Semiconductor and Scintillation Materials for Radiation Detectors

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Semiconductor Detector Technologies

BSI Core Business

HPGe, Si, CdZnTe/CdTe, TlBr

$LaBr_3$, $CeBr_3$, SrI_2

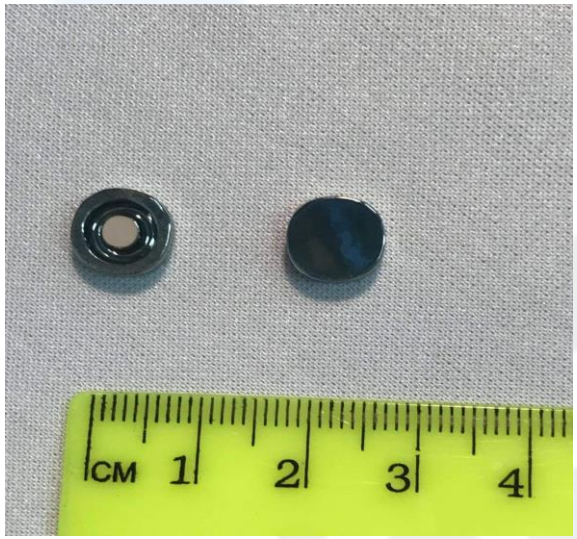
HPGe detectors- leaders in Gamma radiation registration!

3 Industrial companies in the World:

- ***Canberra (USA),***
- ***Ortec (USA);***
- ***Baltic Scientific Instruments (Latvia)***

Industrial HPGe detectors

- **Coaxial,**
- **Planar;**
- **Hemispherical.**



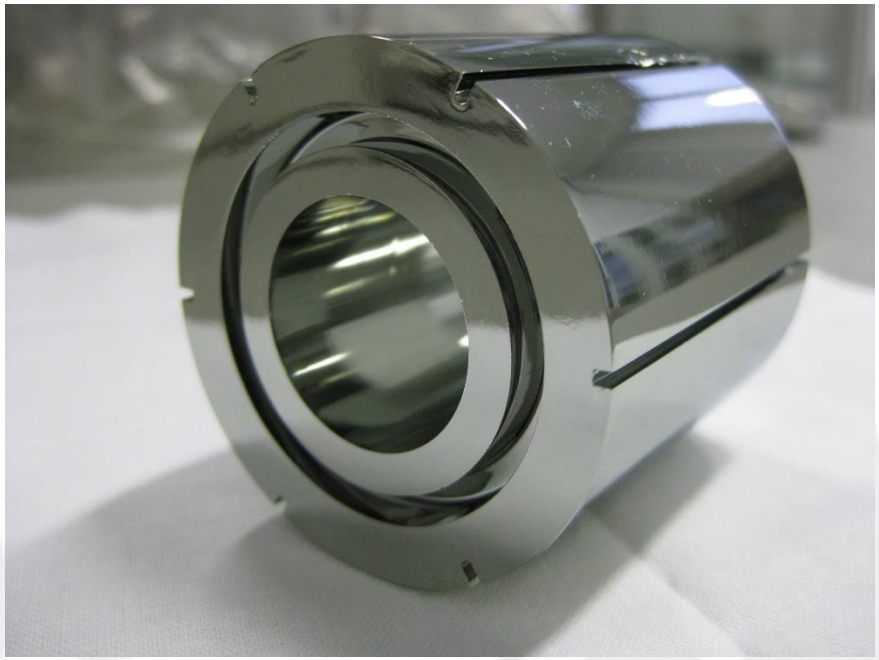
Crystal sizes: Ø (7-110) mm

Δ E = 0.8 keV at 122 keV
Δ E = 1.8 keV at 1.33 MeV

Segmented HPGe detector for Nuclear reaction study

Six-fold segmentation allows the determine direction of individual photons emitted in the nuclear reactions from a source placed inside the detector.

ΔE = 1,0 keV at 122 keV
ΔE = 1,9 keV at 1332 keV



Ultra Low Background applications

Four-crystal system for neutrino-antineutrino registration

Underground measurements

System with cooper low-background cryostat for underground laboratory of Join Research Center of EU, Geel

ΔE = 1,0 keV at 122 keV
ΔE = 1,9 keV at 1332 keV

The main task of such investigations is registration of very rare particles (1 pulse per day).

