Pecularities of innovation process in Russia and Siberia

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CHEMRAWN XVI conference

"Innovation: the way from pure to applied chemistry"

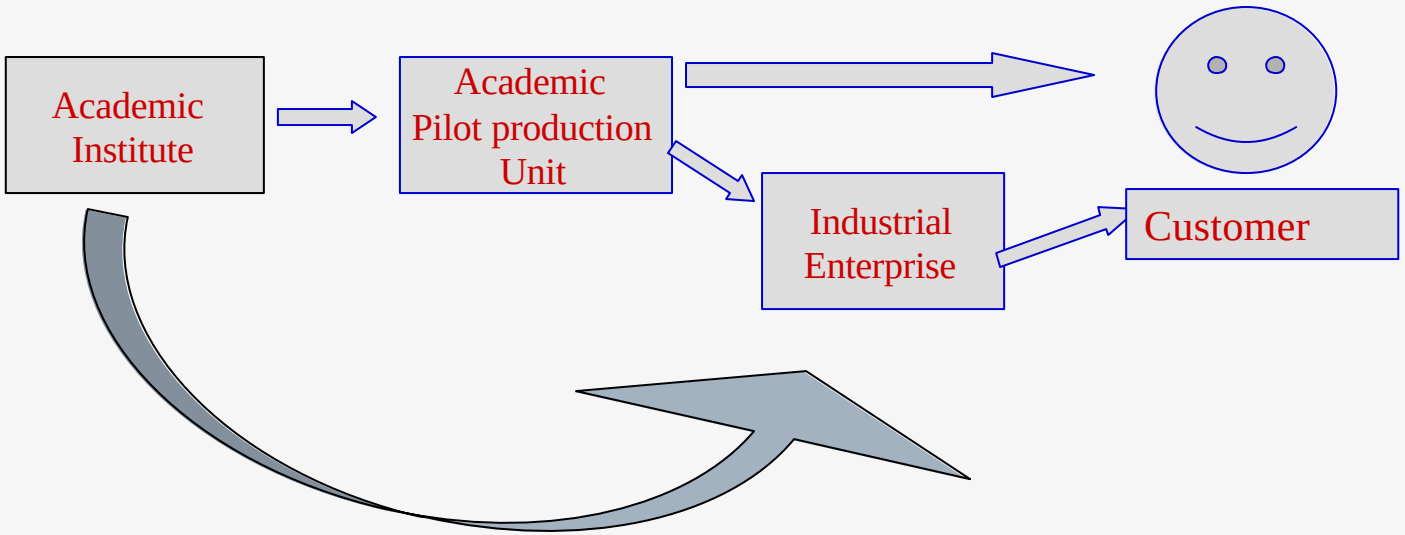
August 9, 2003, Ottawa, Canada

Plan of my talk

1. General schemes of innovation process in the USSR and in Russia
2. Role of Russian Academy o Sciences network
3. Example No 1- oxide crystals
4. Example No 2 – Power electronics
5. Conclusions

Scheme of product development and delivery in the USSR

Present scheme of product development and delivery in Russia

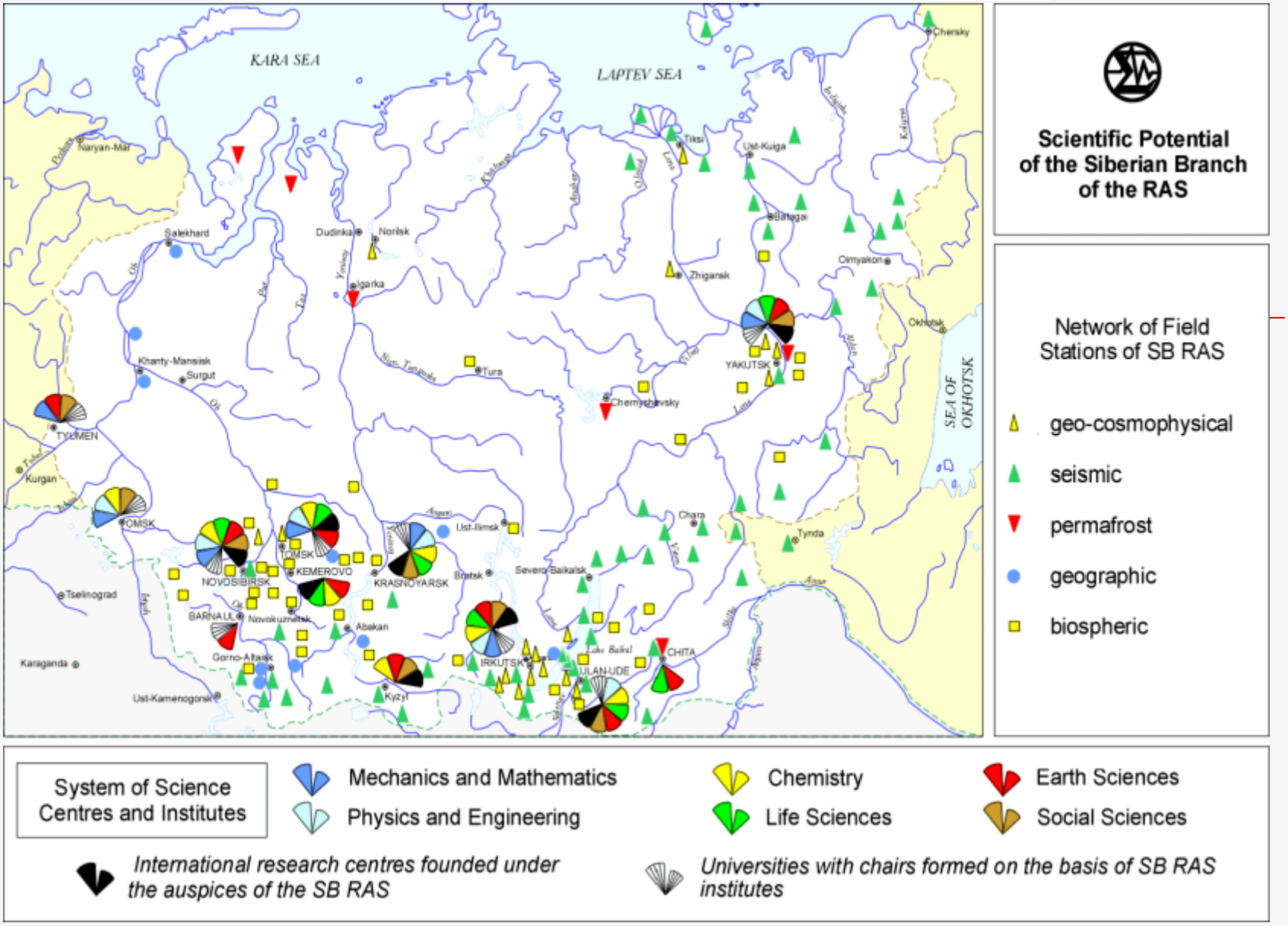


Academic cities of Russia

"Russian might will be added by Siberia and Arctic Ocean"

M.V. Lomonosov

Scientific potential of SB RAS



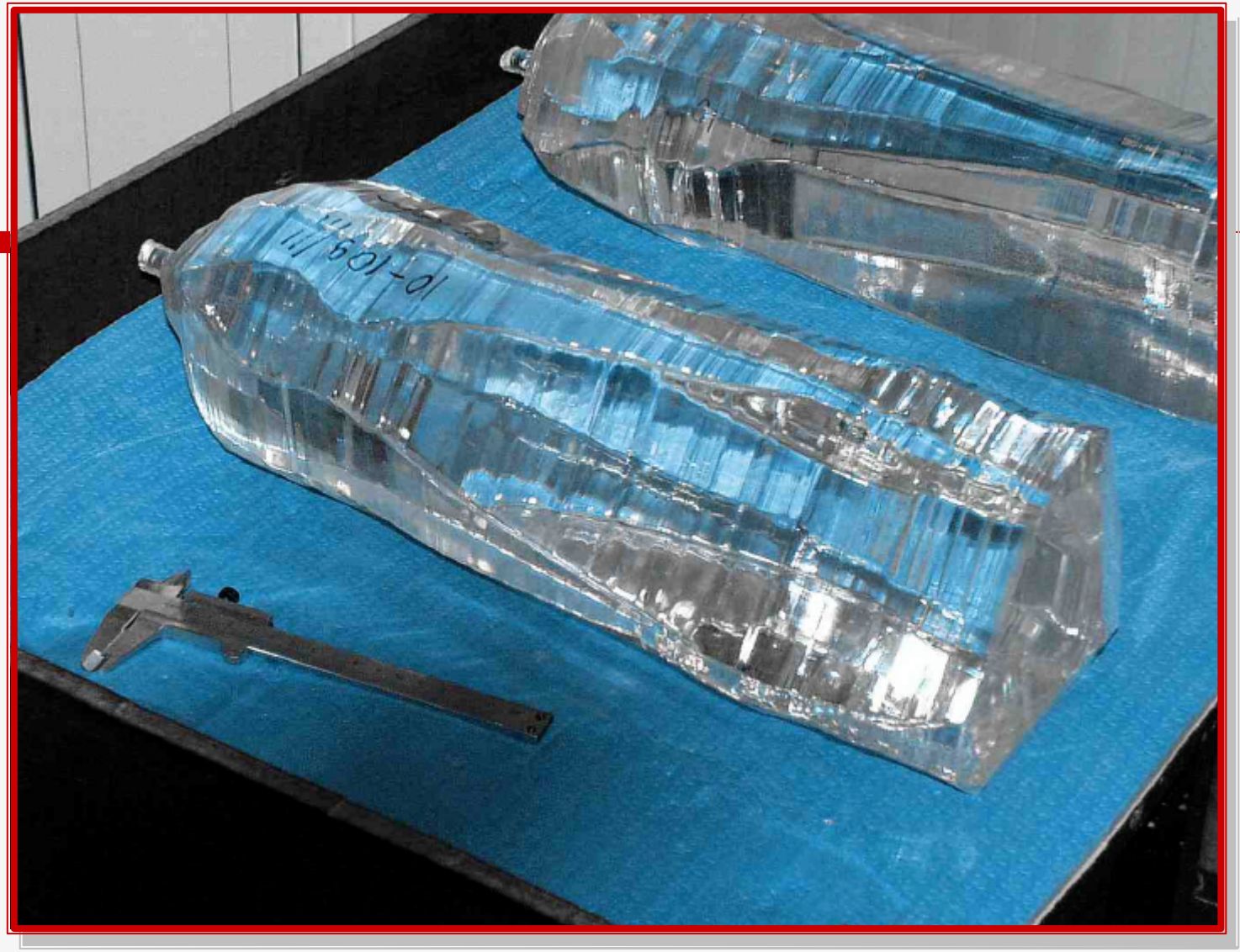
Siberia share in Russian natural resourses:

- Oil - 65%;
- Gas - 85%;
- Coal - 75%;
- Hydro-energy - 45%;
- Timber more then 50%;
- Significant deposits of ores of iron, non-ferrous metals, noble metals, diamonds

