effective approach towards accelerating the development and utilization of new materials. Undergraduate courses are to be offered in a systematic basis to enginee ing, physics, and chemistry bachelors; post-graduate courses aiming to create the research and development capabilities on new materials are a must; special emphasis is to be put on faculty members training programmes.

3.2 Interdisciplinary Approach: The combined efforts of specialists from several fields of knowledge play a decisive role in project, manufacture and utilization of new materials. Sinercism, so common in nature, but seldom appreciated in scientific thinking, is the key role to understand and interpret new material designs. No distinctive ways to carry out a given project on the product and the material from which is is made is allowed in new materials developments. Such an approach however, although needed for advanced materials proper designs, is very much against the third world countries capabilities, due to their lack of qualified personnel.

3.3 Integrated Design

Advanced materials development and utilization claims for an extensive database on materials properties and capabilities in producing sophisticated software for computer modelling and simulation analysis, aiming to know how the properties of the microscopic constituents, acting in a given sinergetic environment, determine the overall behaviour of the desired product.

This constraint, again, acts against third world countries, due to their lack in qualified personnel and computing tools.

3.4 Systems Approach to Costs

One of the characteristics of advanced materials is their hight cost and it is unlikely that such a characteristic is going to change in a near to medium term foreseeable future.

The "system costs" approach, including primary materials manufacturing, utilization properties and life cycle of the product, tries to diminish the cost disadvantage of the new materials; the idea being the cost decrease from US$300 per pound to less than US$20 per pound (that actually occured to the standard high strength carbon fiber), repeating and decreasing further to the US$5 per pound range to compete satisfactorily with common metalic products (that actually is far from happening).

Two very important costs in favor of the economicity of some advanced materials, as composites, ceramics and engineering polymers, are the energy and labor costs.

3.5 Attitude toward R+D

Research and development activities are officially spoken of being very necessary and of utmost importance in almost any government official and businessman speech all over the world.

In the industrialized countries R+D is an integrated part of the running enterprise and is the responsible for maintaining the competivity of a given company and or for improving a given country's supremacy. Even in these countries R+D expenditures are heavily financed by the government.

In the third world countries, however, R+D expenditures either from government or from local industry are extremely poor, thus widening the distance from the central economies. Why is this so? Answers to this question are normally given in terms of social economical priorities: Transportation, basic health, production, etc....

Such answers do show a remarkable lack of real meaning and understanding of the role of science and technology. They are not an end per se, they are the way to overcome and reach the ultimate goals imposed by the country!

In any country and specially those of the third world a coupling of resources is a must: there are not enough facilities to be utilized for R+D purposes; there are not enough conventional and specialized equipment to deal with; and there is credibility from the industry (and government) towards local R+D groups!

What to do then? Firstly, government has to view R+D programmes not as perfunctory actions to which some illuminated people dedicate themselves for their own satisfaction; secondly, local industrial business, eager to go around and brin any "expert" they can find available,has to promote R+D projects that fit their own needs; thirdly, R+D personnel has to understand that they are not divine inspired and need to sweat in order to have credibility.

Therefore, from a national standpoint, a consortium of acticns and activities, coupling availabl≥ scientific capabilities with engineering skills, laboratory and scale-up facilities, as well testing operations, is to be carried out if any chance of success is to be assured.