BSUIN - *Baltic Sea Underground Innovation Network*

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The gamma background radiation measuring.

The background integral count rate per kg of germanium of the HPGe-detector was 0.028 s^{-1} x kg^{-1}.

After purging the measuring chamber with nitrogen gas at a rate of 0.15 L/h the count rate was reduced to 0.021 s^{-1} x kg^{-1}.

Europe's deepest **Pyhasalmi mine (1444 m)**

Our experience in Ultra Low-Background technique with HPGe spectrometers

1. **Institute for Nuclear Research, Kiev, Ukraine**

   Underground laboratory in Solotvino Cave

2. **V. G. Khlopin Radium Institute, St. Petersburg, Russia**

   Underground laboratory in Metro ("Gostiny Dvor" station) 120 meters water equiv.

3. **National Research Centre "Kurchatov Institute", Moscow, Russia**

   Multi-crystal HPGe detector with active shield

4. **Institute of Theoretical and Experimental Physics, Moscow, Russia**

   HPGe detectors for GEMMA experiments at Kalinin NPP, 70 meters water equiv.

5. **Joint Institute for Nuclear Research, Dubna, Russia**

   HPGe spectrometers for research applications

6. **Joint Research Centre of EU, Institute for Ref. Materials and Measurements, Geel, Belgium**