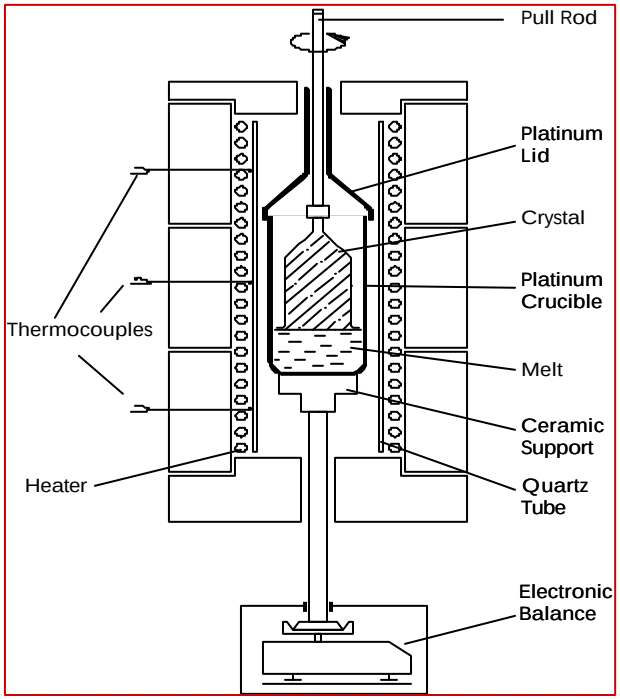
Some Statistics

	Russia	Siberia	Canada	USA	CHINA
Area, (sq.km)	**17075**	**9653**	**9976**	**9373**	**9597**
Population, (x1000)	**148306**	**25530**	**28434**	**263814**	**1.203097**
Population density (mep/sq.km)	**8,7**	**2,7**	**2,9**	**28,1**	**125,4**

Example No 1- oxide crystals



The General Features of the LTG Cz Technique



- During the entire process the grown crystal stays inside the crucible
- Weighing control at all the stages of the process including the seeding
- Temperature gradients within 0.05-1.0 deg/cm. Temperature fluctuations in the melt, usually causing crystal inhomogeneities, are practically not developed
- Evaporation and decomposition processes are suppressed by the pipe socket, which works as a diffusion barrier
- The faceted interface develops and layered growth mechanism prevails

NEW LASER MATERIALS

TUNGSTATES: $M^{+}Ln(WO_4)_2$, M=Na, K, Cs; Ln=Y, La, Nd, Gd, Ho, Er

Formula	Crystal type	Temperature of growth, C^0	Method of growth	Crystal size (mm)	Laser parameters
KY(WO4)2	Monoclinic "a-$KY(WO_4)_2$" type I 2/c	1017	Fluz-Cz	40X40X80	Nd; λ=1.0688 mkm, $\Delta\nu_{Lum}$=20 cm^{-1}, σ=4.1x10^{-19} cm^{-2}
KGd(WO4)2		1005	Fluz-Cz	70X70X150	Nd; λ=1.0672 mkm, $\Delta\nu_{Lum}$=24 cm^{-1}, σ=4.3x10^{-19} cm^{-2}
KDy(WO4)2		1025	Fluz-Cz	30X30X80	
KHo(WO4)2		1025	Fluz-Cz	20X20X60	
KEr(WO4)2		1040	Fluz-Cz	20X20X60	Er: λ=2.8070 mkm
KLu(WO4)2		1025	Fluz-Cz	20X40X100	Nd; λ=1.0702 mkm, $\Delta\nu_{Lum}$=11.5 cm^{-1}, σ=3.3x10^{-19} cm^{-2}
RbNd(WO4)2		830	Fluz-Cz	10X20X30	Nd; λ=1.0650mkm, $\Delta\nu_{Lum}$=20 cm^{-1}, τ=10 msec
RbGd(WO4)2		820	Fluz-Cz	10X10X10	
RbDy(WO4)2		825	Fluz-Cz	10X15X20	
CsLa(WO4)2	Tetragonal γ-$RbPr(MoO_4)_2$ P_{nnn}	1035	Fluz-Cz	∅10X30	Nd; λ=1.0575 mkm, $\Delta\nu_{Lum}$=3 cm^{-1}, σ=1.7x10^{-18} cm^{-2}
Na5Nd(WO4)4	Tetragonal Scheelite $Ca(WO_4)_2$ I 4s/a	735	Fluz-Cz	15X20X20	Nd; λ=1.0630 mkm, τ=90 msec, σ=2.4x10^{-19} cm^{-2}

NEW LASER MATERIALS

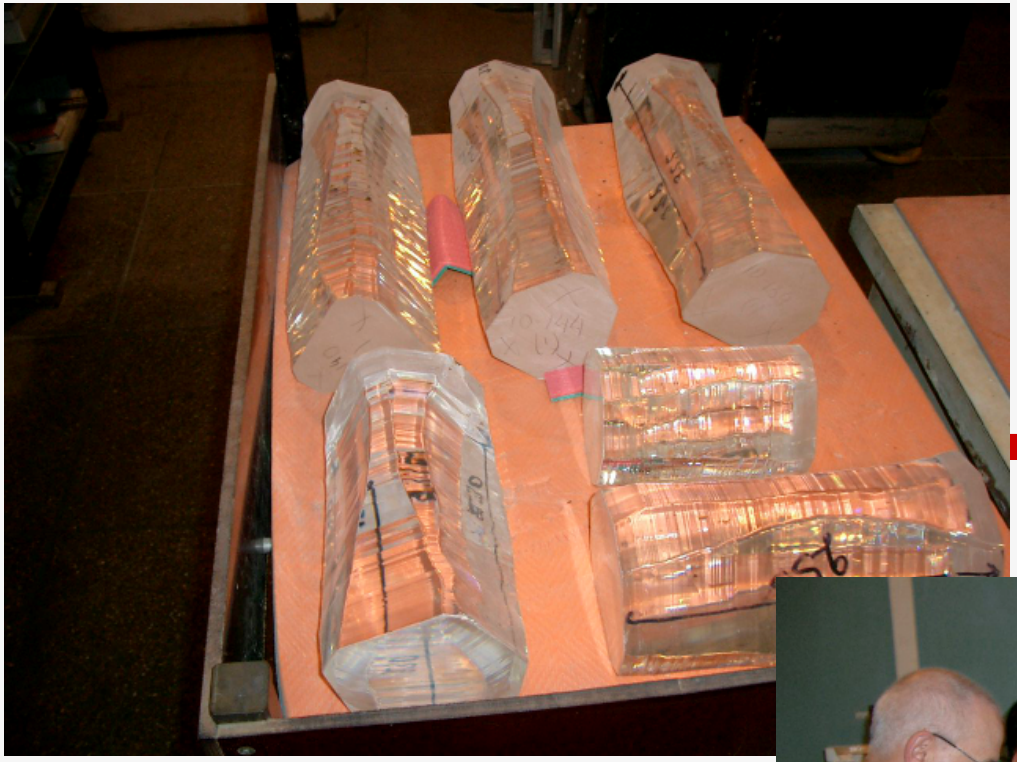
MOLYBDATES: $M^{+}Ln(MoO_4)_2$, M=Na, K, Cs; Ln=Y, La, Nd, Gd, Ho, Er

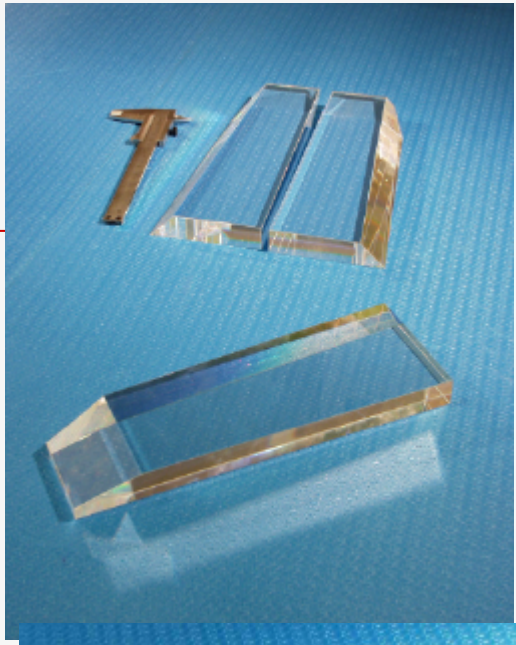
Formula	Crystal type	Temperature of growth, C^0	Method of growth	Crystal size (mm)	Laser parameters
$NaLa(MoO_4)_2$	Tetragonal Scheelite, CaWO4 I 4 1/2	1163	Melt-Cz	60x60x150	Nd; l=1.0653 mkm, Dn_{Lum}=50 cm^{-1}, s=3,3x10^{-19} cm^{-2}
$NaGd(MoO_4)_2$		1170	Flux -Cz	10x20x20	Nd; l=1.0667 mkm, Dn_{Lum}=45 cm^{-1},
$NaY(MoO_4)_2$		1110	Flux-Cz		Nd; l=1.0674 mkm, Dn_{Lum}=45 cm^{-1},
$KLa(MoO_4)_2$		1050	Melt-Cz		Nd; l=1.0587 mkm, Dn_{Lum}=48 cm^{-1},
$KY(MoO_4)_2$	Rhombic mica-like structure of $KY(MoO_4)_2$ type	970	Flux-Cz	Æ20x150	Nd; l=1.0669 mkm, Dn_{Lum}=12 cm^{-1}, s=2.0x10^{-19} cm^{-2}
$KHo(MoO_4)_2$		965	Flux-Cz	Æ30x20	
$KEr(MoO_4)_2$		955	Flux-Cz	Æ30x20	
$KGd(MoO_4)_2$	Triclinic of a-$KEu(MoO_4)_2$ type P_1	860	Flux-Cz	2x5x20	
CsNd(MoO4)2	Rhombic mica - like structure of $CsPr(MoO_4)_2$ type P_{ccm}	980	Flux-Cz	Æ30x15	Nd; l=1.0638 mkm, Dn_{Lum}=20 cm-1, t=5 msec
CsGd(MoO4)2		1030	Flux-Cz	Æ30x15	

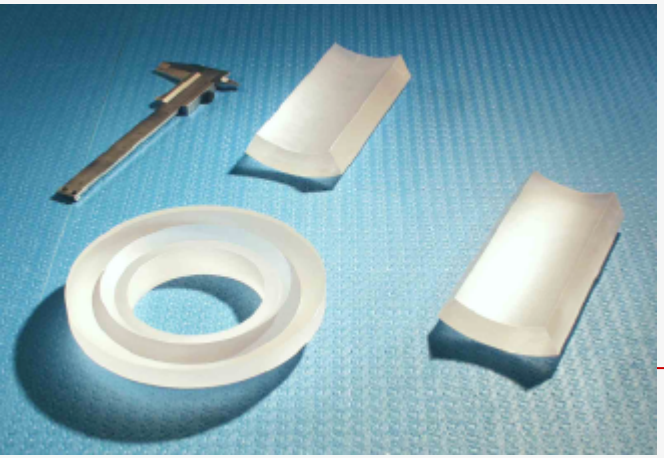
Nd-doped Potassium Gadolinium Tungstate Single Crystals

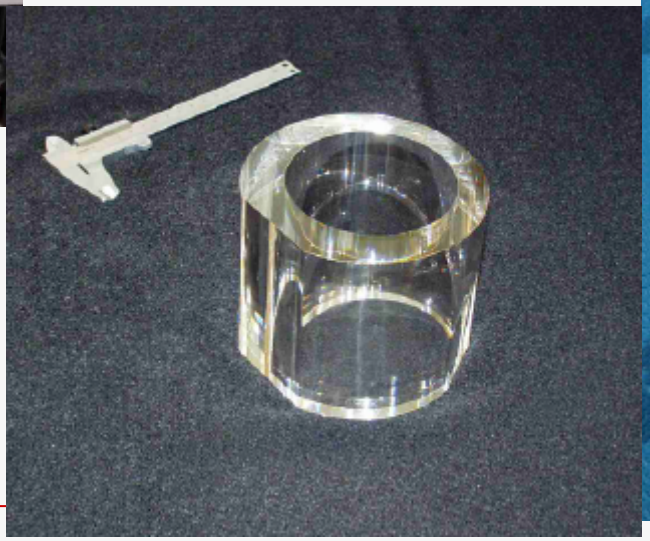
a-$KGd(WO_4)_2$ - Nd^3 (KGW:Nd)

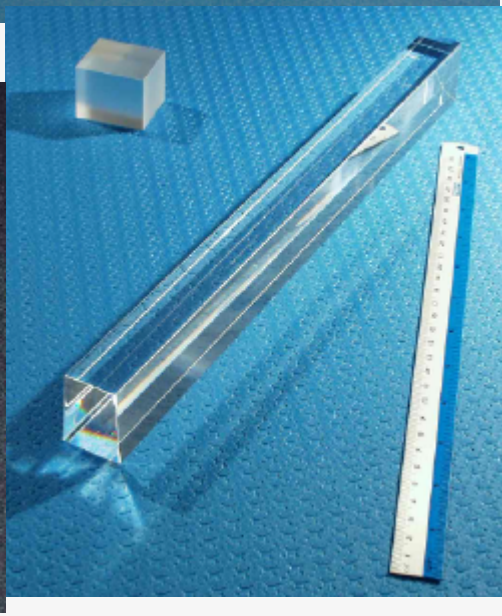
BGO crystals











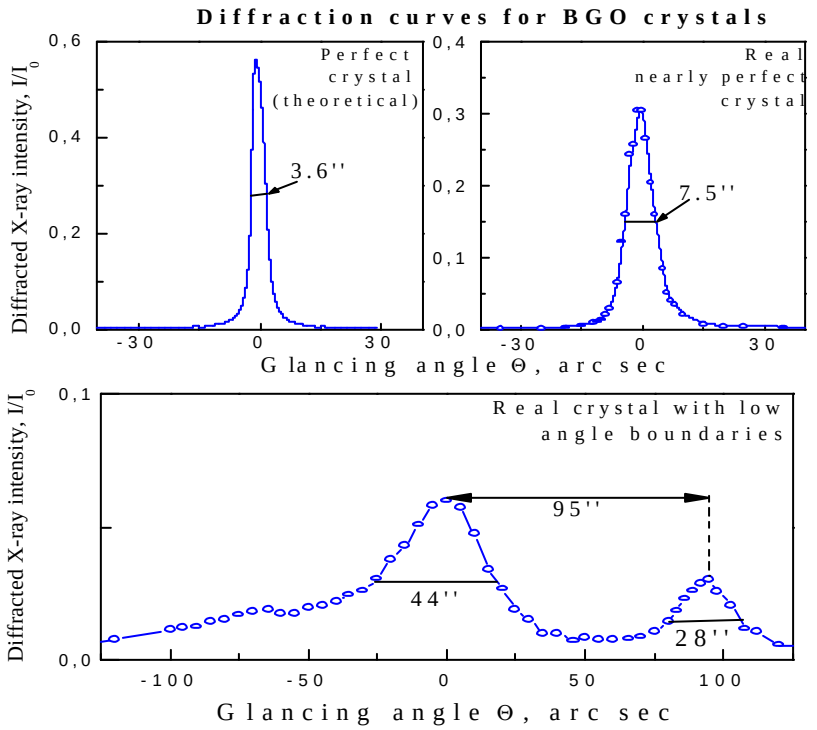
of the Imager IBIS as one of two main gamma-ray instruments on board of the ESA mission INTEGRAL - The International Gamma-Ray Astrophysics Laboratory.

- The area to be shielded is about 8000 cm^2
- 20 krad radiation environment (induced by ionizing particles) for the lifetime of 5 years
- Due to features of light collection, top-quality transmission properties are needed.

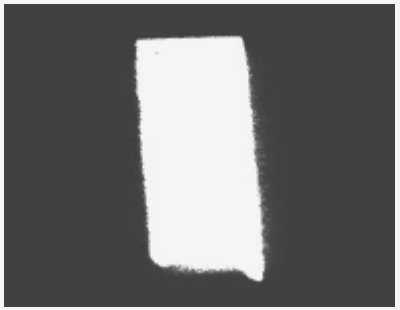
Attenuation length has to be better than 3 m

[P. Ubertini et al., The IBIS Telescope On Board INTEGRAL, Proc. 2nd INTEGRAL Workshop, 1997, ESA SP-382, p. 599;
http://www.ias.rm.cnr.it/ias-home/imager/imager.htm]

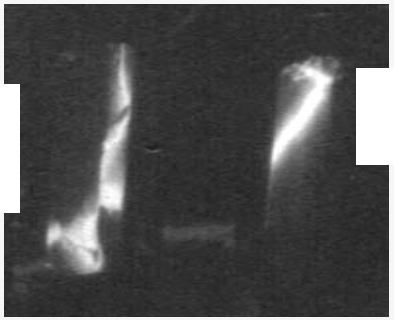
High Resolution X-RAY Diffractometric and Topographic Studies (NPL, India) of BGO Crystals Grown in IICh (Russia)



Traverse topographs

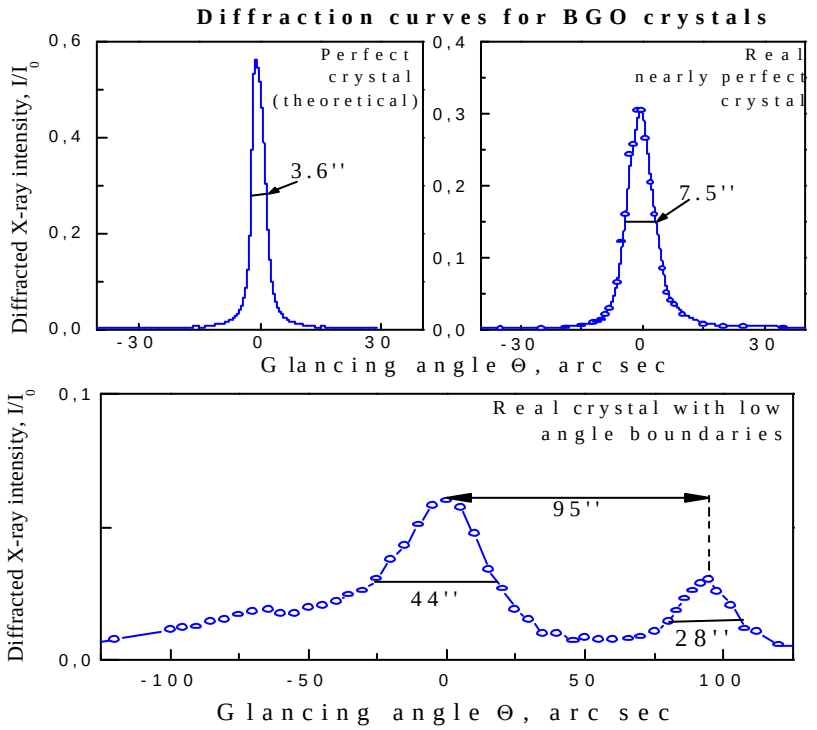


Nearly perfect crystal

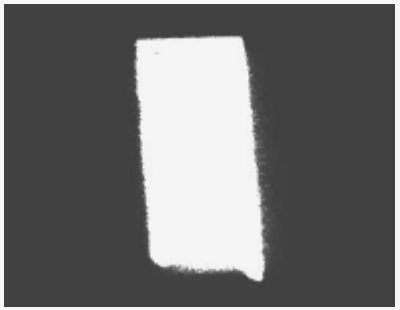


Crystal with grain boundaries

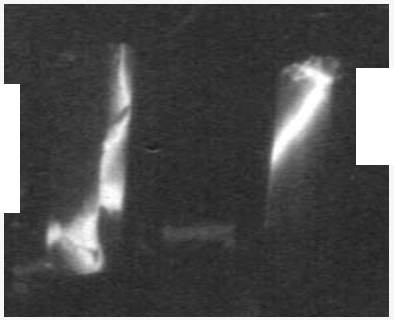
High Resolution X-RAY Diffractometric and Topographic Studies (NPL, India) of BGO Crystals Grown in IICh (Russia)