   Underground laboratory in HADES

7. **CEA Saclay, Gif-sur-Yvette, France**

   Edelweiss experiment - Black matter search project

8. **Max-Planck-Institut für Kernphysik, Heidelberg, Germany**

   Black matter search project

9. **Tsinghua University, Beijing, China**

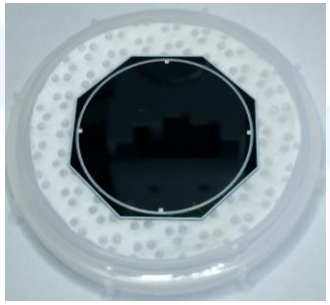
   Black matter search project

Si Ion-Implanted Detectors

I = (1 ÷40) nA

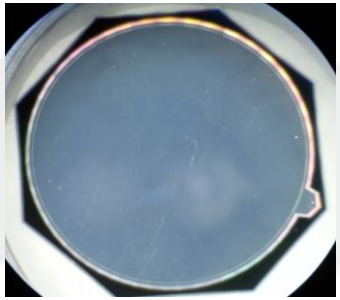
S_{active} = (50 ÷ 1200) mm^2

ΔE = (12 ÷ 35) keV



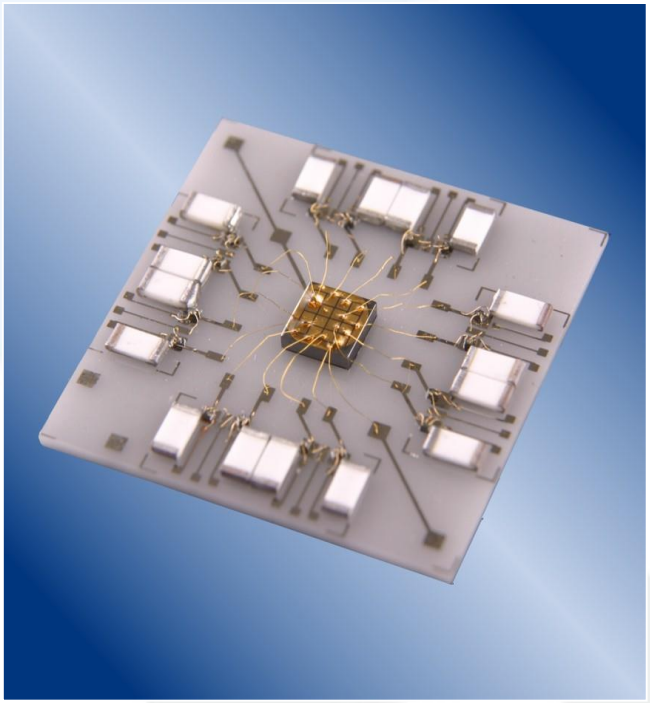