Traverse topographs

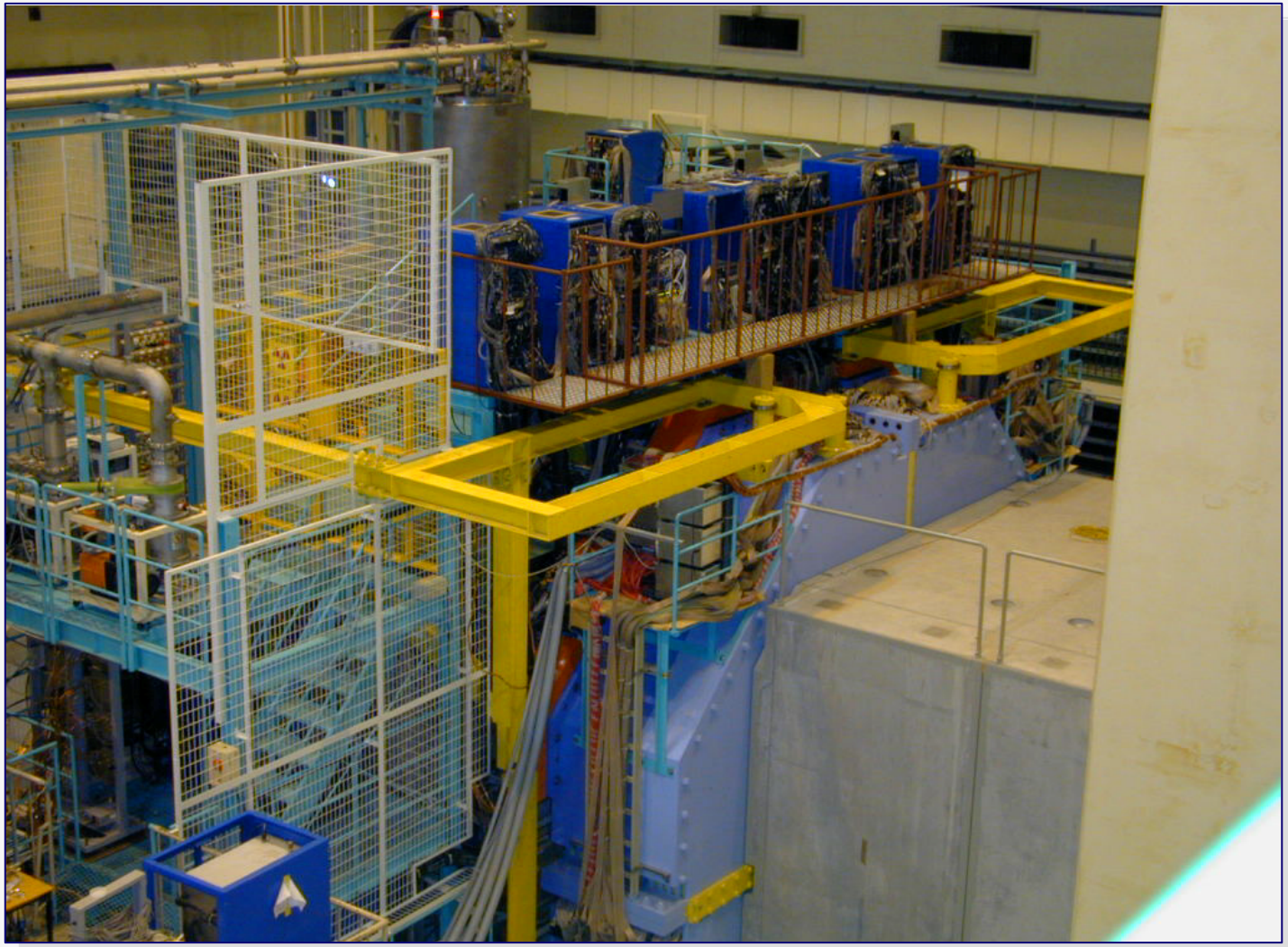


Nearly perfect crystal



Crystal with grain boundaries

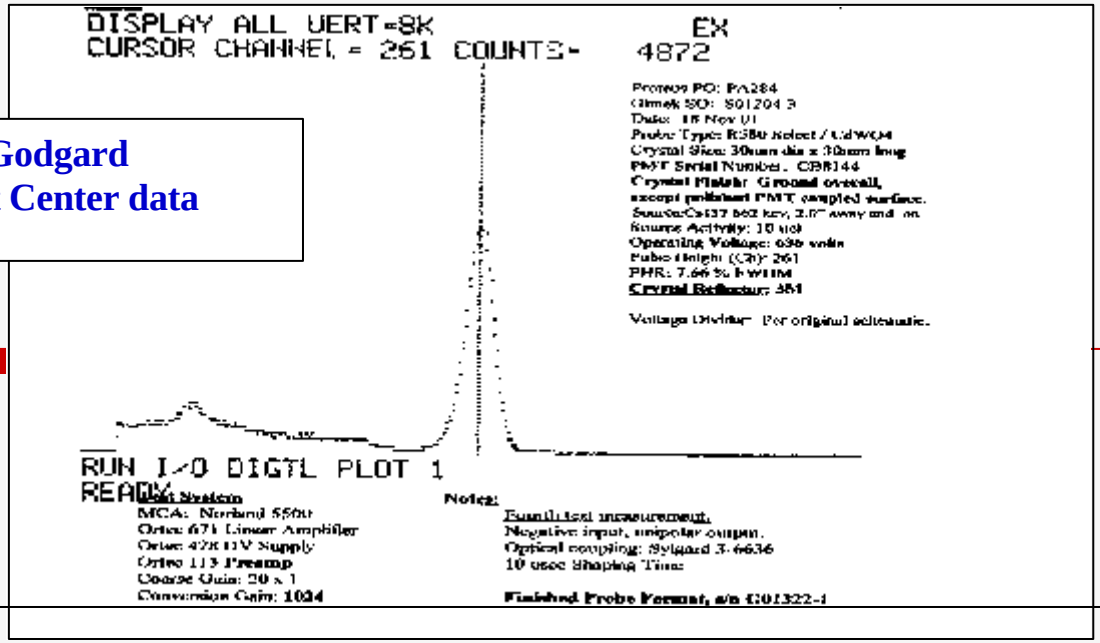
Belle detector in KEK (Tsukuba)

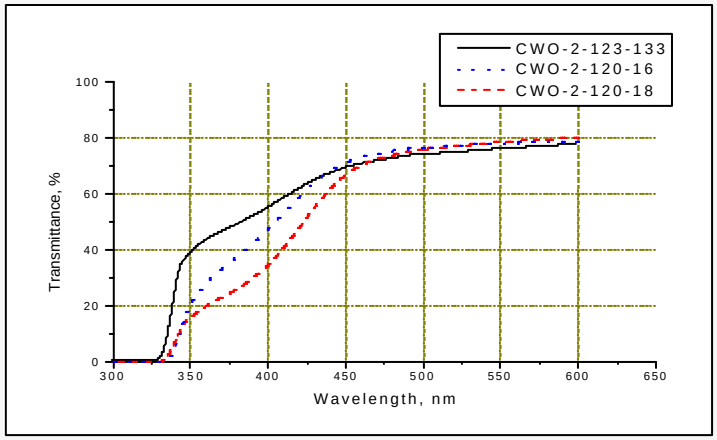


$CdWO_4$

CWO properties

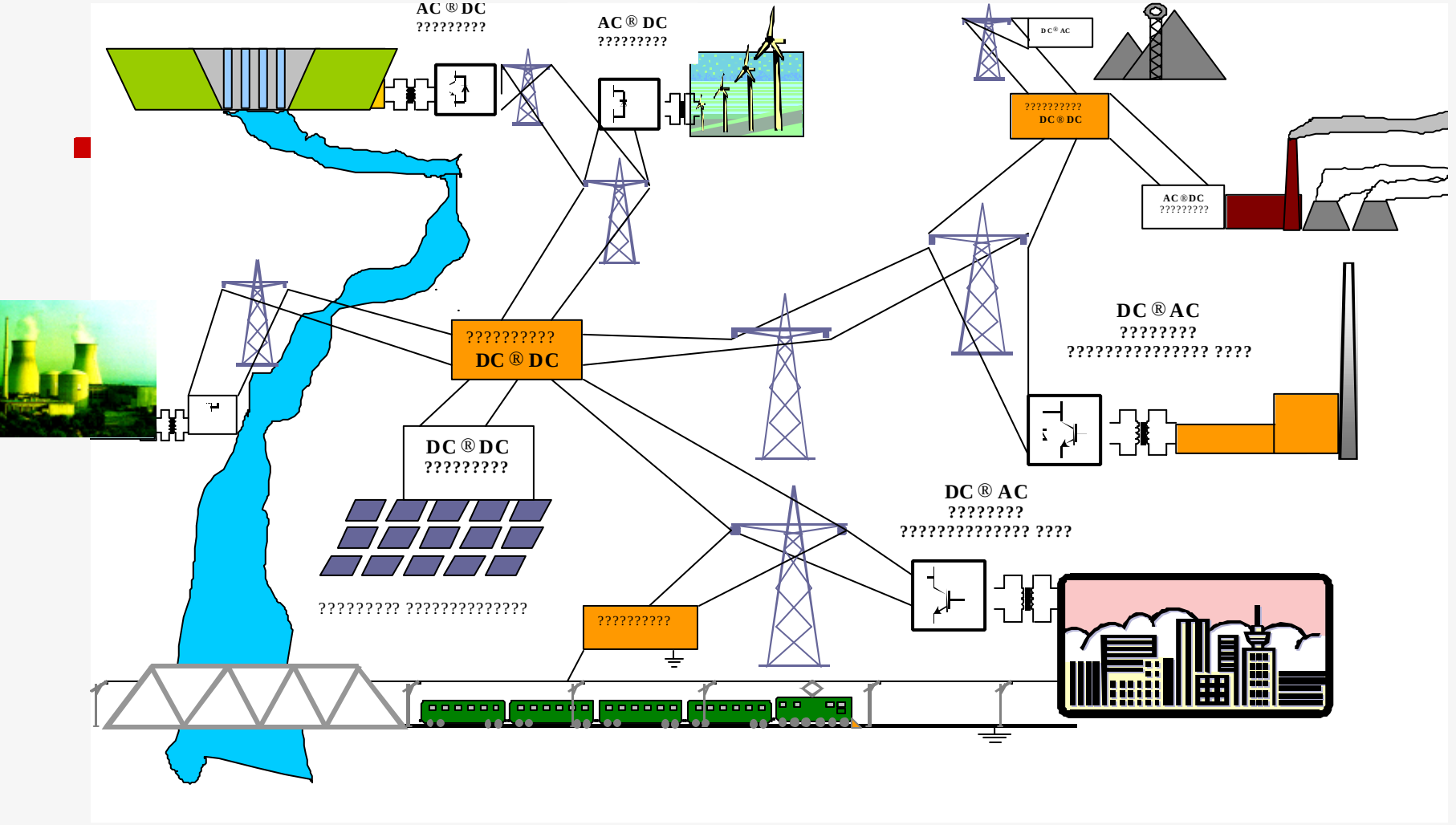
NASA Godgard
Space Flight Center data





Example No 2 – Power electronics

- Production of electricity
- Transport of electricity
- Use of electricity

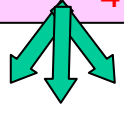


Present scheme at KMC

iO_2 → $SiHCl_3$ → Si_{Poly} + $SiCl_4$ → Si_{mono} → Si_{wafers} → $Si_{devices}$ → Si_{system}

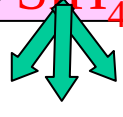
Present scheme at NCC

iCl_4 + **LiH** → SiH_4 → Si^*_{Poly} → Si^*_{mono} → Si^*_{wafers} → $Si^*_{devices}$ → $Si_{systems}$