Open entrance window

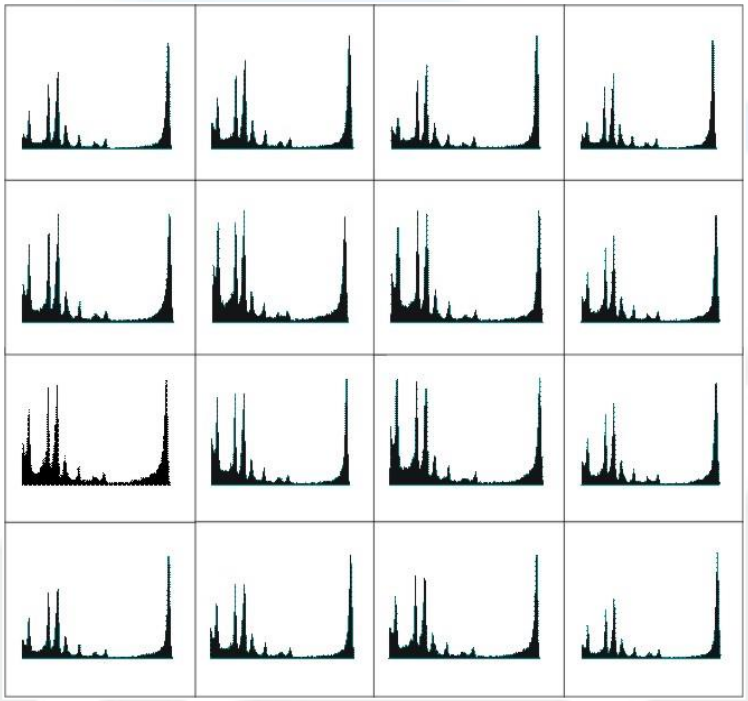
Metalized entrance window



Protected entrance window

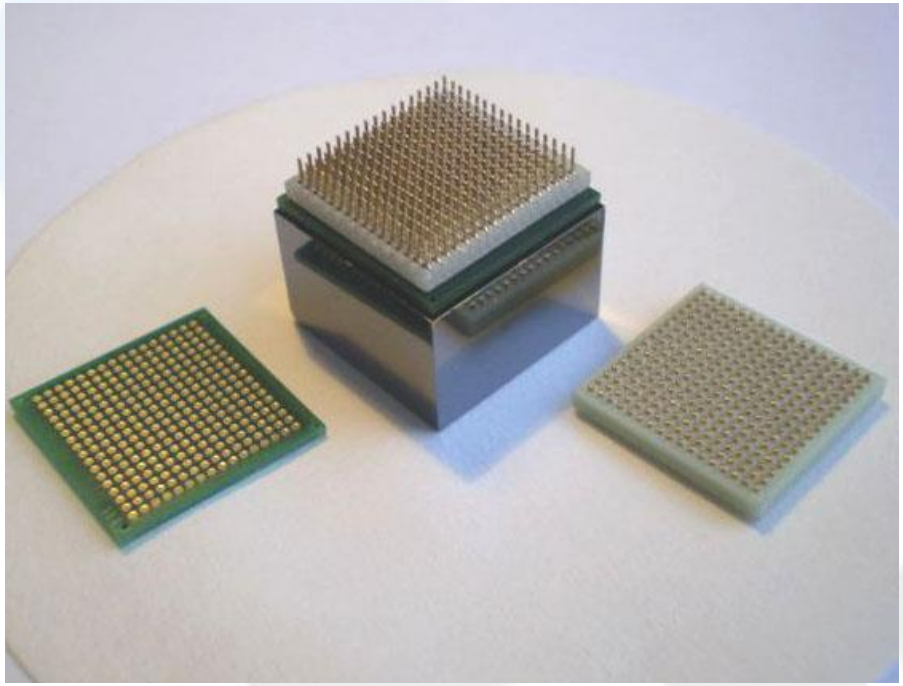
CdZnTe (4x4) Pixel Detectors



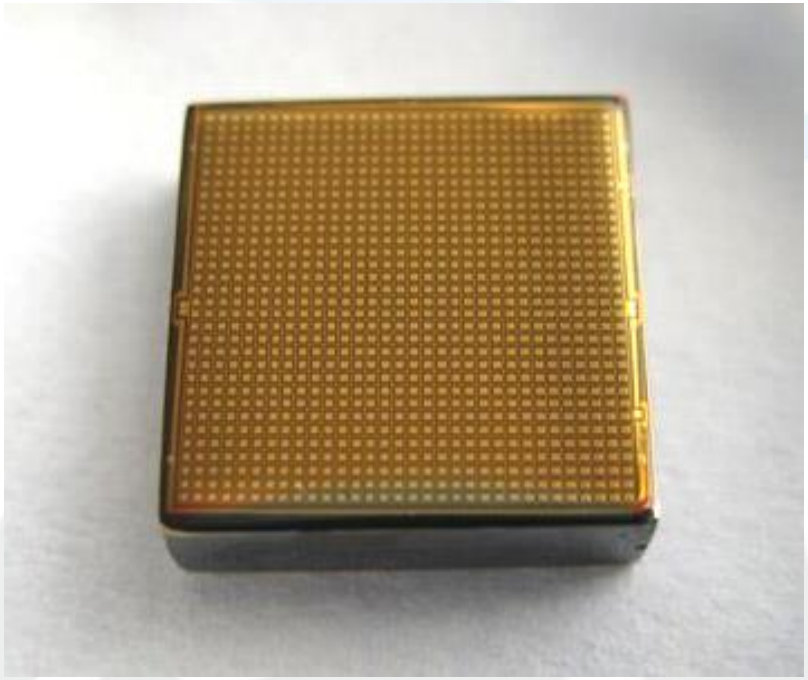


- *High spectrometric performance from pixel to pixel*
- *Imaging in medicine and industry*
- *Space research applications*

CZT Pixel Detectors

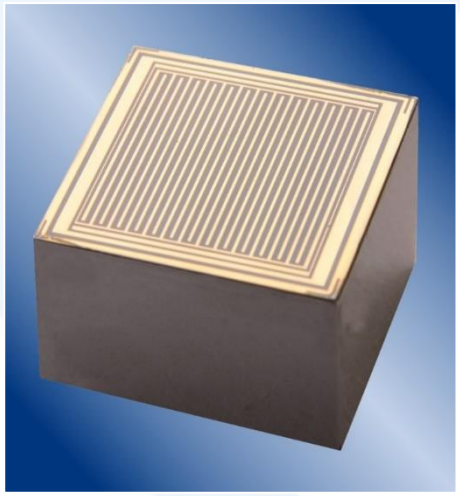


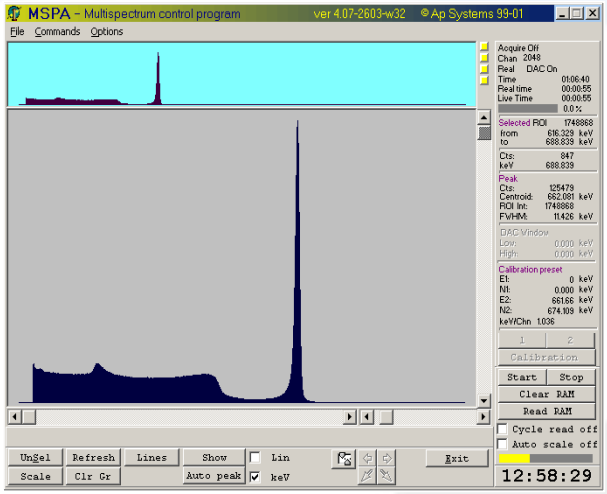
16x16 pixel detector based on crystal (15x15x10) mm^3

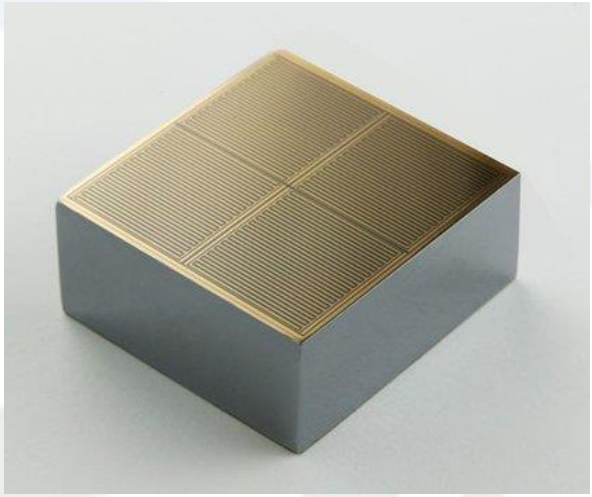


32x32 Pixel Detector based on crystal (12 x 12 x 5) mm^3

CdZnTe Co-planar Grid Detectors





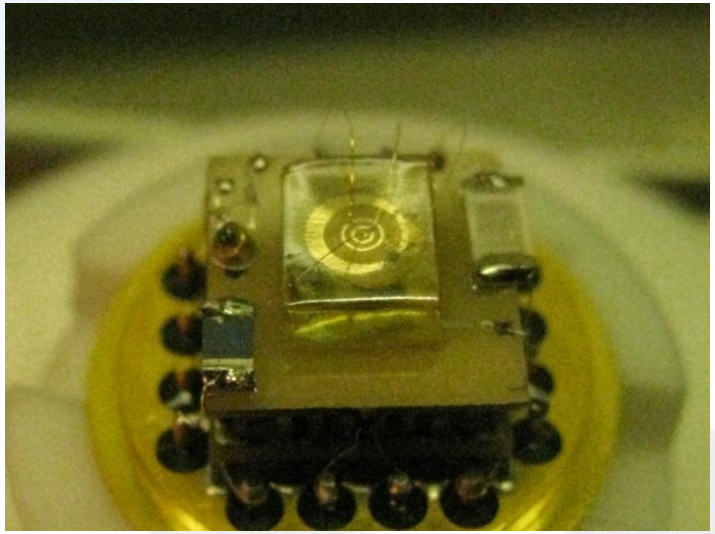


4-segmented Coplanar Grid Detector

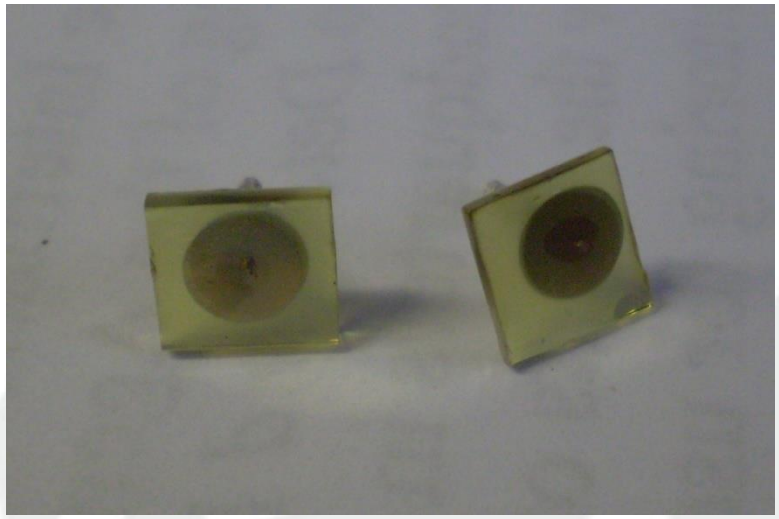
- *State of the art performance:*
  - volume – 15 x15 x10 mm^3;
  - energy resolution - 1.7 % at 662 keV (^{137}Cs)
- *Application: Safeguard in nuclear industry*

TlBr detectors

High atomic numbers Z (Tl=81, Br=35)