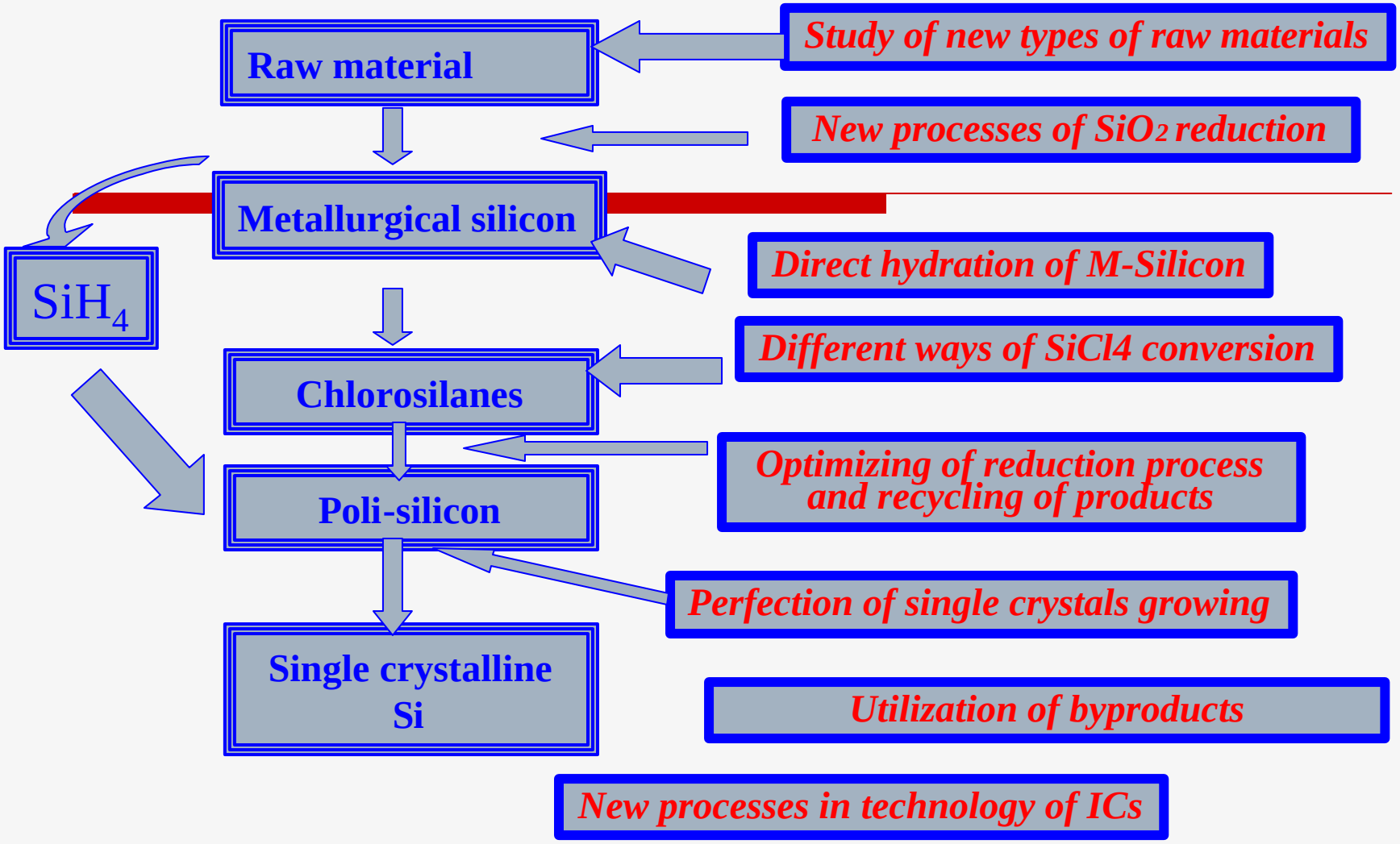


Alternative scheme at NCC

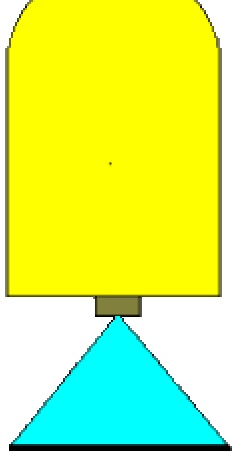
iO_2 + **LiH** → SiH_4 → Si^*_{Poly} → Si^*_{mono} → Si^*_{wafers} → $Si^*_{devices}$ → $Si_{systems}$



Contribution to Silicon processing



Conversion of $SiCl_4$ under electron beam

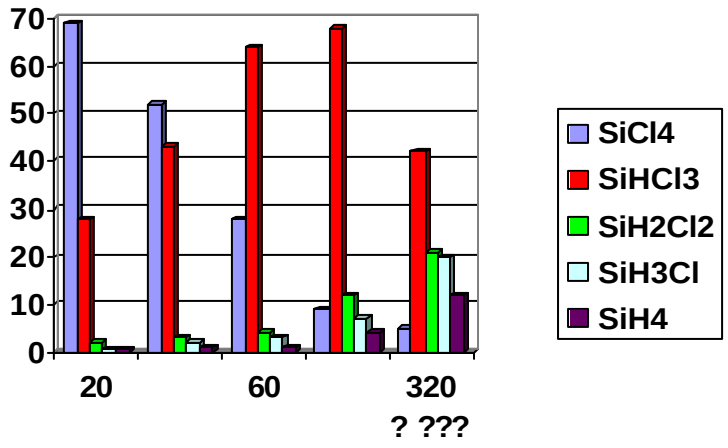


$$SiCl_4 + H_2 \rightarrow SiHCl_3 + HCl, \ldots \Delta H^\circ = 16{,}5???/??? \text{ ???}$$

$$SiCl_4 \rightarrow SiCl_3 + Cl, \ldots\ldots\ldots\ldots \Delta H^\circ = 111???/??? \text{ ???}$$

$$H_2 \rightarrow H + H, \ldots\ldots\ldots\ldots\ldots\ldots \Delta H^\circ = 105???/??? \text{ ???}$$

Content of different hydrochlorides in reaction products as a function of irradiation dose. (10 M rad= 4,1 Kcal/mol)



$SiCl_4 + H_2$

$$\downarrow \cdot \downarrow \cdot \downarrow \cdot \downarrow \cdot \downarrow \cdot \downarrow \cdot \downarrow$$

$$SiCl_4^+ + SiCl_3^+ + H^+ + H$$

$$Cl^- + ne^- + \hbar w$$

$$\downarrow \oplus \downarrow \cdot \downarrow \oplus \downarrow \cdot \downarrow \oplus \downarrow \cdot \downarrow$$

$$\downarrow * \downarrow \cdot \downarrow * \downarrow \cdot \downarrow * \downarrow \cdot \downarrow * \downarrow$$

$$SiCl_4 + SiHCl_3 + SiCl_3^+ +$$

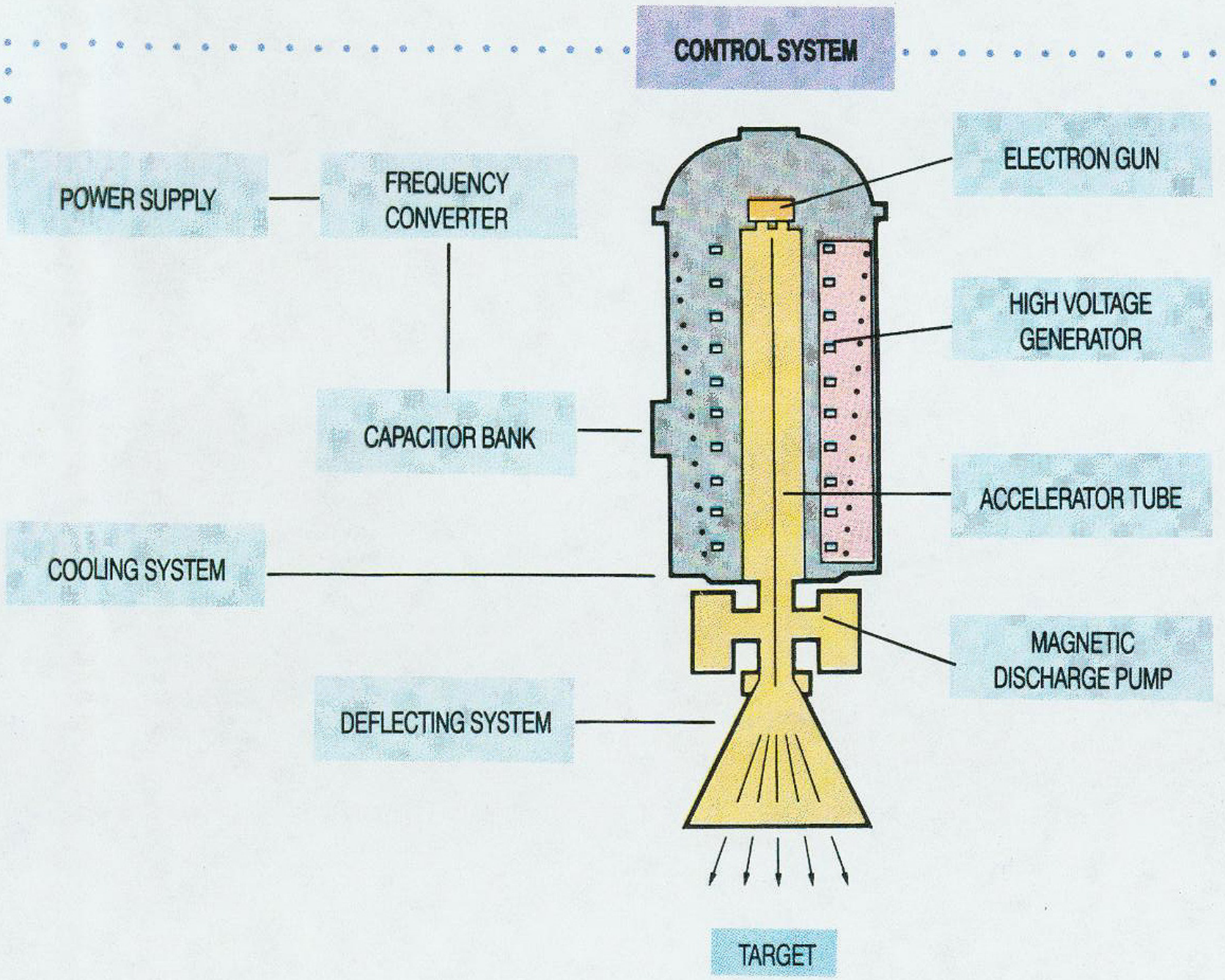
$$SiHCl_2^+ + SiCl_2^+ + SiH_2Cl_2$$

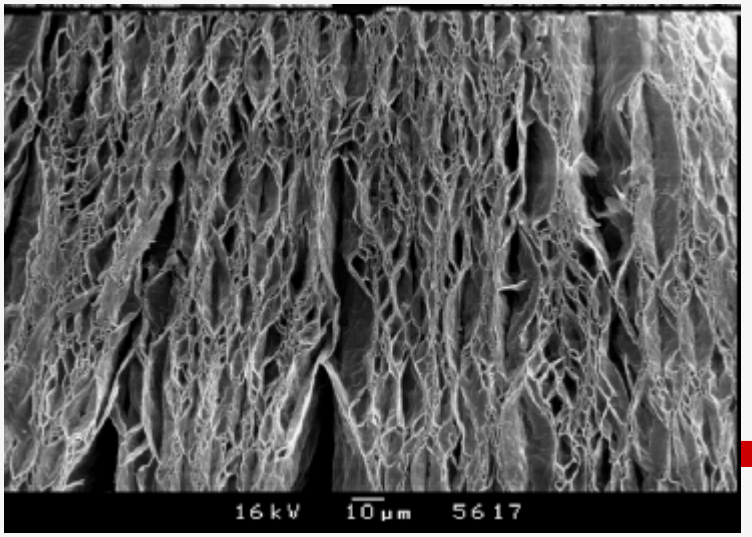
$$HCl + H^+ + H + me^- + \hbar w$$

$$\downarrow \bullet \downarrow \circ \downarrow \bullet \downarrow \circ \downarrow \bullet \downarrow \circ \downarrow \bullet \downarrow$$

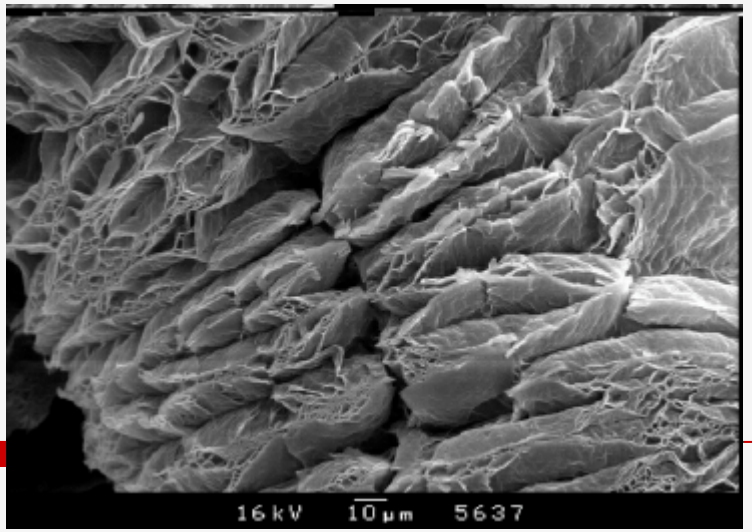
$SiHCl_3 + HCl + H_2$

$SiCl_4 + SiH_2Cl_2 + SiH_3Cl + SiH_4$


CONTROL SYSTEM
POWER SUPPLY
FREQUENCY CONVERTER
ELECTRON GUN
HIGH VOLTAGE GENERATOR
CAPACITOR BANK
ACCELERATOR TUBE
COOLING SYSTEM
MAGNETIC DISCHARGE PUMP
DEFLECTING SYSTEM
TARGET

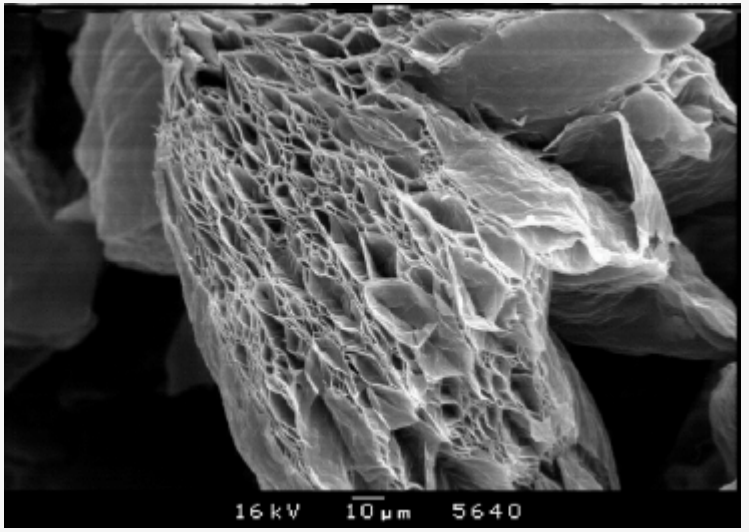


Foam of thermally expanded graphite (other angle and magnification)



Foam of thermally expanded graphite

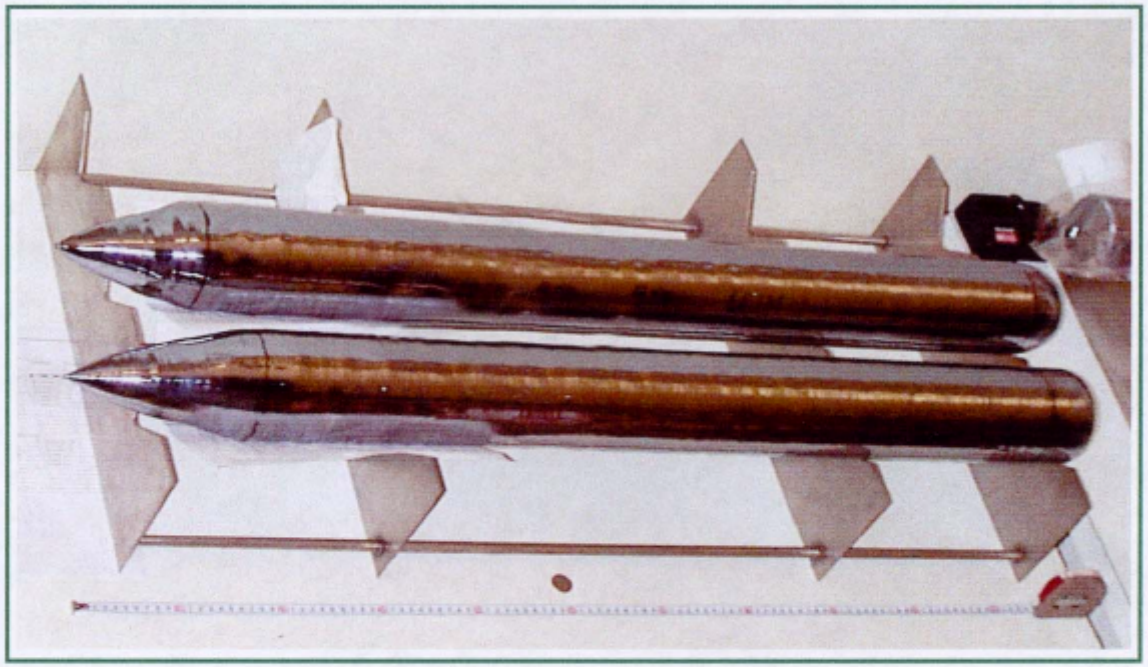
Caterpillar's particles of thermally expanded graphite



Pop corn particles of thermally expanded graphite

INSTITUTE OF SEMICONDUCTOR PHYSICS, RUSSIAN ACADEMY OF SCIENCES,
SIBERIAN BRANCH

FZ-Si crystals of 4″ diameter oriented on <111>



Crystal Parameters:

ρ=1-2 kΩ·cm

$n \leqslant 10^{12}$ cm^{-3}

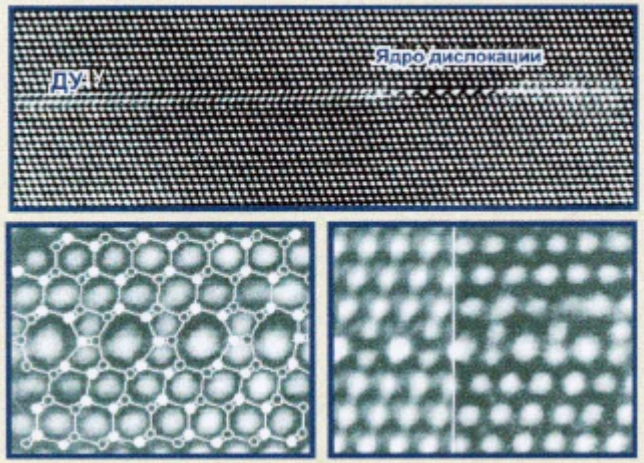
τ= (1-2)·10^{3} μs

[O], [C] < 10^{16} cm^{-3}

The relation of pull rate (v) to axial temperature gradient (G)
is nearly $2 \cdot 10^{-5}$ cm^2/sK

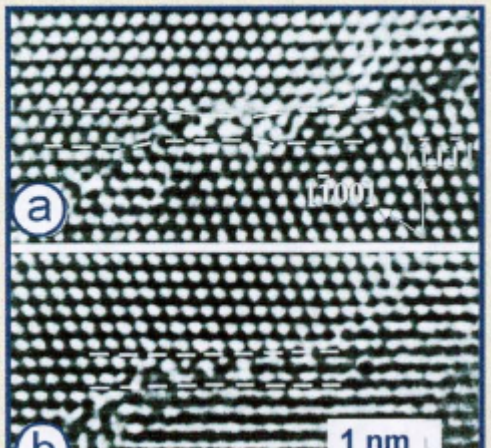
Реакции точечных дефектов в высокосовершенных кристаллах БЗП–кремния

Метастабильные конфигурации междоузельных атомов в ядре дислокации Франка в кристалле кремния

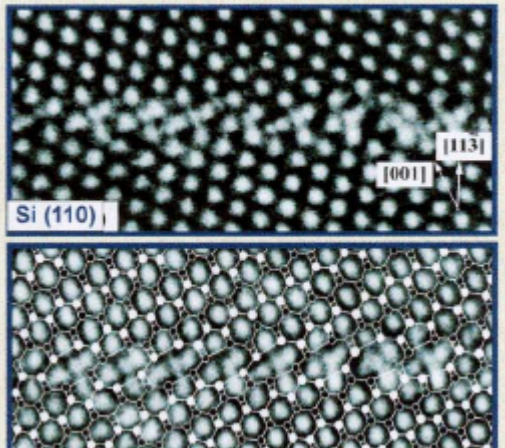


На основе in situ экспериментов по облучению полупроводниковых кристаллов электронами в ВРЭМ исследованы реакции взаимодействия точечных дефектов между собой, с атомами примесей, поверхностью и дислокациями. Установлено, что особенности этих реакций определяются метастабильными конфигурациями точечных дефектов в алмазоподобной кристаллической решетке

Последовательные стадии формирования вакансионно-междоузельного кластера в кремнии



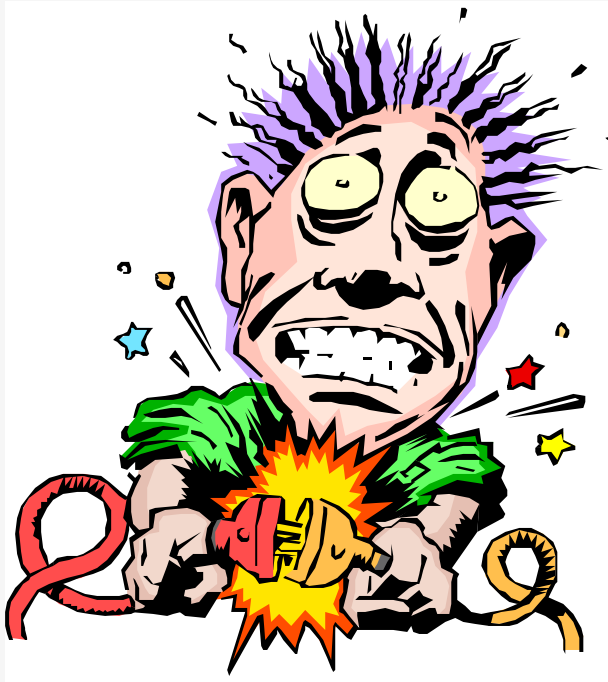
Скопление вакансий по плоскости (113) в кристалле БЗП-кремния



Divisions of Program
“Power Electronics of Siberia”

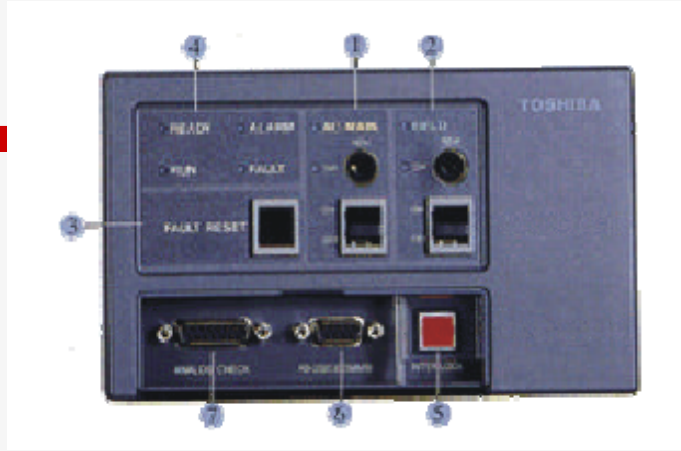
- Starting materials
- Wafers and structures
- PE devices
- PE Systems
- Application of PE