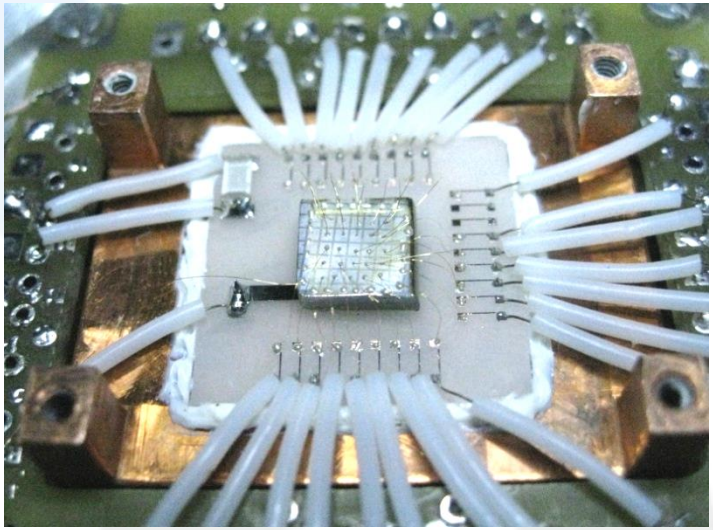


TlBr ring detector

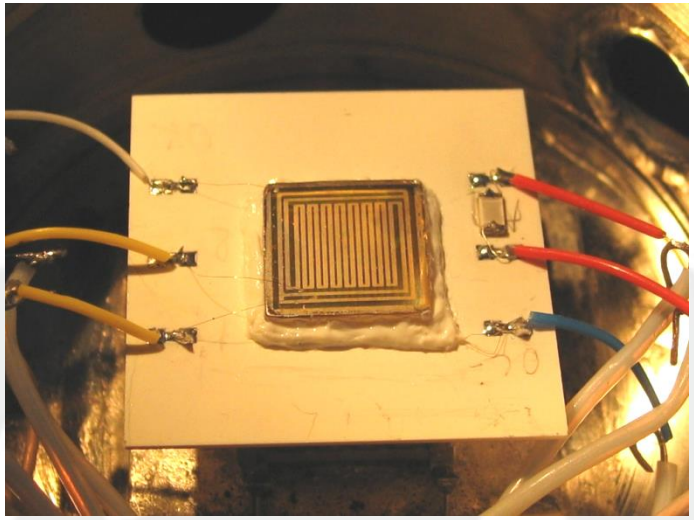


TlBr single detectors

TlBr pixel and coplanar detectors



Prototype of TlBr pixel detector



Prototype of TlBr coplanar detector

Scintillation detectors

KEY PROPERTIES OF SOME SCINTILLATION MATERIALS

	Hygroscopic	Own Background	Density, g/cm^3	luminescence time, microsecond	Light Yield, photon/keV	FWHM@ 662 keV (2”x2”), %	Detection Efficiency (5 cm, point, Cs-137, 2”x2”), %	Emitted Light Wavelength, nm
NaI(Tl)	+	Low	3.67	0.23	38	~6.5	~0.65	415
$LaBr_3$(Ce)	+	Significant	5.08	0.016	63	~ 3	~1	380
$CeBr_3$	+	Low	5.23	0.018	60	~ 4.2	~1	370
SrI_2 (Eu)	+	Low	4.60	1-5	90	~3.1-3.6 (1.5”x1.5”)	~0.4 (1.5”x1.5”)	450

Mobile gamma spectrometric system **GammaCART** for radiation monitoring of terrain based on $LaBr_3$ (Ce)

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Chemical Etching

Photolithography

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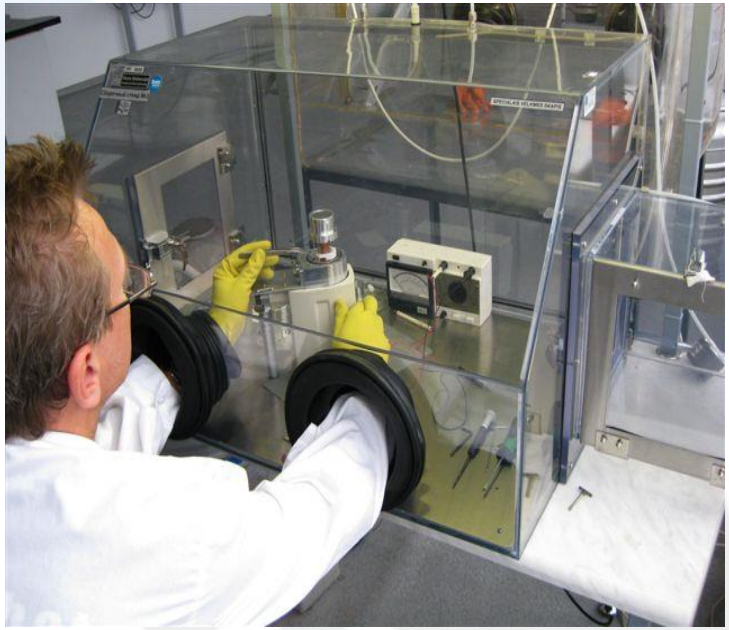
Vacuum Deposition

Assembling



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Thank you for your attention!

Questions ?