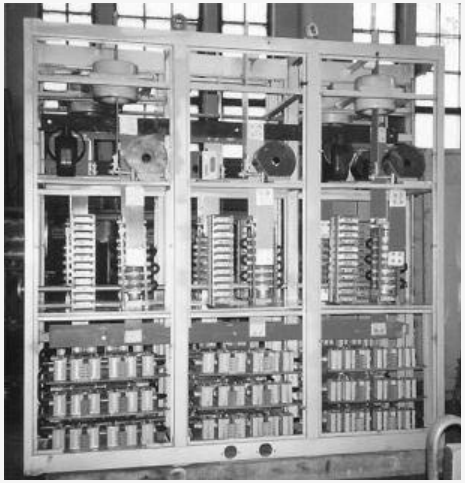
  - System planning
  - Economics
  - Legal support
  - Ecology



Systems of power electronics

Universal frequency convertors for industrial applications





Electric motors controllers ERATON

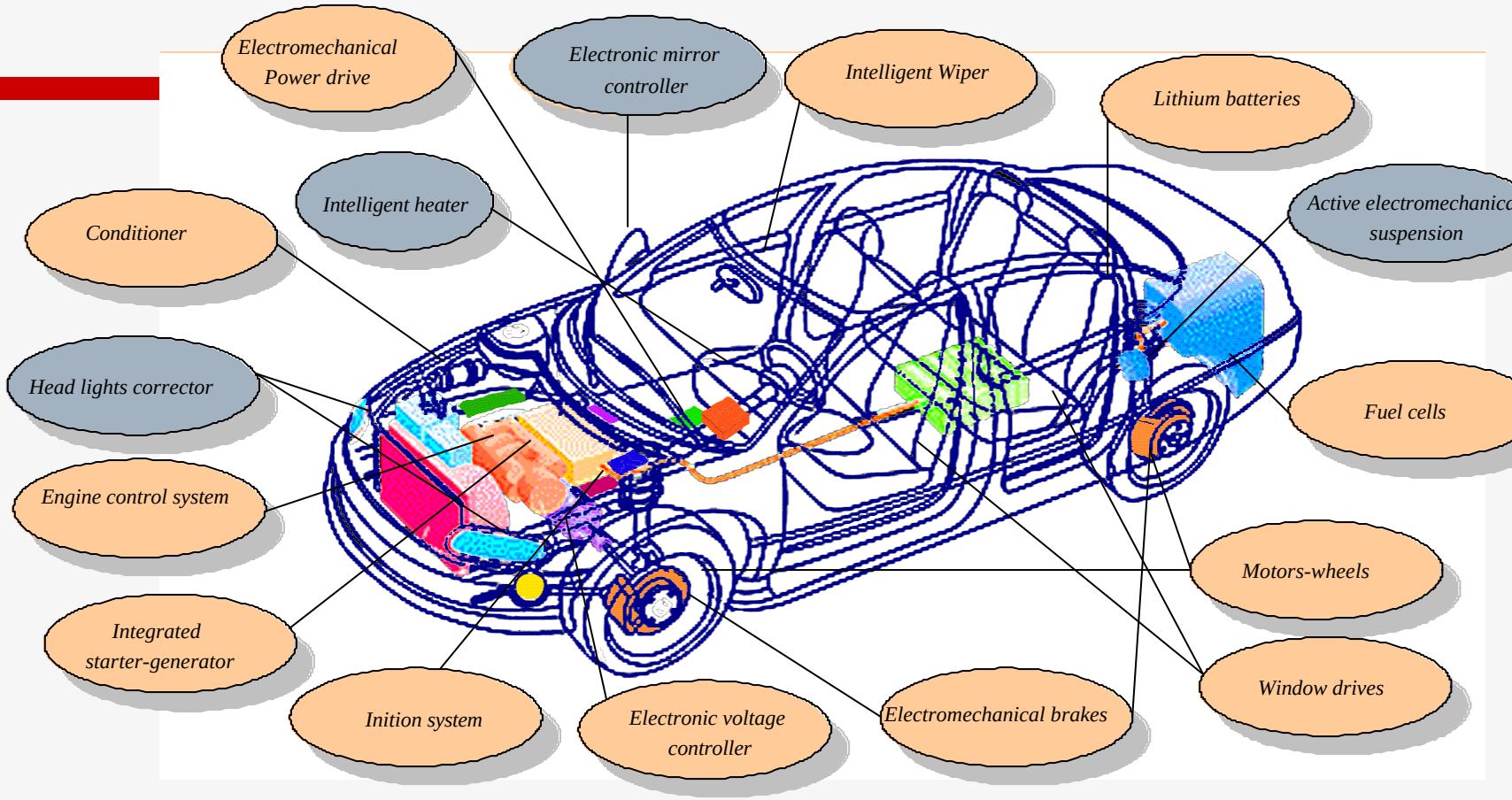
The semiconducting electric drives ERATON continuously adjust a rotational speed of AC and DC electric motors

They are used everywhere, where it is necessary to expand technical feasibilities of the equipment, to increase service life of drives, to save the electric power and raw materials, to increase productivity and quality

??????-?	??????-M4	??????-?	?????
11 – 132 ??? 1 – 45 ??	2,2 – 315 ??? 1 – 100 ??	11 – 200 ??? «??????» ?????	200–160 «??????

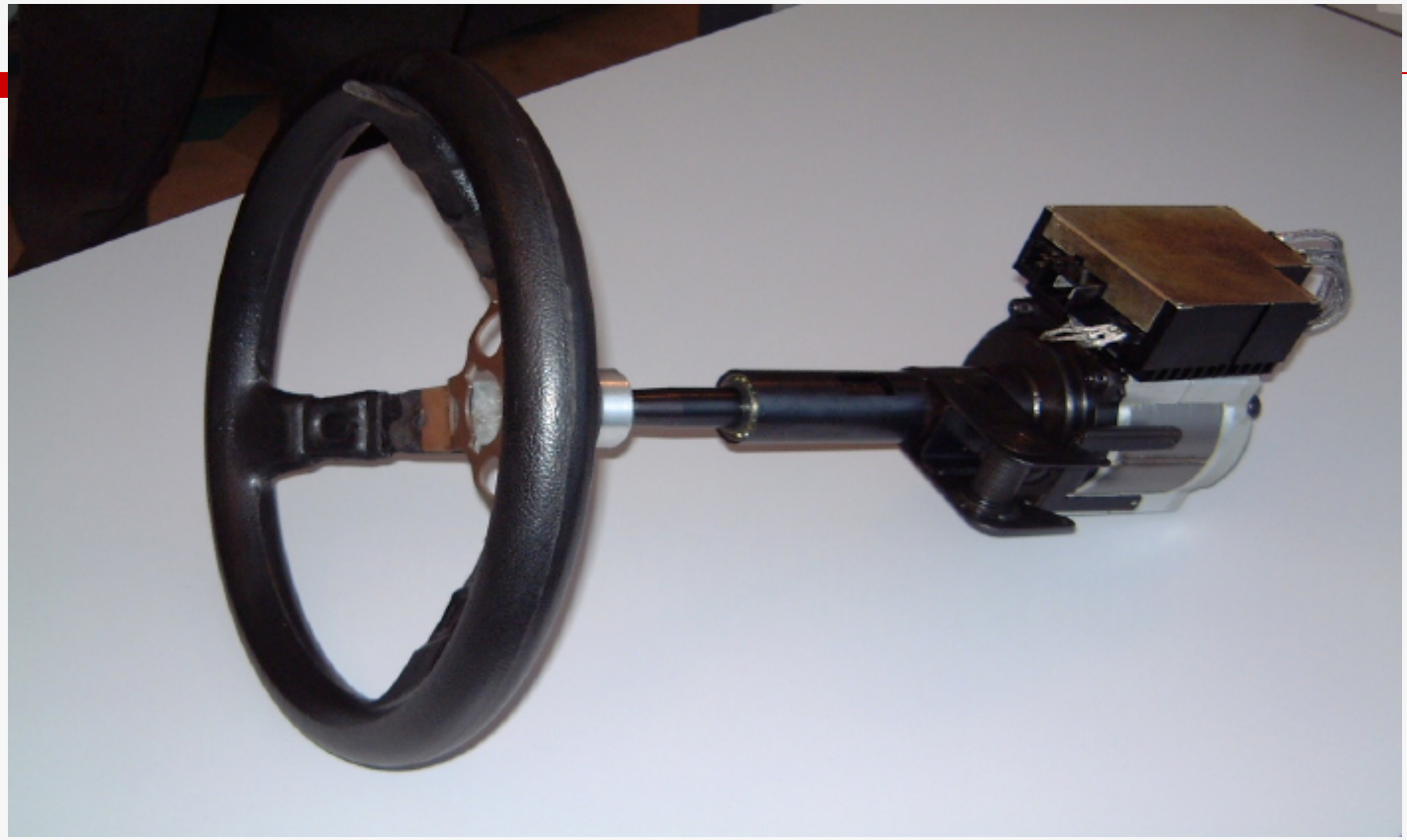
The projects in a stage of realization

(automobile electronics)

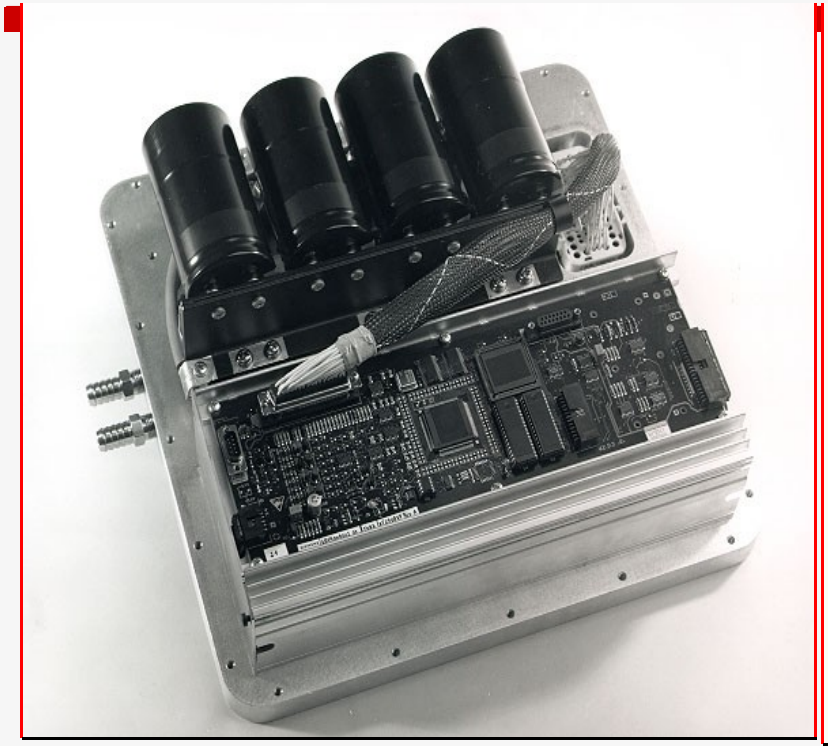


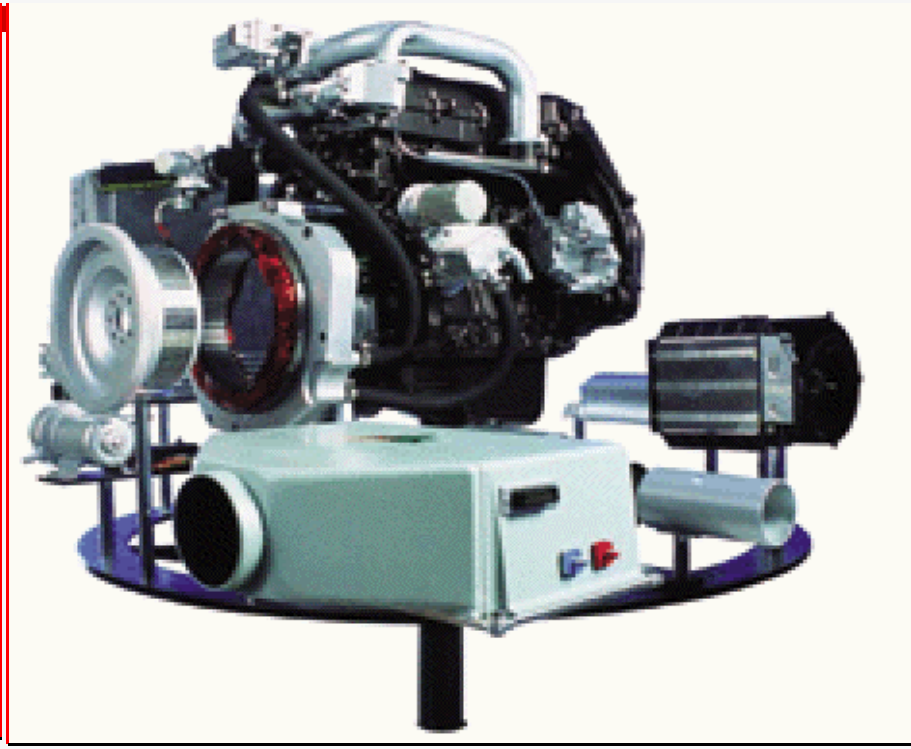
The projects in a stage of realization

electromechanical power steering



The new projects
Starter - generator

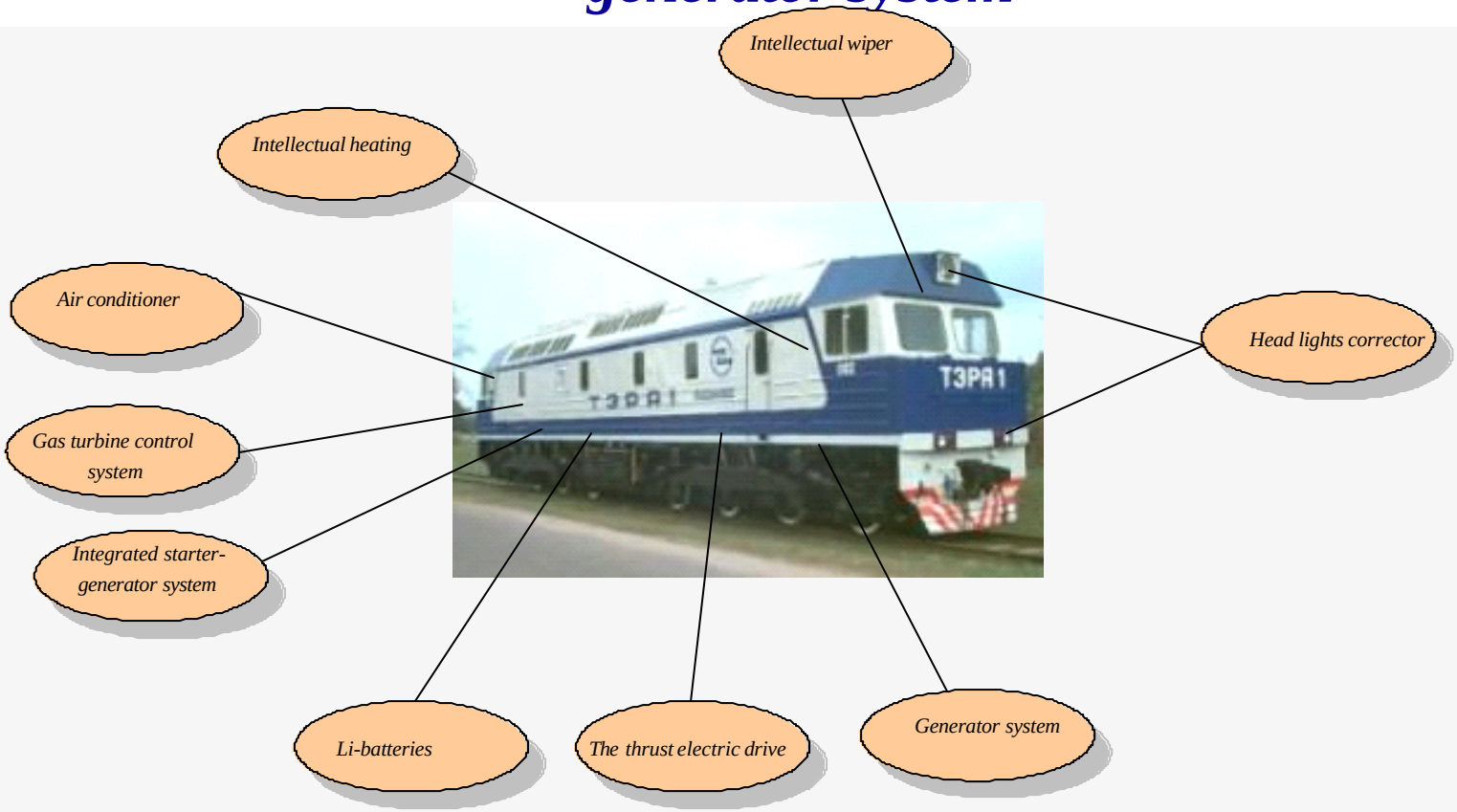




New Projects

Power electronics for Ministry of Transport

Gasturbo-locomotive: The thrust electric drive, starter-generator system



Possible directions
of International cooperation if field of POWER Electronics

High quality silicon

Thermoelectric materials

Storage batteries

Portable phone communication systems

Automobile electronics engineering

Crystal chips production

Crystal chips incapsulation

The household electrical appliences

Present main participants

? ?? ?	Novosibirsk factory Chemical concentrate (MinAtom RF)
? ? ? ? ? ? ? ? ,	Inst. Inorganic Chem. SB RAS
? ? ? ? ? ? ? ? ,	Inst. Nuclear Physics, SB RAS
??????????? ? ? ? ,	Krasnoyarsk Mining Chemical combine , MinAtom RF
? ? ? ? ? ? ? ?	Inst. Semicond. Phys. SB RAS
? ? ? ? ? ? ? - «? ? ? ?»,	JSC “NEVZ-Soyuz”
? ? ? ? ? ? ? ? ,	State enterprise “Novosibirs semiconductor devices plant”
? ? ? ? «??????»,	State enterprise “Vostok”
? ? ? ? ? ? ,	Research Inst. for power electronics
? ? ? ? ,	Novosibirsk state technical University
? ? "? ????"	Production assiciation “Sever” MinAtom RF
? ? ? "? ? ? ? ? ? ? ",	JSC “ERASIB”
? ? ? "? ? ? ? ? ? ",	Science-Production Association “ELSIB”
? ? ? ? ? ? ?,	JSC “BEMZ-Berdsk electro mechanical plant”
? ? ? "? ? ? ? ? ?? ? ? ? ? ? ",	Science-production company “Zheldortrans”
"????????????? "	JSC “SibElectroTherm”
? ? ??????????????????????"	JSC “SibStankoPrivod”
"???????????? "	JSC “Electrosignal”
? ?-? ? ? ? ? ? ? ? ? ?	Institute of economics and industrial management SB RAS
? ? ?	Institute of energy SB RAS
? ???????????? ? ? ? ? ???? ?????	Administration of Novosibirsk region and Siberian OKRUG

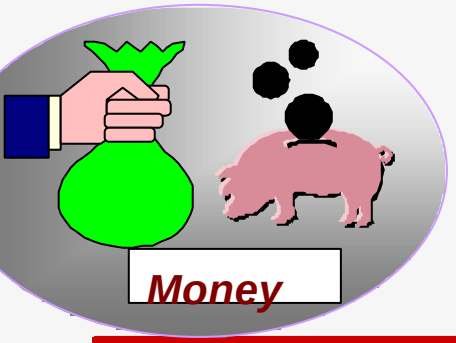
Program divisions, projects of the first step, required investments, present participants

Program divisions	Projects of the first step	Required investments (estimation)	Present main participants
Starting materials	Organizing of production of monosilane and polysilicon (up to 20 tons/year).	– 280 mln. Rubles	? ???, ??? ?? ???, ???????????? ???, ??? ?? ???, ??? ?? ???
Silicon single crystals	Organizing of pilot scale production	16 mln. Rubles	??? ?? ???
Wafers and structures	Organizing of department for production of epitaxial structures for MOSFET	- 150 mln. Rubles	???? - «????», ??? ?? ???, ??? ?? ???
Power electronics devices	**Development of new types of PE devices and organization of their production.** 1. IGBT transistors and modules,	217 mln. Rubles. ? ??? ?????: - 100 mln. Rubles.	??? ?? ???, ??? «????-????», ???? ????, ???? «??????», ??????, ????, ????? ??? ?? ???, ??? "???? - ????"
	2.Drivers for IGBT transistors with working voltage 1200 V.	- 30 mln. Rubles	??? ?? ???,???? ????, ??????,????
	3. Drives for MOSFET -	- 25 mln. Rubles.	??? ?? ???, ???? "??????", ??????, ????
	4. Development of optoelectronic devices for drivers of high voltage PE devices.	- 40 mln. Rubles	??? ?? ???, ???, ?? "?????"

		5. Development of controllers	- 23 mln. Rubles.	?????, ???? ??????, ???? «??????»
4	Power electronics systems	Modernization of some of participating enterprises in connection new products (a wide variety of PE systems including high voltage systems).	– 180 mln. Rubles	??? "??????", ??? "?????", ??? ???? ?, ?? "?????"
		Design of systems and organization of their production: 1. High voltage controllers for high power motors (more then 400 kw).	- 70 mln. Rubles	??? "?????", ?? "??????", ??? "?????????????", "????????????"
		2. Frequency converters for metal work machines. 3. Power electronics for automobiles (ignition systems, engine control systems, voltage controllers for 42 V and higher, electromechanical power steering, starter-generator system).	- 20 mln. Rubles - 150 mln. Rubles	????, ?? "?????", ?? "????????????????????" ????, ?? "?????", ?? ??? ?, ???? - «????», "????????????"
5	??????- ?????????????????? ??????	?????????, ????????, ???????? ???????????, ????????? ????????????		??-? ???? ?? ??? ??? ???????????? ??? ? ?????????

Total 1083.0 mln Rubles / 31= 35 mln USD

Program "Power Electronics of SIBERIA"



State power

Founders: *Reg. Gov.*
SB RAS
MinAtom
MinElectron.

Science

Education

Program council

Development foundation

Executive body

JSC PES

Producers

I Materials

II Devices

II I Systems

Foreign partners

Competitors

Customers

Power Electronics of Siberia –Chon International
Joint Mission, Novosibirsk, Russia, 9-14 June 2003